A HISTORY OF AGRICULTURE IN INDIA

VOLUME IV
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PREFACE

INDIA's most impressive achievement since Independence is in the field of agriculture. Feeding and clothing a population of 690 million, more than the combined population of the USA and the USSR, is indeed a creditable performance. To realize the significance of this achievement, let us look back to the India before Independence. Canal irrigation began during the British period, from the middle of the 19th century onwards, when the country was plagued by droughts and famines. In Punjab, Madras and United Provinces of Agra and Oudh large irrigation projects were launched by the Britishers. Up to the middle of the present century, extension in canal irrigation was the major input in agriculture. Even so, foodgrain production during the British period stagnated with an insignificant growth rate (0.11 per cent annually), while the population rose at the rate of 1.5 per cent annually.

Since Independence, great emphasis has been laid on multipurpose dams. The dams provide canal irrigation as well as power for tube-wells which tapped ground-water resources. Since 1950, the increase in the production of foodgrains has been 2.8 per cent annually, while the population growth rate was about 2.1 per cent. The increase in food production was higher as compared with China, where it is estimated at 2 per cent annually. From 1950 to 1960 the traditional technology was relied upon. More area was brought under irrigation and waste land was reclaimed. Mellor states: "As much as a fifth of the production increase was due to the expansion of irrigation, some two-fifths to the increased utilization of labour associated with population growth, and perhaps a third simply to increasing the amount of land under cultivation. The latter two factors and even the first can be attributed in large measure to new energies released and new incentives provided by national independence[1]."

Owing to the adoption of modern technology by the farmers, foodgrain production increased in a remarkable manner. It went up from 50.80 million tonnes in 1950-51 to 131.37 million tonnes in 1978-79 and 142 million tonnes in 1983-84. The increase in wheat production was most spectacular. It rose from 19.59 million tonnes in 1965-66 to 34.89 million tonnes in 1978-79. The productivity rose from 827 kg/ha to 1500 kg/ha. Rice production rose from 30.58 million tonnes in 1965-66 to 53.82 million tonnes in 1978-79. The production of oilseeds increased from 5.22 million tonnes in 1949-50 to 9.55 million tonnes in 1978-79. In 1965-66, when

[1]Mellor, J. W. The agriculture of India, *Scientific American*, September 1977

the area under sorghum was 17.68 million hectares, the production was 7.58 million tonnes. In 1978-79, although the area under sorghum declined to 16.12 million hectares, the production increased to 11.56 million tonnes. This was due to the increase in productivity per unit area, from 429 kg/ha in 1965 to 715 kg/ha in 1978-79.

With the release of hybrids of *bajra*[2] ('HB 1', 'HB 5') in 1965-66, the production increased from 3.78 million tonnes to about 8.02 million tonnes in 1970-71. Thereafter, with the outbreak of downy-mildew disease, the production came down to 3.27 million tonnes in 1974-75. The plant breeders have developed *bajra* hybrids like 'BJ 104', 'BK 560', 'PHB 10' and 'MMB 110', which are resistant to downy-mildew. The production started showing an upward trend, and during 1978-79 a record production of 5.5 million tonnes was achieved.

Detractors of the Green Revolution ascribe all types of evils to it and repeat in parrot-like fashion that the rich have become richer and the poor poorer. But a study of Punjab and other areas in India has shown that all sectors of the population have benefited from the Green Revolution. Moreover, it has saved millions of people from starvation. Besides, tractorization has promoted multi-cropping and generated great demand for manual labour. The small farmers, instead of leasing their land to others, now enjoy the benefit of custom-ploughing by owners of tractors and keep the entire produce.

The most difficult problem which confronted India on the attainment of Independence was that of resettlement of refugees from West Pakistan. The best cotton- and wheat-producing areas in the Canal Colonies had gone to Pakistan. West Punjab inherited 55 per cent of the population, 62 per cent of the area, 70 per cent of the canal irrigation built by the British, and 70 per cent of the income of the old province. The exchange of people was almost even — 4.3 million coming to East Punjab against 4.2 migrating to Pakistan. But while the Hindus and Sikhs had abandoned 1,592,487 hectares of land in Pakistan, of which 1,022,044 hectares were irrigated, 502,906 hectares perennially, there were only 991,010 hectares to offer to them, of which 308,990 hectares were irrigated, barely 95,073 hectares perennially.

Thus in 1947 East Punjab was the poorer of the two new States, and was deficit in foodgrain by about 35,000 tonnes. The problem of resettlement of refugee farmers was skilfully handled by the Punjab (I) Government, assisted by the Government of India, and by 1950 the enterprising farmers of the new State started improving their newly acquired farms, dug tube-wells and purchased tractors. Ultimately, they were the people who sparked off the Green Revolution and made Punjab (I) the granary of India.

[2]Pearlmillet, *Pennisetum typhoides* (Burm. f.) Stapf. & C. E. Hubb.

This work is not adequately known or appreciated in India or abroad; hence it is described in some detail in the preliminary chapters of this book.

When people talk of land reform they usually refer to a single measure—imposition of a ceiling of land holdings and subsequent redistribution of surplus land to the landless. What is even more important is consolidation of scattered and fragmented holdings. This unsatisfactory arrangement of holdings with numerous tiny plots scattered over a large area is the greatest source of waste in regard to land. Punjab and Haryana have solved this problem. This is the main factor which explains their phenomenal success in agricultural development. I have dealt with this subject in sufficient detail with the hope that the policy-makers and administrators in the States which are lagging behind would take note of it and follow the lead of Punjab and Haryana. What is required is a political will, followed by vigorous administrative action.

No study has as yet been made of India's Industrial Revolution, which began in 1950 and is still continuing. The construction of steel mills during the first two Five Year Plans ushered in the Industrial Revolution. These mills provided steel for improved agricultural implements and agricultural machinery, and pipes for tube-wells. Tractors, which were not manufactured in the pre-Independence India at all, are now manufactured in significant numbers and are also exported. Hence, those who criticise the authors of the first two Five-Year Plans for laying too much emphasis on steel mills are misleading the people. In fact, there is a direct relationship between the input industry (including steel mills) and improved agriculture.

A most important development in free India is the growth of the fertilizer industry and the use of chemical fertilizers by our farmers. Fertilizer consumption increased from 306,000 tonnes in 1960-61 to 2.8 million tonnes in 1977-78. Now India is the fourth largest producer of chemical fertilizers in the world. Another development in this area is the development of the pesticide industry to provide chemicals for plant protection.

In this book I have dealt primarily with the achievements of scientists, engineers and technologists in agriculture, animal husbandry, veterinary, irrigation and related areas. This does not, however, mean that the role of administrators in the process of development was less important. India survived the shock of partition, speedily resettled the refugees from Pakistan and within three years earnestly undertook the job of rebuilding its agriculture. This was largely due to the dedicated work of P. N. Thapar, N.K. Kripalani, Tarlok Singh and the present author. P.N. Thapar was an innovator, and his support to the scheme for the development of agricultural universities and agricultural research in general was of crucial importance. Raja Surendra Singh of Nalagarh, who headed a committee known after his name, recommended improvement in the pay-scales of agricultural scientists and extension workers. Tarlok Singh played an important role in the formulation of the scheme of intensive agriculture in irrigated areas. Vishnu Sahai promoted sugarcane cultivation in U.P. His younger brother Bhagwan Sahai took great interest in development of agriculture, when he was Joint Secretary, Ministry of Agriculture, Government of India.

H.M. Patel gave a strong support to the programme for field trials of fertilizers. B. Sivaraman had an important role in the development of fertilizer factories and recommended the establishment of a countrywide network of fertilizer stores. M. S. Sivaraman promoted the practice of green-manuring in the States where it was not known. The spread of green-manuring with the use of *dhaincha (Sesbanea aculeata)* in northern India is largely due to his efforts.

Apart from these men of exceptional ability, there are scores of others who efficiently managed the development projects entrusted to them. The organisation of the Intensive Agriculture Development Project and the Intensive Agricultural Areas Programme over a large area require administrative skill of the highest order.

The administrative apparatus inherited from the British was overcentralized and had too many in-built constraints. Its main object was to maintain the status quo. Confronted with the task of agricultural development, vast in scale and magnitude, the Government of India and the State Governments adopted the device of organizing corporations with their own funds and staff and with considerable flexibility in their working. The Food Corporation of India made arrangements for the purchase of foodgrains from the farmers and the sale to the consumers through fair-price shops. The Marketing Federations in the States also purchased wheat, rice and other foodgrains from the farmers at prices fixed by the Government of India, and they sold to the farmers inputs such as chemical fertilizers and agricultural machinery. The Poultry Corporations supplied poultry feed to its members and also made arrangements for the purchase and sale of eggs. The Agro-Industries Corporations supplied tractors and spare parts to the farmers at reasonable rates. They also checked the malpractices of private dealers through competition. The milk co-operatives made their own arrangements for purchasing milk from the farmers and selling it to consumers. This type of decentralization with the organization of corporations deserves to be adopted by other countries facing the problems of developing their economies.

While assessing the pace of agricultural development we must not forget the size of the country and its farming population. After all, it is the farmer who has to perform, while scientists, extension workers and administrators are there to help. India's geographical area is 328.78 million hectares. In size the country is the fourth largest in the world after the USSR, the USA and China. The total cropped area is 175.18 million hectares, of which 37.96 million hectares are irrigated. There are 81.5 million operational holdings, of which 44.5 million are below 1 hectare and are classified as marginal. There are 14.7 million holdings between 1 and 2 hectares, classified as small. Holdings between 2 and 4 hectares are classified as semi-medium and are 11.6 million hectares in area. Medium holdings are those between 4 and 10 hectares, and they number 820,000. Holdings of 10 hectares and above are classified as large and are mostly in arid areas. They are 243,000 in number. This distribution of operational holdings indicates that ownership of land is widespread among 81.5 million farmers (as on 7 August 1981). The census of India, 1971, showed that, apart from 78.3 million cultivators, there were 47.5 million agricultural labourers. This indicates the magnitude of the problem of transforming agriculture in India. The farmers are in various stages of development. Most of the small farmers could use improved seeds and chemical fertilizers, as they were liberally helped by the Government with crop loans through banks. Others with larger holdings used their savings for constructing tube-wells and buying agricultural machinery. There was no coercion, no herding of farmers into communes or collective farms. It is these small and medium, independent farmers who, by their hard work, were instrumental in bringing about the Green Revolution.

I felt the urge to write this history of agriculture in India largely because I have a rural background and belong to a farming family. I had experienced the hardships of farming life in my village, Bodal, in Hoshiarpur district of Punjab. Later on, I lived for a while in the Nili-Bar, the Canal Colony of Montgomery district. I had seen how the farmers cleared the scrub jungle infested with snakes and made it into a smiling land producing bumper crops of wheat and cotton. After passing my M.Sc. examination in Botany in 1930, I lived in a mud hut in Chak 2 FFB in the Ganganagar Canal Colony of Bikaner State, where my father had purchased land. It was there that I prepared for the ICS competitive examination, studying books on botany and zoology, sheltered by the straw roof of a *chhapar*. On entering the Indian Civil Service I served in the United Provinces of Agra and Oudh. In Saharanpur, Fyzabad, Almora, Allahabad and Agra districts, I took great interest in rural development work and did my best to improve the lot of the rural people.

Since 1945 I have been actively associated with agricultural development schemes and research, first as Secretary of the then Imperial Council of Agricultural Research, and later as its Vice-President. As Development Commissioner of the Punjab I administered the schemes of consolidation of Holdings and Community Projects. As adviser on Natural Resources to the Planning Commission, I carried on a number of studies on problems relating to agriculture. When India was facing a food crisis in 1964 on account of a prolonged drought and rising population, I was entrusted with the job of organizing and administering the Scheme of Intensive Agriculture in selected irrigated areas all over India. The infrastructure laid during this period promoted the Agricultural Revolution in 1966. From 1968 to 1976 I renewed my contacts with agricultural research, as Vice-Chancellor of the Punjab Agricultural University, Ludhiana, and participated in the process which brought about the vast change in the production of foodgrains and in the life-style of the farmers. Such a change from despair to hope, and from stark poverty to well-being, had occurred after many centuries. Moreover, I have personally known nearly all the people, especially scientists, administrators and political leaders, who promoted this change. Hence, I felt that the history of development of agriculture must be recorded.

A history of this type is a record of facts and of persons who played a leading role in bringing about changes in agriculture. The facts were provided by the scientists themselves and were checked and double-checked. The mosaic which has thus been presented is of facts provided by people who are leaders in agricultural research. A large organization would have been required for this purpose, but I performed single-handed, while living on my small farm, in Punjab, assisted by a devoted and tireless stenographer. This is a work which is not only of labour but of synthesis and a single vision based on my own experience. In these four volumes I have related the past to the present. Agricultural history is a record of developments which have occurred and its successes and failures can be used to guide the planning of agriculture. In agricultural development there is a basic sequence, e.g. land reforms, consolidation of fragmented holdings, agricultural research, provision of improved seed, chemical fertilizers, plant-protection chemicals, tractors, electric motors, extension services, schools, roads, electricity, credit facilities and marketing co-operatives are all necessary. The basic fact is that the farmer must be motivated by giving him incentive prices for his produce.

The farmer should be our first care, and he must be brought forward to the centre of the stage. At present he has practically no interpreter in the Indian press, which is largely owned by business interests. But there is no basic cause for antagonism between agriculture and industry. People in both professions must co-operate in a common endeavour to serve the country. The profession of farming must be respected, and this can happen when educated people turn to it and face the problems which the dumb peasantry is facing. Agriculture not only provides food and fibre for our population but also a good deal of industry, e.g. flour-milling, textiles, fruit-canning, vanaspati and *ghee*-making, tobacco manufacture and leather industry are all dependent on agriculture. The farmers' purchase of inputs, including fertilizers and machinery, has facilitated the development of several industries, storage business, transport agencies and banking and credit organizations. Thus national well-being and progress are closely connected with agriculture.

No country can ensure development on its own without contact and help from other countries. The history of dwarf Mexican wheat varieties and improved strains of rice amply proves this. Japan contributed the dwarfing 'Norin' genes to the wheat project at CIMMYT, Mexico. The USA provided the scientists, and Mexico the land and labour. It is by their joint work that the high-yielding varieties were evolved and were introduced into India and other countries. Indian scientists, however, were not mere recipients of this material; they improved it significantly. They also worked out packages of practices, including agronomic and plant-protection measures, in respect of these crops. The newly started agricultural universities forged a link between scientists and farmers. The new varieties found ready acceptance by farmers who adopted tractor cultivation, tubewell irrigation and started using chemical fertilizers and plant-protection chemicals.

This is just one example. The World Bank, the TCM of the USAID, the Federal Republic of Germany, the Soviet Union, Denmark and a number of other countries all helped in various ways. Agricultural machinery was supplied by the USSR to the seed farms at Pantnagar, Suratgarh, Jetsar, etc. Indo-German projects have done splendid work in modernizing agriculture and horticulture and in the improvement of cattle by cross-breeding in Himachal Pradesh. Substantial assistance has been provided by the Food and Agriculture Organization, and the Colombo Plan. The volume of such assistance has, however, been low in comparison with the needs, size and diversity of agriculture in the country. Besides, most of the resources were provided by the country itself.

Now that India has developed its agriculture, it is in a position to lend a helping hand to other developing countries who are facing problems which we have solved. It is in this respect that this history of agriculture in India from 1947 to 1981 would be of practical value to administrators and policy-makers, not only in India but in all developing countries. Even in India much leeway has to be made up in some of the States which are lagging behind. If this book helps in clearing the fog, which sometimes obscures the primary objectives in policy-making, I would feel that my labour has been amply rewarded.

Garden Colony
Kharar (near Chandigarh)

M. S. RANDHAWA

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Reclamation of the Tarai tracts[1] in the district of Nainital is an important development in the history of agriculture in free India. There is no worthwhile publication on this project, which amply illustrates the indifference of our people to the recording of contemporary history. Fortunately, Harpal Singh Sandhu, who was Deputy Director (Colonization) in this project, is still alive and he provided an authentic account. Mr Anand Sarup, Vice-Chancellor, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, provided pamphlets published by the Public Relations Department of the Uttar Pradesh Government.

Information on the progress of consolidation of holdings in Punjab has been supplied by Mr S. P. Karwal, Director, Consolidation of Holdings, Punjab, Jullundur. For India, information on the progress of the scheme has been given by Dr P. D. Srivastava, Director (PC), Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India.

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Dr Sukhdev Singh provided a note on the life and work of Sardar Labh Singh, cotton botanist. Dr C. T. Patel sent me a note on his work on 'Hybrid 4' cotton, and Dr Khem Singh Gill, on millets.

Pushkar Nath gave detailed information on high-yielding varieties of potatoes evolved by him and also on seed-plot technique for raising seed

[1]Submontane region at the foothills of the Himalayas.

potatoes in the plains. Mr R. S. Rana, Director of Horticulture, Himachal Pradesh, provided information on the progress of apple cultivation in Himachal Pradesh. Dr P. P. Nanjappa, Joint Director of Horticulture, gave information about grape cultivation in Karnataka, and Dr A. Gopalakrishna Murthy on grape cultivation in Andhra Pradesh. Dr J. B. Ghugare gave detailed information about pioneers in grape cultivation in Maharashtra. Dr K.S. Nandpuri provided a note on his work on vegetables including tomatoes and musk-melon.

As regards veterinary science and animal health I have relied on the information provided by Dr B. S. Gill, Dean, College of Veterinary Science, Punjab Agricultural University, Ludhiana. Dr J.M. Lall, Senior Scientist, ICAR, gave a note on the Rinderpest Eradication Scheme. Dr Dalbir Singh Dev, Animal Science Department, PAU, provided useful information on the history of poultry farming. Information on cross-breeding of cattle was supplied by Dr D.S. Gorhe, Bharatiya Agro-Industries Federation, Pune, and by Dr S.S. Gill and Dr Dalbir Singh Dev. Information on development of dairying has been provided by Mr Verghese Kurien, Dr S.S. Gill and Mr Gurbhagwant Singh Kahlon.

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Information on farm mechanization and innovations made in India has been supplied by Dr S. R. Verma and Dr B.S. Pathak of the College of Agricultural Engineering, PAU, who placed their research notes at my disposal.

Mr C. Subramaniam very generously permitted me to quote from his book *The New Strategy in Indian Agriculture,* published by Vikas Publishing House (Pvt.) Ltd. Regarding history of agriculture in the USA, Japan and Mexico, I have relied on articles published in the journal *Agricultural History* in 1967. I am indebted to Messrs Prentice-Hall, Inc., Englewood Cliffs, NJ, for quotes from N. Platt and M.J. Drummond's *Our Nation from its Creation, a Great Experiment,* 1964.

I have been generously assisted by Dr A.K. Sharma, Indian Agricultural Research Institute, in researching information about the work of late Dr Harbhajan Singh, whose work on vegetables is memorable.

My personal Assistant-cum-Research Fellow, Mr Ram Lal Sharma, worked indefatigably in typing and retyping the text, denying himself all holidays. Apart from typing the text, he typed scores of letters addressed to persons concerned with agricultural development in India as well as abroad.

He was also of great assistance in reference work and had to carry heavy loads of books from Ludhiana to Chandigarh and back. What he has been able to handle single-handed would have required a whole section elsewhere.

All but the last two chapters were edited by late Dr Kishan Singh Bedi, Joint Director of Agriculture (Research and Education), Punjab. He died on 18 December 1981 and thus missed to see this work in print, to which he had contributed so effectively.

Mr T.P. Saxena, former Librarian of the Punjab Agricultural University, Ludhiana, a doyen among the librarians of India, prepared the index.

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Messrs P.L. Jaiswal, S.N. Tata and R.S. Gupta helped in editorial work. Mr Krishan Kumar assisted by Mr J.B. Mehra looked after the production of this book and saw it through the press with a sense of dedication.

CONTENTS

LIST OF ILLUSTRATIONS

CHAPTER 1

PARTITION OF INDIA, MIGRATION OF REFUGEES TO PUNJAB (INDIA) AND THE BIGGEST LAND RESETTLEMENT OPERATION IN THE WORLD 1947–1950

On 15 August 1947, India was partitioned, and a new country, called Pakistan, appeared on the map of Asia. Sind, Baluchistan, the North-West Frontier Province, the Bahawalpur State and 16 districts of the West Punjab formed the Western Wing of Pakistan. Thirteen districts of the East Punjab and the States of Patiala, Nabha, Faridkot, Jind, Malerkotla and Kapurthala remained a part of India. The West Punjab included 55 per cent of the population, 62 per cent of the area and controlled 69 per cent of the income of the old Punjab Province. On the other hand, the East Punjab obtained 45 per cent of the population, 38 per cent of the area, and 31 per cent of the income of the original Province. Thus the West Punjab had bigger resources in land, water and income.

The entire Hindu-Sikh population of West Pakistan migrated to India and the Muslims of the East Punjab migrated to West Pakistan (Fig. 1). This great migration of people is one of the major events in world history. How the refugees resettled in India, and how Punjab (I) rose like the proverbial phoenix out of the ashes is the story told in the following account. It was the biggest land-resettlement operation in world history. When one considers the unsolved problem of the resettlement of the Palestinian Arabs who were expelled from Israel, and were much smaller in numbers, one cannot help admiring the administrative skill and political will-power which led to the happy solution of this problem in India.

As against 2,711,396 hectares (67 lakh acres, equivalent to 3,935,131 standard acres) abandoned by the Hindu-Sikh landholders in West Pakistan, only 1,902,024 hectares (47 lakh acres, equivalent to 2,448,830 standard acres) was available in the East Punjab and the PEPSU (Fig. 2). The gap in the area to the extent of 601,480 hectares (20 lakh acres or 1,486,301 standard acres), i.e. 38 per cent of the total area abandoned, precluded the possibilities of full compensation being given to the displaced landholders. The gap in the area was bad enough, but the position was actually much worse when we consider factors such as the fertility of the soil and the means of irrigation. Our landowners left 1,022,044 hectares (43 lakh acres) of irrigated land against 308,990 hectares (13 lakh acres) of irrigated area left by the Muslims. Out of the irrigated area left in West Pakistan, 522,906 hectares (22 lakh acres) was perennially irrigated

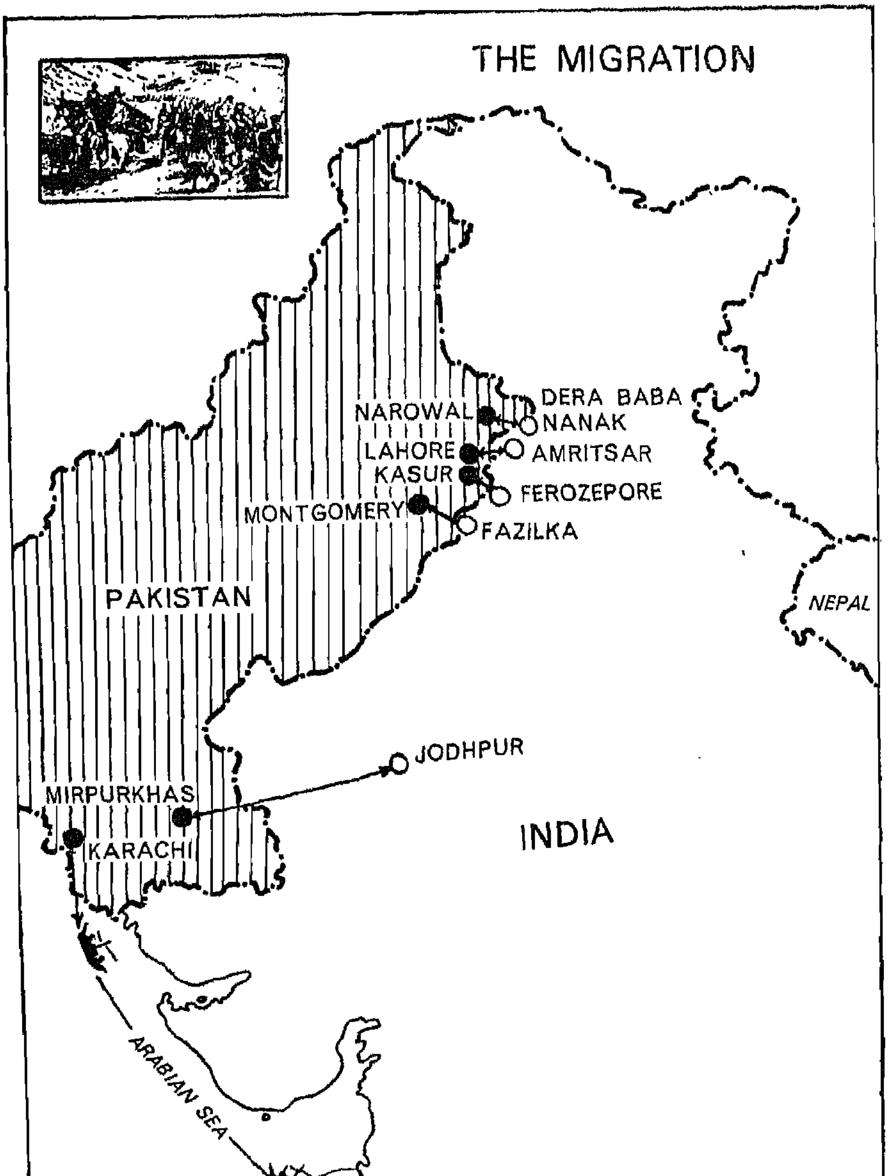


FIG. 1. A map of India and Pakistan, showing migration routes of refugees by land and sea. Almost the entire Hindu-Sikh population of Pakistan (W) migrated to India from 15 August 1947 onwards.

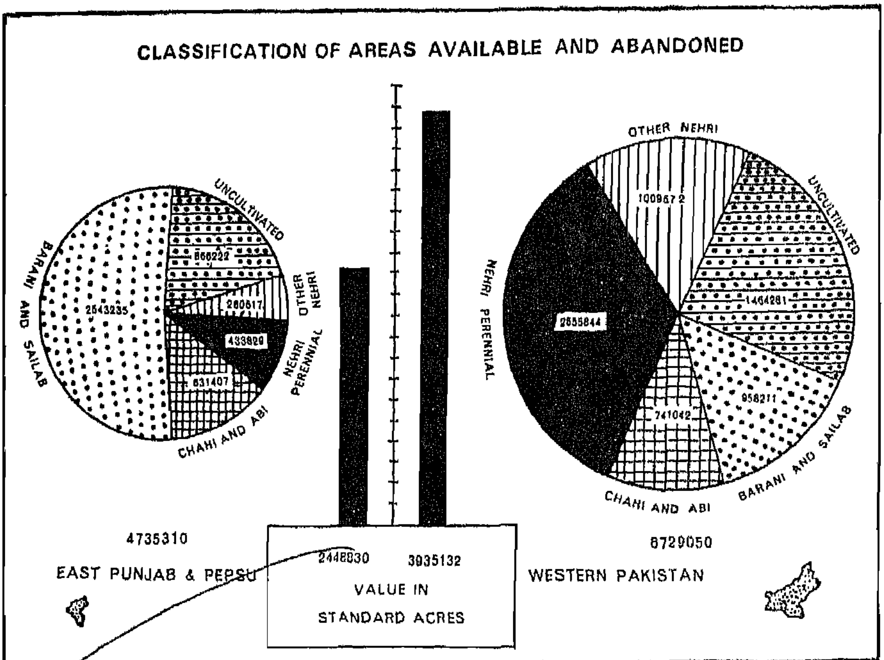


FIG. 2. As against 2.7 million hectares of land abandoned by the Hindu-Sikh landholders in West Pakistan, only 1.9 million hectares was left by the Muslim evacuees in the East Punjab and the PEPSU. The diagram shows the classification of land.

against 95,073 hectares (4 lakh acres) of such land left by the Muslims in the East Punjab and PEPSU.

Temporary Allotment of Evacuee Land

The migrant rural population was sustained for $2\frac{1}{2}$ years through a system of land allotments, which later on came to be known as temporary allotments. Each family was given a plough unit, i.e. about 4 hectares (10 acres), regardless of its holding in Pakistan. No distinction was made between a tenant and a landholder, and both were equally eligible for allotment of the evacuee land.

Plan for Distribution of Population

The scheme of temporary allotment of the evacuee land was conceived in the beginning of September 1947. It was decided to settle the agricultural section of the displaced persons arriving in India in the evacuee villages, where land and houses were available because of the migration of the Muslims. A plan for an even distribution of the displaced peasantry in the various districts of the East Punjab was drawn, indicating where the persons belonging to a particular district in West Punjab were to be settled on land. Handbills, explaining the plan in Urdu and Punjabi, were freely distributed in relief camps in India and Pakistan so that many persons, even before they crossed the border, knew to what place they should go to get the allotment of land. The concentration of too many persons in some districts and too few in others was avoided as a result of this plan. There was still another gain from this procedure. Since particular areas in East Punjab were earmarked for persons belonging to particular districts from the West Punjab, these persons got easily concentrated in the areas earmarked for them, and a very large measure of homogeneity was secured. Thus in their sojourn in a land which was more or less foreign to them, the displaced persons were surrounded by people who knew and understood them, and who were facing similar problems. This procedure, in no small measure, contributed to their psychological rehabilitation.

Group Allotments

The temporary allotments of the evacuee land were, as a rule, given to groups of families in preference to individuals. In the early phase of migration, friends and relatives, because of insecurity and uncertainty about their future, collected and formed small groups. The Government also found it easier to deal with these groups than to deal with individuals or single families. Each group selected an intelligent and influential person as its spokesman, and acknowledged him as their group leader. It was through him that the *patwari* of the village or the *halqa* revenue officer dealt with that group. The advantages of the group system for quick distribution of land as well as for the happy and successful settlement of displaced persons in villages, which they had never seen or heard of before, are obvious. Living together among friends and relatives or in their own *bradari* gave them a sense of security in these distant and foreign lands and helped to rehabilitate them psychologically. There was an advantage from the point of view of cultivation also. All of them did not individually have the wherewithal of agriculture, such as bullocks and implements. Working in groups, they could pool their manpower, bullocks and implements and, thus, to a certain extent, overcome their shortages. Group allotments should not be confused with group cultivation. The allottees were not obliged to cultivate jointly the area allotted to a group. If a particular allottee at any stage wanted to cultivate his share separately, he was at liberty to have it demarcated.

Unless the evacuee area in a village was very small, it was rarely that a whole village went to one group, because the strength of a group generally did not exceed 20 families. Larger villages contained three or four or even more groups. At the time of the quasi-permanent allotment, a very large number of these temporary allottees were confirmed in the villages of their temporary allotment and, thus, homogeneity was achieved in the rural resettlement.

FINANCIAL ASSISTANCE

After the farmers had been put on land, financial assistance was given to them by the Government through *taccavi* loans. These loans were for various purposes, but the food loans and loans for the purchase of seed and bullocks were the most popular ones. Food loans were advanced at the rate of Rs 3½ per adult and Rs 2 per child to displaced persons living in the villages to enable them to tide over the period, their dispersal from the relief camp and the raising of their first crop. The least popular of the loans were those for the repairing of houses and wells. With the talk of quasi-permanent allotment in the air, nobody wanted to invest in houses and wells which he might have to leave. Owing to the disturbed conditions, there was also a lack of building material and equipment for wells. In all, the Government advanced *taccavi* loans, amounting to over 30 million rupees, for purchasing bullocks, seeds and fodder, and for repairing houses and wells.

The temporary allotment of the evacuee land provided the displaced farmers with some occupation and means of subsistence, and, thus, created an atmosphere of comparative quiet in which allotment work could be carried on. Those who worked at the Jullundur Secretariat know that it was not very quiet outside the barbed-wire enclosure, but things would have been much worse if nobody had had anything to do, and the progress of work would have been slower.

In another respect also, the temporary allotments had a bearing on the quasi-permanent allotment of the evacuee land, which followed. They set the pattern of quasi-permanent allotment and decided its outline. The earmarking of particular East Punjab districts for West Punjab districts, to which a reference has already been made, was, in the main, adhered to in the quasi-permanent allotment of the evacuee land. An overwhelming majority of the temporary allottees remained where they were sitting as temporary allottees. They were, in a way, outside the discretionary powers of officers who were allotting land on quasi-permanent basis.

ALLOTMENT OF EVACUEE LAND IN PUNJAB, 1949-1950

At quite an early stage in the migration of the population, it became clear to the Punjab Government that this migration was going to be a permanent one. There was obviously no possibility of the displaced persons returning to the country which they had left for very good reasons only a few months earlier. Therefore, as soon as arrangements for temporary settlement were complete, the Government began to concentrate on some sort of a permanent distribution of the evacuee land among the displaced landholders. This distribution would also be related to their holdings abandoned in Pakistan. It was decided that the evacuee area in Punjab and PEPSU should be made use of for the settlement of displaced landholders from the West Punjab only, and of such others from West Pakistan as were of Punjabi origin. In February 1948, a press note was issued, announcing that the original scheme of temporary allotment would be replaced by a revised one, in which possession would not be disturbed and allotments would bear some proportion to the holdings abandoned in West Pakistan.

It is reasonable to presume that people had entertained visions of some such system when they abandoned their homes. Before packing up, they persuaded the *patwaris* of their villages to make out copies of the revenue records, showing how much land stood in their name, and carried these copies as precious documents. They had some sort of a conviction that it was this area that they were abandoning which would ultimately determine the size of their future holdings.

At this stage, the Government had no record in its possession to show how much area a displaced person had abandoned. Complete data were not available even about the credit side. The revenue records of a large number of villages in which the evacuee land was situated were lost, destroyed, or stolen during the disturbances. In the Hoshiarpur District, for instance, there existed only 867 *jamabandis* out of a total of 1,515; in Ludhiana, 506 out of 691. The only source of information about the abandoned area was the displaced persons themselves. They were, therefore, invited to give this information in the shape of claims for land. Since these claims were to form the basis of resettlement, it was important that they should be accurate. Severe penalties were provided for the submission of false claims. A displaced person giving a false or exaggerated claim was liable to punishment with rigorous imprisonment up to five years, or to a fine up to Rs 5,000, or to both. In addition to these penalties, the deputy commissioners were authorized to disqualify for allotment any person who had submitted a false claim, and to cancel, either in whole or in part, any allotment which might have been made on the basis of a false claim.

Verification of Claims

Arrangements for the registration of claims were made at the offices of tahsils and sub-tahsils of East Punjab. The period for receiving these claims was from 10 March to 10 April 1948. In all, 517,401 persons filed claims to land at all these centres. These claims were then collected at the Jullundur Secretariat for analysis and tabulation. The first half of May was an important fortnight. After a couple of weeks of very strenuous work by some 1,100 workers in the Jullundur Secretariat, proposals for land resettlement, the evaluation of tenures, the evaluation of lands in East Punjab and West Punjab and in the states, and the allocation of districts and tahsils, were taken to Simla for discussion in the Provincial Relief and Rehabilitation Board, and for the consideration of the Government. The stage was set for immediate action to make quasi-permanent allotments in terms of standard acres to enable the allottees to begin afresh with effect from the *kharif* of

1948. One serious obstacle, however, blocked the immediate programme.

It was estimated that the claims received contained an overall exaggeration of about 25 per cent. It was not considered proper to proceed with the work of land allotment on the basis of these claims. For one thing, such a procedure would have given an unfair advantage to those who had given false or exaggerated claims over those who had stated their holding correctly. And for another, the inflated claims would have further increased the large difference between the area abandoned and the area available. To eliminate this exaggeration, and to arrive at each person's correct claim, it was decided to have the claims verified by other persons from the old village of the claimant. This verification was to be done not individually but by a *panchayat* of all the claimants from a particular village in West Pakistan. The idea was that a revenue officer would read out each person's claim before the *panchayat*, who would then verify it. They were required to assemble at a certain place on a notified date. The programme for village assemblies was printed in the form of a brochure. Copies of this brochure were extensively circulated well in advance, so that each person, wherever he was settled, could know where the claimants from his village were to present themselves to verify one another's claim. As a result of this publicity, attendance at these village assemblies was generally good. As each claim was read out to the *panchayat* by the revenue officer, the *panchayat* confirmed its correctness or incorrectness.

The policy of land allotment could not be shaped on inaccurate data. Antisocial elements among the displaced landholders, who indulged in making false claims, or exaggerated their areas, considerably contributed to the delay in the quasi-permanent allotment of land. At the spur of the moment, it was not possible to take action against the persons who had filed exaggerated claims, as the entire staff was engaged in allotment work. However, these persons met their doom in due course when the work relating to the issuing of allotment orders was completed. Persons who had filed false claims were prosecuted, and in many cases were given deterrent sentences of imprisonment. Those who had filed exaggerated claims were subjected to cuts in their allotted area, and this proved to be a very heavy punishment, indeed.

As a result of enquiries and explanations, claims and contradictions, the revenue officer had at the end of the day a fairly correct picture of the ownership of land in a village. He put all the information obtained as a result of these enquiries in a prescribed form, and sent it back to the headquarters at Jullundur. In this work of verification of land claims, the *panchayats* played an extremely useful role. They displayed their traditional honesty and fearlessness, and were very helpful to the administration in arriving at the correct area abandoned by each person. This verification work was satisfactorily accomplished with respect to all those villages which had a fair numbr of displaced landholders. But in the case of such villages (specially in the Multan and Rawalpindi divisions) that had only two or three families of landholders, which, even when assembled could not be called a *panchayat*, the verification was inadequate or was not done at all. In many cases, the claimants did not arrive for verification.

Along with the verification of each claim, the claimant was asked where he wanted to receive his quasi-permanent allotment. The preferences indicated by individuals were noted and considered later. But to an extraordinary degree, the applications giving new preferences poured in when the work of allotment was actually begun. It is significant that most of the claimants, when asked where they would like to settle, simply said, "we may be settled along with other persons of our village".

EXCHANGE OF REVENUE RECORDS WITH PAKISTAN

The verification took place from 17 August up to the end of October 1948. Early in July, however, discussions had taken place between the East Punjab Government and the West Punjab Government on the subject of exchange of revenue records. It was decided that each Government would prepare copies for the use of the other. The governments of East Punjab and PEPSU on the one side, and the Government of West Punjab, on the other, agreed to exchange copies of *jamabandis* (revenue records) of all evacuee villages on each side. This was a very useful agreement, since the arrival of records gave a firm basis to land allotment.

After verification, all claims were again collected at the Rehabilitation Secretariat at Jullundur. They were then sorted, categorized and tabulated, so as to give an idea of the requirements for various groups of landholders. On the basis of these tables, the land-allotment policy was framed. Non-official opinion was closely associated with the framing of the land-allotment policy. This was done by means of a Rehabilitation Board, which consisted of representatives of various groups of displaced persons and refugee Members of the Legislative Assembly. A number of meetings of this Board were held at Simla and Jullundur. Tentative proposals were placed by the Rehabilitation Department before the members, who gave their opinions after they had debated these proposals at the meetings, and discussed them in their subcommittees.

The staff at the Jullundur Secretariat had been increasing progressively since April 1948, when the claims received at the tahsil offices were first brought there. In October 1948, when the revenue record was received from Pakistan, there was a further marked increase in the number of *patwaris*, *kanungos*, naib-tahsildars and tahsildars for the work of extracting the holding of each claimant, as given in those records. This complicated task was completed by April 1949.

A few more weeks were given to the work of linking up the claims with respect to the land owned by the same person at different places. This was very important, since the policy was that even if a man owned land at 20 places in the West Punjab, he should receive a consolidated allotment as far as possible in one village. This work was among the most difficult processes, leading to the quasi-permanent allotment of land, but it was also a very important work. There was a separate claim for a holding in one district. Thus if a person owned land in three districts, he had put in three different claims and there were no cross-references to these claims to show that all of them related to the same person. This complicated work of linking claims was spun through in June 1949.

Even with all the efforts of the Rehabilitation Department, a large number of claims could not be consolidated, and in one case, a landholder was given allotment of land in as many as eleven villages scattered in two districts. On collecting their allotment orders, those persons were given an opportunity to apply for consolidated allotment orders, and all those who applied were given consolidated allotment in one village. This was a great gain to the displaced landholders, whose holdings were scattered in many villages in West Pakistan and they now enjoyed the benefit of a consolidated allotment which they could manage more economically.

Material was now ready for the allotment of land. In spite of the material being available, there was great nervousness and lack of faith among the public. So huge and complicated was the task that nobody believed it could ever be completed. Previous unattained targets of Government for this work lent weight to this opinion. The Government was, however, anxious to allay this nervousness; it was also eager to rush through this work which had been in hand for quite a long time.

The strength of the staff was further increased in June 1949. During the peak period, there were some 7,000 officials working in the Rehabilitation Secretariat at Jullundur—almost the population of a small town. It was quite a job to provide residential and office accommodation for such a large number of officials. A city of tents grew up around the Secretariat overnight, with regular streets and street lights, baths and latrines, ration and cloth depots, a *mandir* and a *gurdwara*. Some 30 senior officers were lodged in the newly constructed houses in the Model Town of Jullundur, and the remaining were accommodated in tents. The buildings of local schools and colleges closed on account of summer holidays were acquired, and the land-allotment staff of some of the districts was accommodated in these buildings. There was much increase in the number of visitors to Jullundur. Hordes of nervous displaced landholders tramped the roads of the city, thronged its eating-shops, and crowded its transport. They wanted assistance from the *patwari* or from anybody else who was prepared to help them for love or for money in getting the allotment of land in a good village. The quality of its soil, its easy accessibility, its proximity to a town, and one's settlement among people one knew and liked, were great attractions.

Scheme of Allocation

As the displaced peasantry started pouring into East Punjab, persons belonging to particular districts in West Punjab were directed to proceed to specific districts in East Punjab and the PEPSU. The distribution of the families of landholders, which thus occurred, forms the background of the quasi-permanent scheme of allocation. Those who had migrated from East Punjab to West Punjab as colonists, returned to their ancestral villages in East Punjab. Others went to the specific districts assigned to them. The displaced landholders from Lahore and the non-colonists of Montgomery were settled in Ferozpur; the displaced landholders from Rawalpindi, Sheikhupura and Gujranwala were settled in Karnal and PEPSU; those from Shahpur and Gujrat, in Ambala; those from Multan, in Hissar; landholders from Jhang and Muzaffargarh, in Rohtak; those from Dera Ghazi Khan and Mianwali, in Gurgaon; those from Sialkot, in Hoshiarpur, Gurdaspur and Amritsar. The evacuee land available in Amritsar could not meet the demand of even the colonists of that district. The overflow was, therefore, accommodated in the neighbouring districts of Jallandhar, Hoshiarpur and Ferozpur. This, in rough outline, was the scheme of allocation. An effort was made to settle the population of each district and tahsil of West Punjab in as compact an area as possible.

Standard Acre

Considering the diversity in soil, irrigation and rainfall in various districts of West Pakistan, and of districts in East Punjab and PEPSU, the necessity of evolving a common measure was felt. To meet this demand, the standard acre was evolved. It is a unit of value based on the productivity of land. An acre which could yield 10 to 11 maunds (0.37 to 0.41 approx.) of wheat was given the value of '16 annas' and was termed a standard acre. The physical area of a standard acre thus varies and all classes of land in all assessment circles were given a valuation in annas so that they could be measured easily in terms of standard acres. In the *barani* (rainfed) areas of the Hissar District, where the valuation of one acre was 4 annas, 4 ordinary acres went to make a standard acre. In ordinary canal-irrigated tracts, where the value of an acre was 16 annas, an ordinary acre was the equivalent of a standard acre. For this invention credit is due to Tarlok Singh, the first Director-General of Rehabilitation.

How an Individual's Fields were Determined

The unit for purposes of land allotment was the village. The first step taken in the allotment of the evacuee land of a village was the drawing of a list of allottees according to provinces, districts, tahsils, and villages in the Urdu alphabetical order. If the allottees were from more than one province of West Pakistan, the provinces such as West Punjab, Sind and Baluchistan were arranged according to the Urdu alphabetical system. Further, if the allottees were from more than one district, the districts were similarly arranged, then tahsils and then villages. When a person held land in more than one province, district, tahsil, or village of West Pakistan, his name was arranged in the list in accordance with the name of the village, tahsil, district and province, with the *parcha* (receipt) claim of which the rest of his *parcha* claims were consolidated. Where groups and relations wanted to resettle together, the whole group was placed in the list in which its first member came in the alphabetical order. Small allottees to whom the area due was 1/8 of a standard acre only or less were arranged together according to the Urdu alphabet at the beginning of the list of the allottees as the very first item. The list of allottees, once prepared and signed by the resettlement officer, was not altered later on.

When the list of the allottees was ready, the next question was to consider the quality of the soil in the village. The land close to the village *abadi* is usually fertile, whereas the land far away is not so fertile. Apart from the distinction, the texture of the soil and the means of irrigation available were to be considered. In some villages, particularly in the Hoshiarpur District, the disparity in soils was such that whereas there were some blocks of land in the same village which were of mixed loam, and were highly fertile, there were some blocks which were sandy. To ensure a fair distribution of land among the allottees, the land of the village, if it was of more than one quality, was divided into two or three blocks in which the allottees received proportionate share. The measurement of fields usually started from the north-western corner of the village. The allottee whose name was at serial No. 1 obtained his allotment first till the entire area due to him was exhausted. In some cases, if the seriality of plot numbers was strictly adhered to, irregular blocks resulted. In such cases, the resettlement officers were authorized to make compact blocks. When the allotment of the first allottee in the list was finished, the turn of the next allottee came. Exceptions were made only in those cases in which an allottee was the landlord of certain fields of which an evacuee was an occupancy tenant and he had applied for the allotment of those very fields on the valuation basis, or when an allottee owned land served by an outlet, a well or a tubewell, in the neighbourhood of which certain evacuee fields were situated and he had requested for the allotment of those fields; or in hilly tracts, especially in the Kangra District, in the Una Tahsil of the Hoshiarpur District, and in the Nala Garh and Kanda Ghat tahsils of PEPSU, where colonists were given fields as near to their own land as could be possible. The shares of the allottees in the evacuee irrigation wells were fixed in the proportion in which the area irrigated by a well was allotted to them. The system of allotment of field was of a mechanical nature, and the scope for malpractices was very limited. If a *patwari* wanted to favour someone by breaking the seriality of plot numbers, it could be detected. The method adopted for the allotment of fields ensured impartiality, and thus inspired confidence among the claimants for land. This was altogether a new experiment in the Revenue Administration and its application to the consolidation of holdings was likely to ensure speed.

It was on 25 July 1949, an important date in the land-resettlement operations, that the issuing of allotment orders began. In spite of the fact that this date had been announced in advance as the target date, it was a very big news for East Punjab. From two to five thousand allotment orders were issued per day. Progress was good during August to October.

Review of Land Allotments

In November 1949, however, when about 250,000 allotment orders had been issued, there came a break in these operations. The allottees since the beginning of the issuing of allotment orders had had very little opportunity to express their reactions to the allotments made to them. It was, therefore, decided at this stage to review all completed allotments. The review was to take into consideration all complaints and all cases in which, for any reason, the sitting-temporary allottees had been moved. In considering the complaints, the object was to ensure that close relations were settled together, that no sitting allottee who was entitled to receive allotment of land according to the grade and quality of land left by him in West Pakistan or according to the district allocated to him was shifted, and that such mistakes as might come to notice were corrected before the allottees took possession of the land allotted to them. Applications were invited for review; and about 100,000 applications were received. The allotment of more than 80,937 ha (200,000 acres) was changed as a result of this review.

An Interview Board consisting of the Financial Commissioner, Rehabilitation, the Director-General, and the Additional Director-General of Rehabilitation took up the work of dealing with the review applications. Most of the applications received related to the ousting of sitting allottees from the villages where they had received temporary allotment of land and where they were entitled to quasi-permanent allotment. Other applications were from near relations, such as husbands and wives, brothers, fathers and sons, uncles and minor nephews, and widows who had received allotment of land in separate villages. The Interview Board not only provided a check on the activities of the lower staff who realized that they could no longer act in an arbitrary fashion, but also provided a forum for aggrieved persons for getting their injustices and grievances redressed. It was like letting in fresh breeze in a stuffy building. Corruption and mal-practices could multiply in an atmosphere of secrecy, such as that prevailed within the barbed-wire enclosure of the Secretariat building. Ultimately, it was found that the job of reviews was too much for the three top officials, and the additional deputy commissioners, who were in charge of Rural Rehabilitation in the districts and who had also come to Jallandhar, were also encouraged to listen to various types of complaints regarding the allotment of land. In all, 33,000 applications out of 100,000 were accepted, and the necessary changes were made. The review work provided a corrective for wrong and dishonest work, and saved the scheme from crashing under the sheer weight of objections. No doubt, it delayed the progress of work, but it provided a much-needed check on the staff, some of whom in the early stages thought that they could act as they liked.

When dealing with illiterate persons, the importance of personal touch and hearing the man cannot be over-emphasized. Even the Great Mughal Jehangir used to hear the aggrieved persons who had a tug at his Bell of Justice. The importance of interviews was realized by the British administrators also very early. Mr T.D. Forsyth, Commissioner of Lahore, thus advises his Assistant Commissioner of Murree in 1863: "What I wish to say by way of counsel is that the most trying part of our work in India is to have to listen patiently and appear to be interested in all that a native has to say when he comes to call or appears in court—Many men have acquired an immense reputation amongst natives all through this. This, in fact, has gone far to make McLeod so revered. It is not that he grants every man's request. But they can go to him in confidence, knowing that they will never be turned hastily away, or be cut short in their story. And, after all, it is an immense relief to a man to have it out."

The importance of interviews and listening to the complaints of aggrieved persons, whose whole economic future was at stake in the land-allotment scheme, was fully realized by the top officials. A large number of applicants used to assemble at the house of the Director-General early in the morning. It was impossible to give an interview to a hundred persons at once, for the crowd was seldom less than that number, but at the same time they could not be turned away. They were given passes for admission, and they could enter the Secretariat in the afternoon after 3 p.m. Their applications were sorted out and examined by a section of intelligent clerks. The Director-General interviewed them *en masse* and passed suitable orders from 5 to 7 p.m. everyday. Even when he reached his house, he found another batch squatting there. In fact, the life of the Director-General was not different from that of a prisoner, and even in his walks he was pursued by applicants who wanted to be heard. It was a job which required great sympathy for the afflicted persons and also patience for, and understanding of, their problems. It also required unremitting hard work.

Allotment Order

The allotment order which had been issued to each person entitled to land consisted of three parts. The first part stated the area in standard acres to be allotted, and the name of the village or villages in which the allotment was to be made. The second part gave full particulars of the land held by an allottee in West Pakistan, on the basis of which allotment had been made. These details were given in order to enable each person to check his account and apply for correction if he found any mistake in it. The third part of the allotment order gave particulars of fields allotted to each person.

Distribution of Allotment Orders

The distribution of allotment orders was done through tahsil offices. When an allotment order was made in the name of a certain person, an 'intimation card' was also prepared simultaneously. The card was meant to inform the allottee about the village, the tahsil and the district of his allotment and the number of his allotment order. The allottee was further informed that he should collect his allotment order from the office of the tahsil in which the allotment had been made to him. The intimation cards were meant to be distributed by hand through *lambardars* etc. of the village in which the allottee was then known to be residing. This system, however, did not work well, because most of the intimation cards remained tied in bundles in the tahsil offices and never reached the addressees.

A successful method of spreading information about the place of allotment, however, was through the enquiry counters at the Secretariat. A counter was set up for each district of West Punjab, and one for Sind and Bahawalpur. A clerk with a village-wise list, showing the place of allotment of all the displaced landholders of that district, was posted at that counter. A land claimant went to the counter of the district in West Pakistan from which he had hailed, and asked for the information. In a minute, he was informed about the village of his allotment in East Punjab or PEPSU. An intimation card was also made out for him then and there. This system was started in February 1949, and was maintained for about a year. Thousands of persons received information at these counters. For those who could not come to Jallandhar, there was a system of information through post. The landholders were required to write the particulars of their land to the Department, and an intimation card was sent to them by post. Over 75,000 such applications were received and replied to.

The distribution of allotment orders continued right to the end of June 1951. The sitting allottees, who were mostly self-cultivators, lost no time in collecting their allotment orders, but the serving soldiers, businessmen, and shopkeepers, who had rehabilitated themselves outside East

Punjab, faced considerable difficulty in collecting their allotment orders. They continued to trickle to the Secretariat even after the target date, i.e. 30 March 1951, after which allotments were to be cancelled if the allotment orders were not collected. While dealing with a population, a large percentage of which is illiterate, publicity in the newspapers alone does not suffice. In such cases, rules have to be applied in a humane manner, as a rigid application of them would have created great suffering among the displaced landholders, particularly among widows, minors, and illiterate farmers, who had very hazy notions about the rules framed by the Rehabilitation Department. The literates among the displaced farmers acquired a good working knowledge of the rules, and became quite familiar with the jargon of the Rehabilitation Department, and they could be heard mentioning such English words as, allocation, sitting allottee, overflow, grade, etc., freely. They brought information about irregular allotments, such as a grade-II claimant of land allotted land in a grade-I village and a person allotted land outside his allocation area. In such cases, the informers were given due benefit for the information which they conveyed to the Department, and, in many cases, the irregularities committed by the staff were set right.

Delivery of Possession

As already explained, the allotment order contained the actual field numbers allotted to an allottee. These field numbers were to be identified on the ground and shown to the allottee. After collecting his allotment order from the tahsil office, the allottee took it to the *patwari* of his village and he took him round the fields allotted to him and thus delivered their possession to him. As the allottee went round the fields, led by the *patwari*, he strained his nerves to be able to remember those fields which were going to be his for all time to come. The work of delivering the possession of allotted land lasted till the end of 1950, and really ended only after March 1951.

The best part of the evacuee area in Punjab had been in the possession of temporary allottees, consisting of displaced landowners as well as of tenants since October 1947. Now that this area was to change hands, it was generally feared that here might be disputes between the outgoing temporary allottees and the incoming quasi-permanent ones. But all these fears were belied, and contrary to everybody's expectations, possession passed to new allottees everywhere peacefully. This transference was, in a large measure, due to the justice of new allotments.

Economic Consequence on the Scheme of Graded Cuts

What are the consequences of the scheme of graded cuts? Cuts in land are naturally most unwelcome, particularly when they affect a population, a large majority of whom are self-cultivators of land. The cuts worked very harshly on small peasant proprietors, such as the Labana Sikhs of Gujrat and the Jat Sikhs of Sialkot, whose average holdings did not exceed a couple 0.8-2 ha of acres, as well as the Sikh Jats of Gujrat and Lahore, whose holdings were about 0.8-2 ha (2-5 acres). The middle-class peasant proprietors also suffered, particularly with respect to the quality of the land which they received. The holders of big areas were deprived of their large holdings and, at upper levels, on account of the imposition of graded cuts as high as 95 per cent. Their surplus areas were lopped off, while they were left with sufficient lands to provide them with a decent living, provided they exerted themselves. They could no longer lead a life of lazy loons, living on rents collected by their *munshis* from their tenants, and had to associate themselves actively with the development of the land. The shock of drastic cuts in area, which these big landlords suffered, did them good. This shock-therapy provided them with an incentive to become useful productive units. The fear of tenancy rights on account of rising assertiveness among the tenants encouraged them to take part in farming operations, and quite a number of them went in for mechanical cultivation, and many sank tube-wells in the *chahi* areas. It is a common sight to see a well-dressed Sikh *sardar*, driving a tractor in the fields or with a trailer hitched to his tractor, and loaded with fodder, chugging to the market. Similarly, the Lala *zamindars* also started taking active interest in the development and cultivation of their land and many of them sank tube-wells and purchased tractors. Even the Aroras of Jhang and Mianwali, who were merely money-lenders and shopkeepers, turned a new leaf and took to the plough in some of the villages of Rohtak and Gurgaon.

The scheme of graded cuts was a harsh and cruel measure. It was, however, inescapable and unavoidable in the circumstances when there was such a large gap between the area abandoned and the evacuee area available for allotment. That area, too, was shrinking on account of the restoration of land to the Muslims in the districts adjoining Uttar Pradesh. With all its fault, the scheme represented the widest common measure of acceptance of a national calamity by the displaced landholders, whose representatives from all strata of landholders were associated with the work and were frequently consulted when the land-resettlement policy was shaped. It represents an unparalleled sacrifice by the 350,000 families of refugee landholders at the altar of freedom. The rest of India, which did not suffer on account of the historic partition of the country, owes a deep debt of gratitude to the displaced landholders of West Punjab, who bartered their heritage for the relatively poor land of East Punjab, so that their country might live in peace and harmony. In due course, these farmers improved their land and became leaders in agricultural improvement work.

This gigantic operation required not only unremitting hard work, but also qualities of leadership, such as initiative, capacity to think clearly, and to provide clear guidance in unambiguous terms, so that their orders could be followed by the lowest official. These are the qualities which the top officials, particularly P.N. Thapar, Financial Commissioner (Rehabilitation), had in ample measure. There were no rules or regulations to guide them, and they had to formulate their rules from the various problems which confronted them. In a sense, it was an original work of exciting nature which required freshness of mind and a new approach. That the top officials did not lack these qualities is evident from the successful conclusion of the vast operation of the quasi-permanent allotment of land. Undoubtedly, it imposed a strain on the workers who had to work from early morning till late in the night, and many of them broke down, but the joy of work and the feeling that hard work on their part contributed to the mitigation of misery among the refugee farmers was indeed a great satisfaction to them.

CHAPTER 2

RESTORATION OF A SHATTERED RURAL ECONOMY IN PUNJAB (INDIA)

MODERNIZATION OF AGRICULTURE

1950–1951

LIKE any other industry, agriculture requires capital for its successful prosecution. Most of the displaced persons had no money when they started settling on the evacuee land. Only some of them were able to bring with them their bullocks and carts. But even they were in need of money for purchasing food, fodder and seed. Their traditional financier, the *bania*, who migrated with them, was in difficulties himself. And even if he had managed to escape into India with a little money, his present status or the future prospects of his old clients were not such as to inspire confidence in him or in any other money-lending agency. Under such conditions, it became the duty of the Government to assist the displaced cultivators by lending money to them. From September 1947 to March 1951, more than 45 million rupees was lent to displaced landowners for different purposes. Out of that amount, as much as 11 million were lent for purchasing bullocks, 8.2 million for food, and 5.8 million for seed. Loans were also distributed for repairing and constructing houses, and for purchasing seed, fodder, agricultural implements, Persian wheels, water-pumps, tractors, sinking of tubewells, and repairing and boring of wells.

Taccavi loans were given in two phases: before the quasi-permanent allotment of land and after the completion of the quasi-permanent allotment in 1950. There was a radical change in the attitude of the allottees towards their allotted land after the quasi-permanent allotment, and, therefore, a change in the purposes for which the loans were taken. Under the temporary-allotment scheme, the allottees had only temporary interest in their allotments, and were not, therefore, prepared to avail themselves of the loans which were meant for making permanent improvements in their land or houses or in both. Though loans for the repairing of houses and wells were available during the two years preceding the quasi-permanent allotment, only Rs 33 thousand and Rs 6 thousand, respectively, was accepted as compared with 4.4 million and 1.7 million drawn after the quasi-permanent allotment. Other loans, however, which were not in the nature of a permanent investment, were a fairly constant feature of both the periods. Thus whereas 5.5 million rupees was advanced for the purchase of bullocks before the quasi-permanent allotment, 5.6 million was advanced after the allotment work was over. Similarly, the figures for seed for the two periods were 6.4 million and 4.1 million respectively.

Again, whereas the loans for food and fodder were discontinued after the quasi-permanent allotment of land, the loans for agricultural machinery, such as tractors, water-pumps and tube-wells, were given after the conferment of quasi-permanent rights on the displaced farmers. No landholder can be expected to set up a tube-well or a water-pump on a temporarily allotted holding. Tractors were out of question for small holdings of 10 acres (4 hectares) during the temporary-allotment phase. I will now discuss these loans item-wise.

Food Loans

Before the quasi-permanent allotment of land, the largest single item of loan was for purchasing food. This loan was given to displaced persons when they left the relief camps and settled in villages. The crops sown by them had to mature after about six months, and the refugee farmers were to be fed during that period. They were, therefore, given monthly food allowances for every member of their families. Revenue officers visited the villages and distributed these loans on the spot. The rate was Rs 3½ per adult and Rs 2 per child per month. The problem, however, was not wholly solved by giving cash allowances. Because of the dislocation of the agricultural economy of the State, there was very little food available in the villages which the loanees could buy. Under these scarcity conditions, the object of the food loans would have been defeated if food-supplies had not been made available. The Department of Food and Civil Supplies was, therefore, asked to open retail food shops in selected villages for the supply of wheat to displaced persons. The scheme proved successful, and attracted the rural people from the relief camps to the villages. Rs 8.2 million was disbursed up to 1949. In 1950, when the conditions improved and the people were able to stand on their own legs, the grant of food loans was discontinued.

Fodder

Financial assistance for the purchase of fodder for animals was also not neglected. Rs 850,000 was distributed during 1947-49 as *taccavi* loans for fodder. The rate of this *taccavi* was Rs 20 per month. Like food, there was scarcity of fodder also, particularly in the Ambala Division. To meet this situation, it was necessary to import large quantities of fodder from other States. An officer of the Agricultural Department was appointed Fodder Adviser to the Punjab Government for importing fodder. Fodder dumps were opened in several districts. But, unfortunately, this import scheme did not work well, as there was great delay in transporting fodder owing to difficulties in obtaining priorities. Besides, the availability of fodder improved with the harvesting of the *rabi* of 1948, and the prices returned to normal.

BULLOCKS

The greatest need of a cultivator is a pair of bullocks. Bullocks were essential for his rehabilitation, and could be purchased only with financial assistance from the Government. Naturally enough, about one-fourth of the total amount distributed till 1950-51 (11 million rupees) went to finance the purchase of bullocks. In the dry districts, particularly Hissar and Gurgaon, where cultivation is carried on with the aid of camels, loans were given for buying camels instead of bullocks. To prevent misuse of this *taccavi*, the purchased animals had to be produced before a tahsildar for inspection and branding. A great demand for more loans for this purpose continued. In fact, the lack of bullocks was the most powerful single factor hampering the full rehabilitation of the refugees. Not to speak of the bigger allottees, even some small ones, who very much liked to cultivate their holdings themselves, had been forced to lease their allotments to tenants because they had no bullocks.

SEED

Ordinarily, a peasant farmer uses for seed the savings from the previous year's produce. The displaced persons, however, had no such savings. They were, therefore, given loans for purchasing seed. In addition, the Department of Agriculture started seed depots in selected villages, where good-quality seed was sold to the displaced persons. Loans for the purchase of seed were not given in cash. Permits were issued to loanees to buy seed from seed depots, and the amount loaned was debited to their account. This arrangement proved most successful, and loans to the extent of Rs 6.8 million were advanced till 1950-51 for buying seed.

AGRICULTURAL IMPLEMENTS

There was a great dearth of agricultural implements in the market. Arrangements were, therefore, made with the Department of Agriculture for manufacturing and supplying chaff-cutters, sugarcane-crushers and well-gears at controlled prices. These implements were manufactured by the fabricators, and were approved and stamped by the Department of Agriculture before these were made available for distribution among the displaced persons. These manufactured implements were then transported to tahsil offices according to the requirements of each tahsil. Agricultural fairs were organized at the headquarters of all tahsils in Punjab in March 1950 for the distribution of these implements (Figs 3 and 4). On the day of the fair, the implements and machinery to be distributed in that tahsil were piled up at the tahsil office. The loanees, who had been notified of the date in advance, came to the fair, received their requirements, and carted them home. This system had some advantage over the old system under which the rehabilitation official travelled from village to village with a cash-box,

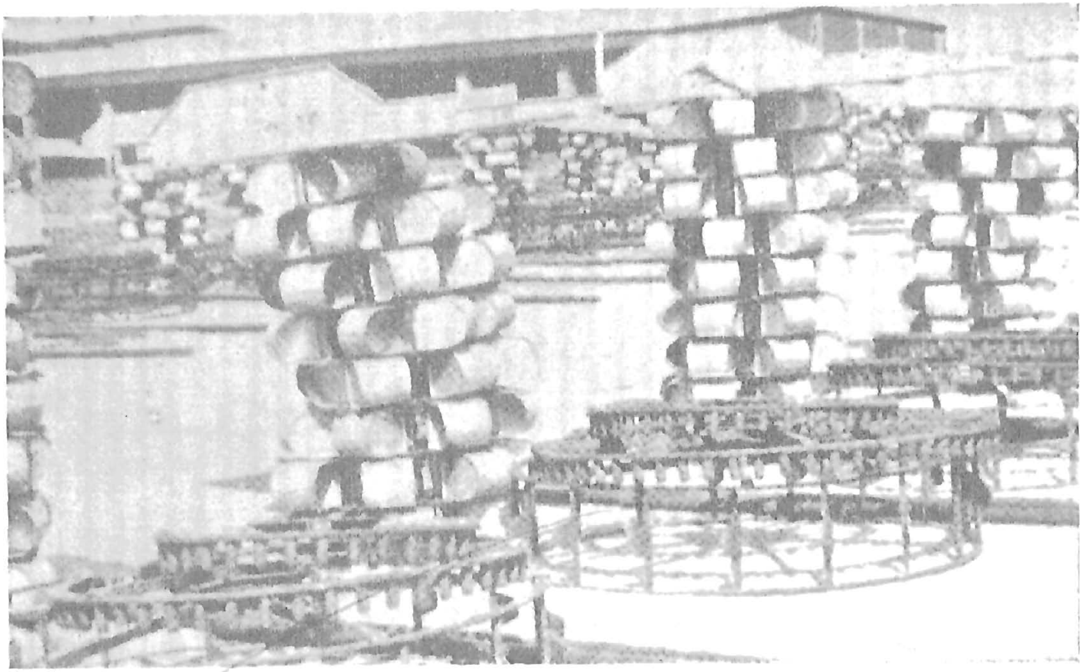


FIG. 3. Agricultural implements ready for distribution among displaced persons at a fair.

FIG. 4. Persian wheels were manufactured in large numbers and were given as loan in kind to the displaced farmers, as soon as they got their allotment orders in 1950.

and handed out lump sums of money to displaced persons to be spent as they liked. The advantages were incorruptibility and speed. The entire benefit reached the loanee, and there were no wayside bites on the financial assistance that the Government wanted to give them. Also, the administration was able to dispose off all work in a tahsil in a day or two. This unorthodox approach speeded up the rehabilitation of agriculture in Punjab.

Loans for Rural Artisans

The partition of Punjab dislocated the economy of the villages to a great extent. The countryside had been denuded of a large proportion of its artisans and village servants. The Government, therefore, decided to afford financial assistance to displaced rural artisans for their rehabilitation in villages. Rs 691,000 was advanced as loans to rural artisans, such as blacksmiths, carpenters and leather-workers, from 1947-48 to 1949-50.

Damage to Houses and Wells

In the post-partition confusion, wells and houses suffered a great deal of damage. For several weeks, they belonged to nobody, but were at the mercy of anybody who wanted to lay hands on them. Even when they were allotted to displaced persons, the allotment was on a temporary basis. And who would take a loan to repair a house or a well which he was to leave after a few months? Sixteen months after the partition, when a census was taken, it was found that 34 per cent of the evacuee houses in Punjab (India) were damaged beyond repair; and only 47 per cent were intact. Of the wells left by the evacuees, 62 per cent were in working order, 36 per cent stood in need of well-gear, and 12 per cent needed the repairing of masonry as well as of new well-gear. Loan schemes introduced before the quasi-permanent allotment for the repairing of houses or wells, therefore, failed, and very few persons came forward to take loans. During 1947-48, Rs 33,000 and Rs 6,000 only were distributed as loans for repairing houses and wells respectively. In the following year, however, a scheme of free grants was introduced, and Rs 180,000 and Rs 80,000 and Rs 300,000 and Rs 25,000 were distributed for repairing wells and houses respectively. After the quasi-permanent allotment, the situation changed, and Rs 800,000 distributed as loans and Rs 600,000 as grants for repairing and constructing houses. Similarly, Rs 100,000 and Rs 70,000 were loaned for repairing wells.

In 1950, Punjab (India) was visited by an extraordinarily heavy monsoon. The riverain areas were flooded, and large areas remained under water for weeks. Rains and floods caused extensive damage to *kaccha* houses in the Jullundur Division, particularly. The Government came to the help of the sufferers with a scheme for loans and grants for repairing houses. Rs 3.5 million was distributed as loans, and Rs 1.3 million as free grants for repairing houses in the flood-affected villages.

MODERNIZATION OF AGRICULTURE, INTRODUCTION OF TUBE-WELLS AND TRACTORS

The most important step taken to modernize agriculture in Punjab (India) was the introduction of tube-wells and tractors. It has a personal background. I was posted as Assistant Collector in the Saharanpur District, U.P., in 1934. In 1935, while touring the Roorkee Subdivision, I learnt about the work of Sir William Stampe, who was the Chief Engineer of the Irrigation Department. He used to tour with a caravan attached to his car, in which he carried his horse. Where the road ended, he rode the horse. I was impressed by his mode of touring. In that age jeeps were not known, and a horse was an absolute necessity for touring the countryside. Stampe was a pioneer in tube-well irrigation and he made a scheme for irrigation with deep tube-wells in the districts of western United Provinces. It was Satmpe who popularized the legend of tapping the underground Sarsvati, which, according to popular belief, joined the Ganga and the Jamuna at the confluence at Allahabad.

In October 1945, I paid a visit to the USA after attending the Second Conference of the Food and Agriculture Organization of the United Nations at Quebec. At that time, the Tennessee Valley Authority area was a show-piece in America. Accompanied by Sardar Ujjal Singh, Sir T. Vijaya Raghavacharya and Sardar Habibulla, we went to Knoxville and saw some private farms. These were highly mechanized. What impressed me most was the use of low-horsepower electric motors for pumping water and for cutting fodder. That idea stuck in my mind.

In 1950, when I was given the responsibility for making schemes for the rehabilitation of agriculture, I gave the highest priority to the scheme of sinking shallow tube-wells fitted with pumps and electric motors. At that time tube-wells for irrigation were not at all known in Punjab. An experiment was made in 1929 in fixing an electrically worked pump on an open well at the Agricultural Farm at Jullundur.[1] After that, nothing was done, though in the United Provinces of Agra and Oudh many deep tube-wells had been sunk.

Lal Singh was the Director of Agriculture of Punjab at that time. A dynamic person, he was all for innovation and experiment. He acquired a number of high-power rigs for boring tube-wells. I asked him to concentrate them in the suburban villages of the Jallandhar and Ludhiana districts, which I had saturated with loans for tube-wells. At the same time, I organized a *Kisan Mela* at Jallandhar, where firms dealing in agricultural machinery were invited. Applications for loans for tube-wells and tractors from refugee farmers who had been allotted land were processed in advance and loan chits were given. The farmers saw the performance of various

[1] Roberts, W. and Kartar Singh, *A Textbook of Punjab Agriculture*, p. 157

brands of tractors, pump-sets and electric motors and purchased them according to their own choice.

When the tube-wells had been bored and farmers were in their villages with pump-sets and electric motors, I got hold of the electricity engineers and asked them to energize the tube-wells, as sufficient load had been created to justify their work. It was in this simple and unorthodox manner that the movement for the modernization of agriculture in Punjab was started. It must be said to the credit of the rufugee farmers that they readily accepted this innovation. To supplement the loans, some of them even sold the gold ornaments of their women-folk. They however knew that with irrigation water at their command, bumper crops would be raised and in a couple of years their women-folk would have their ornaments again. Initially, 2,937 tube-wells were electrified. This however was the beginning of a scheme which, in due course, had a powerful impact on the agriculture of Punjab. These tube-wells and pump-sets served the purpose of demonstration, and they stimulated a demand that had to be met on a large scale from year to year. Now there are more than half a million private tube-wells in Punjab.

TRACTORS

Rs 3,770,000 was provided for tractor loans. Out of this amount, Rs 3,200,000 was given to the allottees of riverain and *banjar* land. At that time, a tractor was a rare sight in Punjab. In reclaiming waste-land and cultivating land in the riverain areas, tractors proved very useful. After the departure of the Muslims, large areas in the riverain tracts got covered with reeds and tall grasses in the absence of cultivation. Tractors were required not only for reclaiming such areas, but also for keeping them under cultivation. The Muslims, who had inhabited the riverain areas, were traditionally poor. Apart from periodic floods, which washed away their houses, it was the grass which defeated all their efforts at cultivation. Only cultivation with tractors could conquer the riverain area which had so far remained an agricultural slum. Similarly, there were considerable areas covered with trees and bushes in the Karnal District, which had been lying uncultivated for ages. There also, the tractor came to the help of the farmers. With the aid of tractors, they were able to reclaim and to bring under cultivation large areas of waste-lands.

It must be said to the credit of the refugee farmers of Punjab that they repaid their loans with interest, keeping up their self-respect.

CHAPTER 3

CONSOLIDATION OF FRAGMENTED AND SCATTERED HOLDINGS

REPLANNING THE COUNTRYSIDE 1951–1965

THE disadvantages of fragmented and scattered holdings are well known. It is a wasteful method of land utilization and many improved agricultural practices cannot be adopted. A farmer owning three or four acres may have his holdings scattered in ten to fifteen tiny bits. In some cases, the strips of land are so narrow that it is difficult for bullocks to plough them, as sufficient space is not available for easy movement and turning. A good deal of time and energy of the farmer and his bullocks is wasted in moving from one field to another. It has been estimated that expenditure on the cultivation and land increases by 5.3 per cent for every 500 m distance for manual labour and ploughing. A good deal of land is wasted in embankments and field boundaries. Canal irrigation is practically an impossibility on scattered plots and a well cannot be economically sunk. Scattered holdings are also a source of dissension among villagers, who spend their hard-earned money on boundary disputes, and quarrels resulting from cattle trespass. The fencing of scattered pieces of land is an impossibility, and the sons of farmers, instead of attending schools, spend their time in preventing cattle trespass. Consequently, large number of fragments per holding and their smallness results in severe under-utilization and wastage of farm resources.

India is an ancient land, with cultivation dating to the third millennium B.C. The sites of the Harappan culture—Mohenjo-Daro and Harappa in Pakistan and Ropar in the Indian Punjab—are as old as 2300-2200 B.C. Cultivation near these urban settlements was close to the river-beds. From the river-beds, the cultivation spread to dry areas with the aid of wells. Considering the long period over which cultivation has been carried on, the increase in population, and the laws of succession, one can imagine their combined effect on land holdings.

The laws of succession resulted in the subdivision and fragmentation of holdings. When the father dies, the land is divided equally among all the sons. Each successor insists on having a share from each location which results in further fragmentation. As this process had gone on for several generations, it produced severe fragmentation of land.

H. CALVERT, PIONEER OF THE CONSOLIDATION OF LAND HOLDINGS

The pioneer of the consolidation of holdings was Hubert Calvert, of the

Indian Civil Service. He served in the Punjab from 1898 to 1933, and was the author of *The Wealth and Welfare of the Punjab* (1922) which made a great impact on administration. In 1921, he hit upon the discovery that co-operation could solve the problem of bringing together fragmented and scattered holdings of the farmers. The first co-operative society was formed in 1921, and in 1931 there were about 800 such societies with 48,000 members. During that decennium, about 336,000 acres (135,974 hectares) were consolidated at a cost of Rs 2 and 5 annas per acre (Rs 5.94 per hectare), the whole of which was borne by Government. 'It must not be expected', said Calvert, 'that whole tracts will be adjusted without great labour and much time, but a real revolution of incalculable benefit to the cultivators of the central districts has been definitely started'.

Of this work, the two maps of the village of Bhoyapur (Figs 5,6) are a sufficient proof. Here, at a glance, we see the effect of reducing 886 fields to 55, and it should be sufficient to convince anyone, not simply of the advantage, but of the absolute necessity of consolidation.

Describing the benefits of consolidation of holdings, Sir Malcolm Darling states, 'In Gurdaspur nearly 2,000 trees, including over 400 fruit trees, have been planted and forty-nine manure pits dug. But the two commonest effects of consolidation are the sinking of wells and the bringing of waste-land under cultivation. In 1930, 993 new wells were sunk, 5,000 acres were brought under cultivation, and 3,000 acres irrigated for the first time.

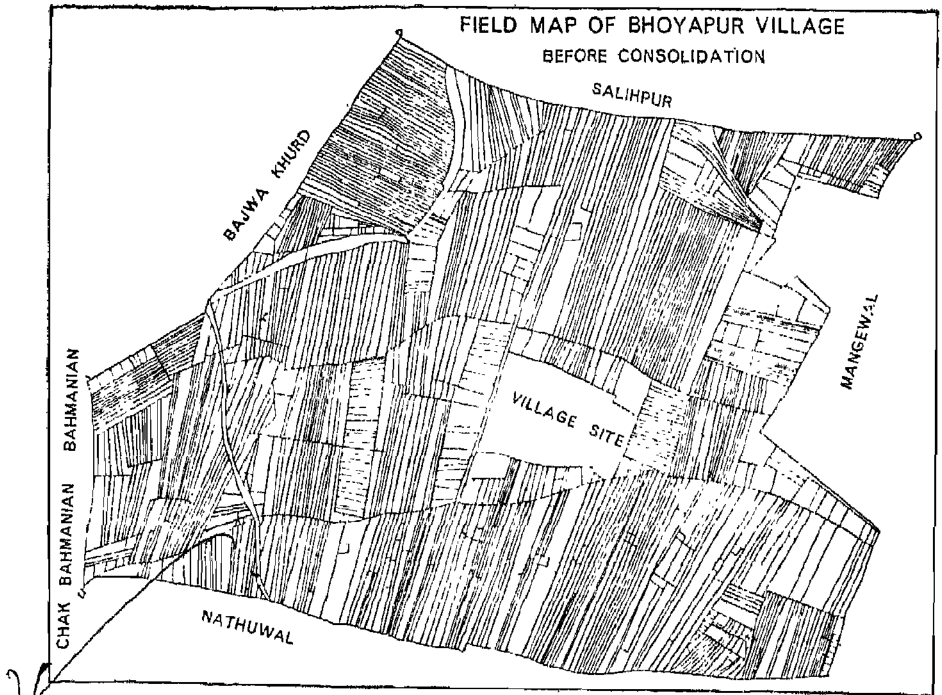
'It is easy to chronicle these results but most difficult to produce them. For every one has to be satisfied and all conflicting interests reconciled. The ignorant have to be enlightened and the stubborn conciliated. The poor, the weak and the speechless have to be as much regarded as the rich, the strong, and the vocal; and the only weapon is the tongue, and the only means, persuasion. Moreover, technical difficulties abound; and underlying all is the peasant's passionate love of his land, and the jealousy of neighbours that passion breeds. In such circumstances, the work must be slow. The marvel is that it is done at all.'[1]

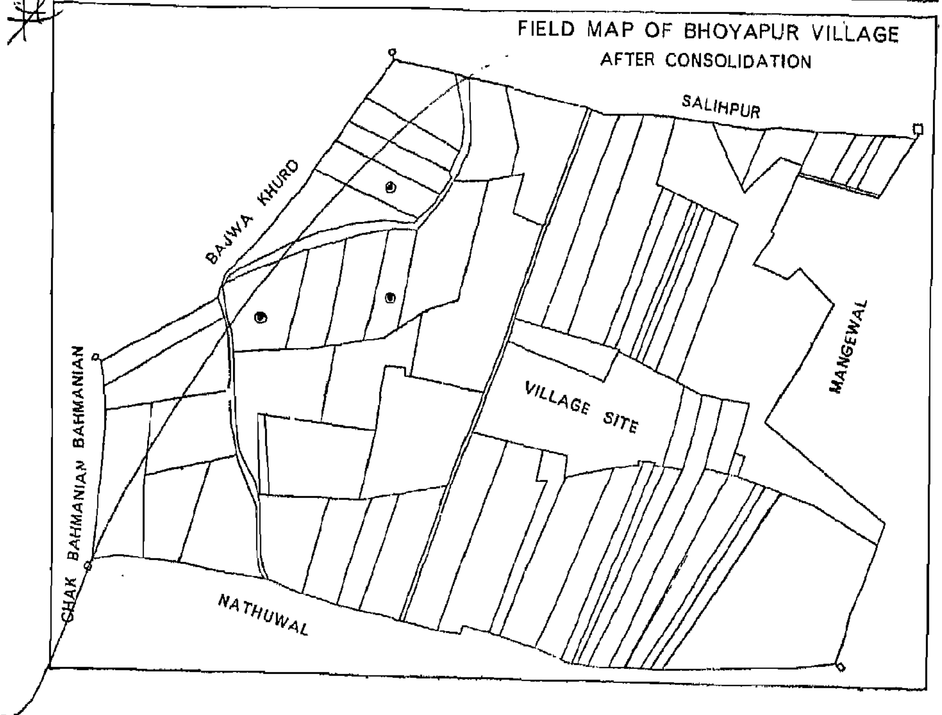
From the experience gained, it was later decided that there should be some element of compulsion. Accordingly, the Punjab Consolidation Act, 1936, was passed, whereby consolidation work in a village could be undertaken if two-thirds of the landowners gave their consent. But even this measure did not prove effective, and by both the methods mentioned above, only about 283,280 ha (700,000 acres) could be consolidated up to 1948.

The East Punjab Holdings: Consolidation of Holdings and Fragmentation Act, 1948

Soon after Independence, the necessity of the consolidation of holdings

[1]Darling, Malcolm Lyall, *The Punjab Peasant in Prosperity and Debt*, pp. 252,253





FIGS. 5 and 6. Field maps of the Village of Bhoyapur before and after consolidation. (After Sir M. L. Darling) was strongly realized and the East Punjab Holdings (Consolidation and Prevention of Fragmentation) Act was enacted in 1948 on the initiative of Gyani Kartar Singh, Revenue Minister. An element of compulsion was introduced and, hence, the progress was rapid.

According to this Act, village advisory committees were formed to advise the staff on all matters concerning the consolidation of land, and, in particular, on the classification and valuation of fields, and preparation of village-consolidation schemes. The preliminary work of the staff was the correcting and bringing the records of rights up to date and the preparing of preliminary statements. The plots were then evaluated, keeping in view the quality of the soil, the source of irrigation, the productivity of land, the distance from the village *abadi*, etc. Irregular fields were consolidated into rectangular blocks, each of 0.4 ha (1 acre).

Replanning the Countryside

Apart from consolidating the holdings of the farmers, the scheme provided a unique opportunity for replanning the countryside, and it included the planning of the location of schools, hospitals and roads. Land was also reserved for community centres, places of worship, and play-grounds. Above all, the village *abadi* and the entire cultivated area were provided with straight roads. Circular roads around the villages, and roads linking one village with another and with the main roads, were also demarcated. The linking of groups of villages with the main roads was done at my initiative in 1953-1954 when, as Development Commissioner, I was in charge of the scheme. These *kaccha* roads were later on made *pacca* ones in 1966-67.

Reservation of Land for the Landless

Landless persons, whether they were Harijans or belonged to other castes, were given a free gift of five *marlas* (1/32 acre; 126.46 m^2) of *abadi*, provided they were helpful to the cultivators directly or indirectly. Such persons included carpenters, blacksmiths, washermen, barbers, weavers, shoemakers, etc.

Finance

The expenditure on the scheme was treated as Plan Expenditure up to 1967-68, and as Non-Plan Expenditure thereafter. The average cost of consolidation is given below.

To meet the expenses on consolidation, each rightholder was charged the consolidation fee at the rate of Rs 5 per acre (Rs 12.36 per hectare) assessed on land other than unculturable. The income thus received was inadequate. The remaining cost was equally shared on 50 : 50 basis by the Central and the State Governments up to 1967-68. The rightholders continued to contribute at the rate mentioned above, and the remaining cost was met by the

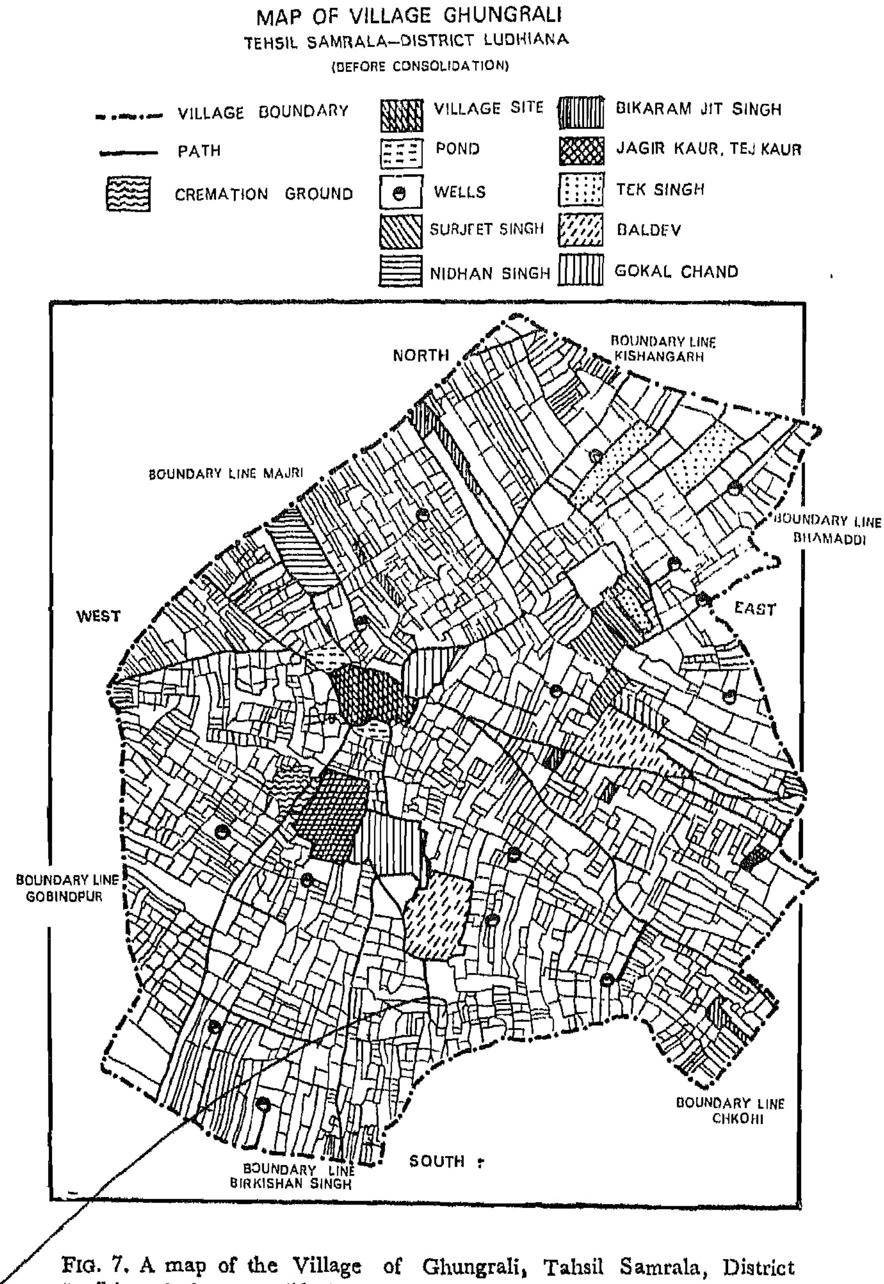


FIG. 7. A map of the Village of Ghungrali, Tahsil Samrala, District Ludhiana before consolidation.

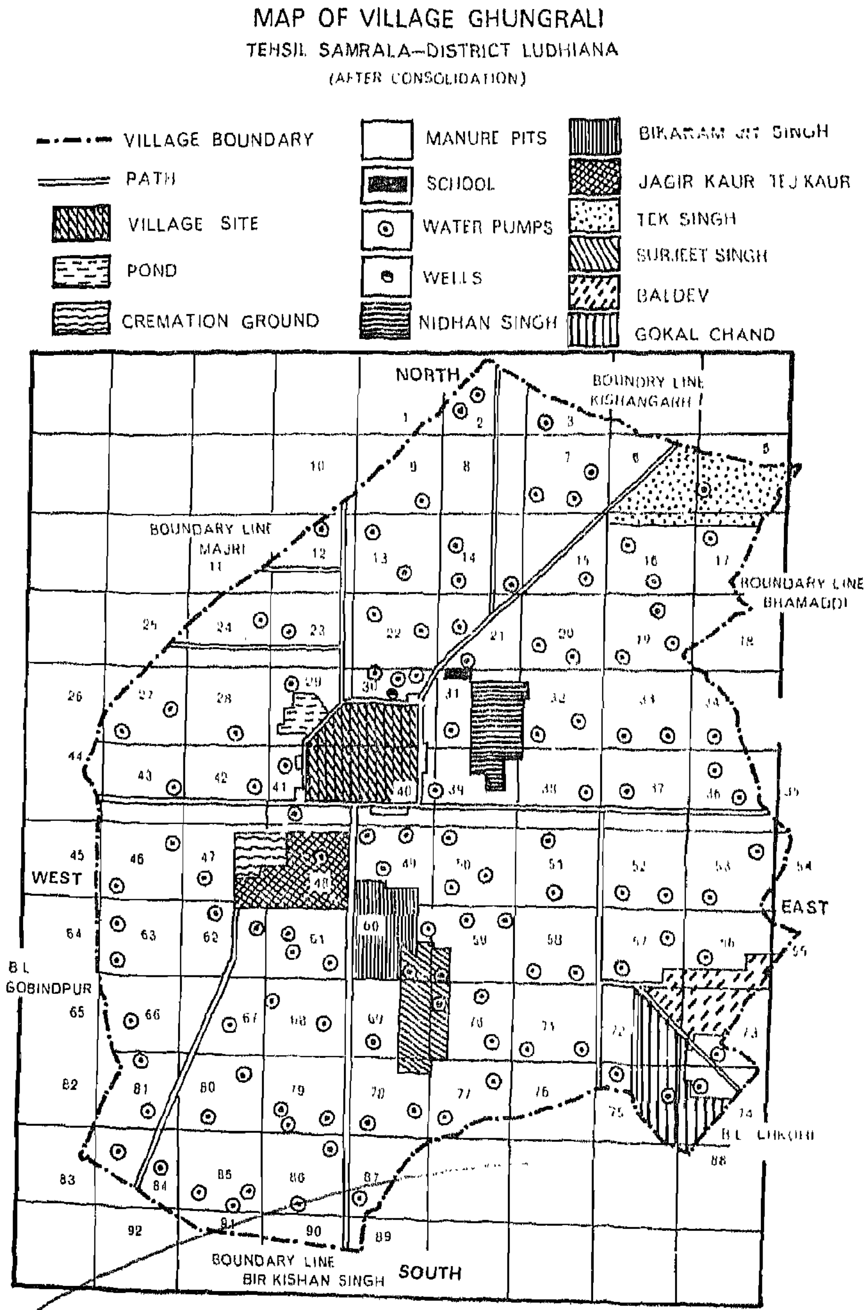


FIG. 8. A map of the Village of Ghungrali, Tehsil Samrala, District Ludhiana, after consolidation. Before consolidation, it had only six tube-wells. After consolidation, the sinking of tube-wells acquired a new tempo. In December 1980, this village had as many as 125 tube-wells.

Year	*Average cost* (*Rs/acre*)	(*Rs/ha*)
1964-65	8.80	21.75
1965-66	11.49	28.39
1966-67	19.23	47.52
1967-68	22.85	56.46
1968-69	25.09	61.99
1969-70	32.88	81.25
1970-71	33.44	82.63
1971-72	37.21	91.95
1972-73	50.23	124.12
1973-74	50.37	124.47
1974-75	60.87	150.42
1975-76	85.27	210.71
1976-77	90.07	222.57
1977-78	169.00	417.62
1978-79	106.61	268.41

State Government. The total expenditure on the consolidation of holdings in the Punjab (including Haryana) was Rs 145.3 million.

Staff

The staff was headed by a Director, who was assisted by Additional and Assistant Directors. There were 11 Settlement Officers (Consolidation), one for each district. At the peak period from 1958 to 1963, the number was doubled. The number of *patwaris* was 2,025 at the start of the scheme, and reached the figure of 5,092 in 1960. The area norm for a *patwari* was 600 acres (243 hectares).

Rectangulation by the Survey of India

If one compares the consolidation work in the village Bhoyapur (Figs 5, 6) with that in the village Ghungrali (Figs 7, 8) one notices that no rectangulation was done in Bhoyapur. Under the scheme of 1948, rectangulation was done on the longitude and latitude lines. The work of rectangulation was entrusted to the Survey of India Department, which carried out a survey of the entire State and made rectangles, each measuring 3,000 acres (1,214 hectares). These rectangles were subdivided into *killas* of one acre (0.4047 hectares) each, equivalent to a rectangle of 220 ft $\times$ 198 ft (67.056 m $\times$ 60.35 m). Pillars were affixed at the spot in the fields to mark the corners of the rectangles.

Main Stages of the Scheme

To reiterate, the main stages through which the consolidation in a particular village had to pass were as below.

1. Preparation of preliminary record, comprising the list of the names

of rightholders, the list of plot numbers, and the classification and valuation of the fields. Valuation was in annas. Even numbers were adopted for the facility of calculation. The best land was valued at 16 annas (Re 1). The other categories were 12 annas, 8 annas and 4 annas.

2. Rectangulation (*killa-bandi*)

3. Checking of implementation of mutations of land and their attestation

4. Preparation of the draft repartition map of the fields

5. Finalization of valuation

6. Preparation of the draft scheme in consultation with the rightholders of the village

7. Publication of the repartition scheme, as prepared by the Consolidation Officer

8. Disposal of objections

9. Confirmation of the scheme

PROGRESS OF WORK ON CONSOLIDATION

Though the Act was passed in 1948, and a Department of Consolidation was created in April 1949, no substantial work could be done till 1951, as the revenue staff remained busy with the allotment of the evacuee land till the end of 1950. The year-wise progress of work from 1951-52 to 1965-66 is given in the statement below:

Year	*Area consolidated*	
	(in lakh acres)	*(in thousand ha)*
1951-52	1.72	69.606
1952-53	10.99	444.795
1953-54	15.38	622.407
1954-55	13.49	545.921
1955-56	13.67	553.206
1956-57	15.51	627.668
1957-58	9.76	394.973
1958-59	9.61	388.903
1959-60	24.40	987.434
1960-61	26.20	1,060.277
1961-62	27.87	1,127.860
1962-63	22.15	896.379
1963-64	12.41	502.215
1964-65	8.69	351.672
1965-66	2.44	98.743
	220.84	8,937.094

It will be seen that the work acquired the tempo in two years, and reached a crescendo after seven years and tailed off after twelve years.

Up to 1965-66, 220.84 lakh acres (8,937,094 ha) was consolidated. It was a remarkable achievement, considering the complexity of the task.

Checking of Corruption

In an operation in which land was transferred on such a large scale among the landowners, it was necessary to adopt checks on arbitrariness on the part of the officials. A provision was laid out in the Act that the *chak* (block) of a landowner was to be created where he had his major area. For example, a landowner owning four acres (1.619 ha) had it in eight locations. Out of these, he had one acre in a single location, and the remaining three acres in seven different fragments. His block would be made where he had one acre.

Besides, an aggrieved rightholder could file an objection before the Consolidation Officer. If he was dissatisfied with the order of the Consolidation Officer, he could file an appeal before the Settlement Officer (Consolidation). If he was still not satisfied, he could file an appeal before the Assistant Director (Consolidation). His last remedy was a revision petition before the Additional Director (Consolidation).

Sometimes, the rightholders were not satisfied with the performance of the staff and there were complaints of corruption made direct to the Chief Minister or the Revenue Minister. A flying squad headed by a Consolidation Officer of high integrity was appointed in 1953 by Sardar Partap Singh Kairon, Revenue and Development Minister (Fig. 11). Six flying squads were appointed to assist the Director of Consolidation. These squads served as an effective check on corruption. The squads were provided with jeep and as soon as a complaint was received, a squad was sent to check the work on the spot. As a further check, the Revenue Minister Kairon himself employed a political worker of sound integrity, Master Charanjit Singh, who used to visit the villages incognito in the garb of a *sadhu*.

In a number of cases, it was found that the complaints were frivolous. Such is a peasant's attachment to his piece of land that it takes time before he gets reconciled to the new situation. The same was the case in the allotment of the evacuee land in 1950. Most of the people were dissatisfied and wanted a change in their allotments. I used to tell them that the relationship between a peasant and his land was the same as that between a husband and his wife in an arranged marriage. 'Be patient, start working, and you will like the land in a year'. Those who met me years after told me that the advice was right.

Beneficial Effect of Consolidation of Holdings

The most beneficial effect of the Scheme of Consolidation was that the farmers were enabled to sink tube-wells on their holdings. In 1950, Punjab had no tube-wells, but in 1978 it had 570,000 of them. Besides, there was

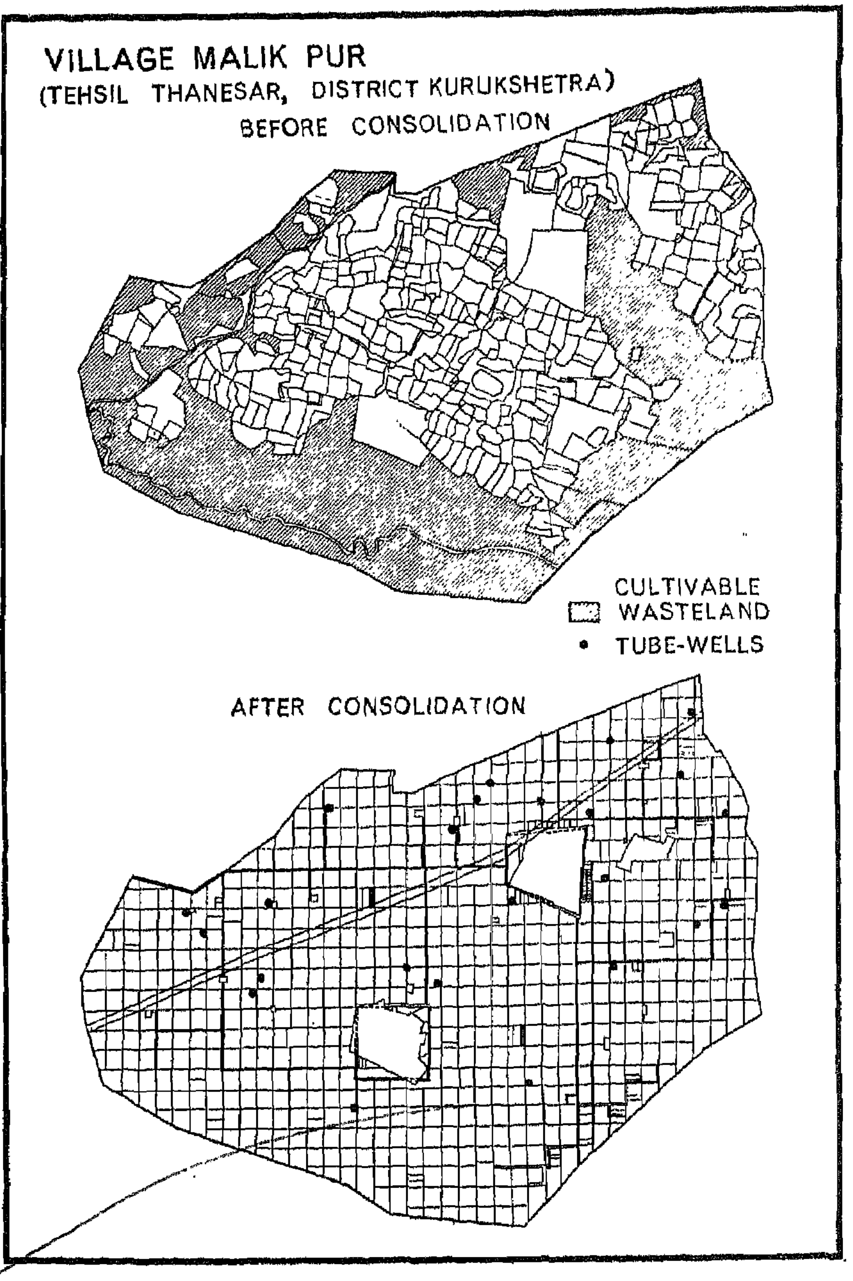


FIG. 9. There were large chunks of waste-land in the Kurukshetra District (previously the Karnal District) in Haryana. During the consolidation of holdings, this land was distributed among the right holders. Consequently, it was reclaimed and now produces bumper crops of rice. (After Dr Jasbir Singh, Geography Department, Kurukshetra University)

a considerable reduction in the land leased out, and this change indicated that the owner-cultivators had started cultivating their land themselves owing to the reduction in the number of fragments. There was also an increase in the cultivated area which was previously lost in field bunds. Large chunks of waste-land were also reclaimed as they were distributed among the land-owners (Fig. 9). The consolidated plots could also enjoy the benefits of canal irrigation. Increase in agricultural production due to consolidation alone without any change in techniques was reported to be about 25 per cent.

In the history of agriculture, the only parallel which can rival Punjab's Consolidation of Holdings Scheme with respect to its beneficial effect on the general life of the people and on agricultural production were the eighteenth-century Enclosures in England. The large landholders absorbed the small holdings of the yeomen and the peasants. "It was radicalism of the rich at the expense of the poor," as Trevelyan remarks. In the Punjab Scheme, however, every proprietor of land retained his entire area in one or two blocks, whether it was large or small.

If Punjab has provided such a sound base for intensive agriculture, it is entirely due to the consolidation of holdings. This success was achieved on account of a sound political and administrative rural-based leadership provided by ministers, such as Gyani Kartar Singh and Sardar Partap Singh Kairon, who came from farming families. When the Scheme of Consolidation of Holdings was formulated, there was much talk in the air about co-operative and joint farming, in which the entire land of a village community and their bullocks and implements were to be pooled. "Why go in for a costly and time-consuming process of consolidation of land holdings," some people asked, "when joint or co-operative farming could provide the solution?" The co-operative farming succeeds when there is a well-educated farming community with a business sense, and one whose members are also selfless and angelic. This was not the situation in Punjab. These ideas were tried in a few evacuee villages where the refugee farmers were settled, but did not succeed. Co-operation in the supply of inputs and in the marketing of agricultural produce can be rewarding and has made a headway, but not in the cultivation of land. The political leadership realized that, instead of building castles in the air, it was better to launch the Scheme of Consolidation of Holdings, which was the keenly felt need of the Punjabi farmers who knew that farming was best done by a hard-working family bound together by family ties, and realized that schemes were no substitute for hard work which people put in with the profit motive, which might be ignoble, but it was there and could not be ignored.

Punjab and Haryana states have the top position in the country, as the entire cultivable area in them was consolidated by 1969. The Scheme has made little or no progress in Orissa, Andhra Pradesh, Bihar, West Bengal

State	*Net cultivated area* ('000 *ha*)	*Area consolidated* ('000 *ha*)	*Percentage*
Punjab	41.67	41.67	100.00
Haryana	36.44	36.44	100.00
Uttar Pradesh	173.75	134.48	77.40
Maharashtra	182.96	127.53	69.70
Himachal Pradesh	5.52	1.85	33.51
Madhya Pradesh	183.34	34.58	18.66
Karnataka	92.06	10.83	11.76
Gujarat	96.18	11.16	11.60
Rajasthan	150.60	17.12	11.37
Bihar	83.50	5.65	6.77
Andhra Pradesh	106.02	3.31	3.12
Jammu and Kashmir	7.11	0.22	3.09
Orissa	58.77	0.11	0.19
Assam	26.79	—	—
West Bengal	61.85	—	—
Total	1,306.56	424.95	43.4

and Assam. These states can make much greater progress in agricultural development, if the land holdings in them are also consolidated. In the hill areas, the consolidation of holdings can only be done on a rough exchange basis. States such as Kerala and Tamil Nadu, with large plantations of coconut and arecanut, have a less scope. However, in the flat areas in these states, with very few trees, there is a scope for this very beneficial work.

CHAPTER 4

LAL SINGH (1896–1963)

INTRODUCTION OF NEW FRUITS
PROMOTION OF THE FRUIT-PRESERVATION INDUSTRY
CO-OPERATIVE GARDEN COLONIES IN PUNJAB

FROM 1926 to 1952, horticulture in India was dominated by an outstanding person, Lal Singh, born in March 1896 in a family of Sikh Jat farmers in the Village of Nandpur in the Ludhiana District. He passed the Matriculation examination of the Panjab University from the Malwa Khalsa High School, Ludhiana, in 1914, and went to the USA for higher studies immediately thereafter. He spent about 10 years in that country, during the course of which he worked and studied for his Master's Degree in Horticulture. He passed this examination with distinction, standing first in a nation-wide contest in Chicago, for the best thesis on fruit products. As a part fulfilment of the conditions for the award of the M.Sc. Degree by the University of California, he carried out some original research in the field of fruit preservation. In America, he was elected to Sigma XI, a nation-wide scientific honour society of American Colleges, in 1920. He took active part in the patriotic revolutionary organization of Indians in America, known as the Ghadar Party. He was also the editor of a newspaper, called *Shamsher Khalsa*, and the President of the Hindustan Students Association. In America, as Honorary Secretary of the Pacific Coast Khalsa Diwan Society, he collected funds to build the Stockton Gurdwara and for providing Indian students in the USA with scholarships.

Lal Singh returned to Punjab in 1922. Soon after, he joined as Professor of Agriculture in the Khalsa College, Amritsar, where he worked for four years and organized the teaching of agriculture.

FRUIT SPECIALIST TO THE PUNJAB GOVERNMENT

Lal Singh joined as the first Fruit Specialist to the Government of the Punjab at the Punjab Agricultural College and Research Institute, Lyallpur, in 1926, and continued on this post till 1944. During this 18-year period he placed horticulture on a sound commercial footing. On account of his dynamism and untiring efforts, a number of new fruit-orchards were planted on a scientific basis in the districts of Lyallpur and Montgomery, the famous Canal Colony districts of the Punjab. A number of old orchards were improved by removing such common defects as overcrowding, the introduction of cultural practices such as improved manuring and plant-protection measures. A great impetus was given to the cultivation of fruit-trees by organizing the Fruit Development Board, of which he was the Founder-

Secretary. One of the notable achievements in this field was the procurement of extra canal water for the fruit-growers, the greatest single factor that contributed to the planting of new orchards. Fruit preservation received his special attention. He may be rightly called the Father of Fruit Preservation in the Punjab.

The Fruit Section of the Department of Agriculture of the Punjab Government became the biggest of its kind in India. The Punjab State Co-operative Fruit Development Board came into existence as the result of his efforts. He was its Honorary Secretary and did remarkable extension work. In 1934, he was deputed to visit Palestine, Italy, France, Germany and the UK to study agri-horticultural research and development (Fig. 12).

Introduction of New Fruits

Plant introduction was taken in hand by Lal Singh in a big way in 1928. Many fruit varieties were introduced for testing their suitability in Punjab. These included the following:

Sweet orange: 'Pineapple', 'Jaffa', 'Mosambi', 'Valencia', 'Washington Navel' and 'Hamlin'

Grapefruit: 'Marsh Seedless', 'Foster' and 'Duncan'

Limes and lemons: 'Mexican', 'Berass Seedless', 'Eureka', 'Lisbon' and 'Villafranca'

Mandarin: 'Nagpur', 'Natal Tightskin', 'Satsuma', 'Coorg', 'Srinagar', 'Dancy', 'Kinnow' and 'Wilking'

Grapes: A large collection of grape varieties was made at the College of Agriculture, Lyallpur. On the basis of observations made on the performance of these varieties, seven grape varieties, including 'Bedana', 'Khalili', 'Foster Seedling', 'Waltham Cross' and 'Black Prince', among others, were recommended for cultivation in Punjab. These varieties were also introduced for trial at a number of other research stations. The programme, however, did not make much headway, as emphasis at that time was on the cultivation of citrus, particularly sweet orange, in the Canal Colonies of Punjab.

The credit for introducing new fruits, such as grapefruit, persimmon and pecan also goes to Lal Singh.

Extension Work

Lal Singh was a great extension-worker. He was equally at ease and persuasive with a common fruit-grower to encourage him to plant new orchard as well as with the top man in the Punjab Government to obtain facilities for fruit cultivation. He organized the first fruit-show in the Punjab in 1928. The fruit-shows motivated the prospective fruit-growers. He organized the Punjab Provincial Co-operative Fruit Development Board in 1935. To introduce the latest research findings to the fruit-growers, Lal

Singh started the *Punjab Fruit Journal* in English and Urdu in 1937. The papers published in the journal are a source of knowledge to the researchers and the fruit-growers even today. Lal Singh and his colleagues published a number of extension bulletins for the benefit of the fruit-growers.

Research in the Propagation of Fruit-Plants

The fruit-growers experienced much difficulty in establishing new mango and jujube (*ber*) orchards. The propagation of these fruit-plants by budding *in situ* was developed to overcome this problem. This method helped to establish several new orchards of mango and jujube in the Punjab.

One of the outstanding achievements of Lal Singh was the planning and planting of a citrus-rootstock trial at Montgomery in 1937. The results of the experiment are still the basis of recommendations on that aspect, and rough lemon ('Jatti Khatti') was adapted as a standard rootstock for citrus varieties. Similarly, elaborate fertilizer trials were started on citrus. They yielded scientific data as a basis for formulating manurial recommendations for use by the fruit-growers. Research on the storage and preservation of fruits was also initiated at Lyallpur under his direction.

Fruit Development Adviser, Government of India

Lal Singh was appointed the first Fruit Development Adviser in the Ministry of Food and Agriculture of the Government of India in 1945. In this position, he actively promoted the development of orchards and fruit preservation throughout India. Till then, the tendency was to regard fruit cultivation as a rich man's hobby and the importance of fruit in the diet of the people was barely recognized. The concept of protective foods had not received recognition in India at that time. He promoted the manufacturing of fruit products within the country to save foreign exchange and also to take care of production in the glut years. During that period, he also worked as Secretary of the All-India Fruit-Preservers' Federation, into which the leading fruit-preservers of the country were brought together for meaningful association. He organized the Indian Institute of Fruit Technology of which he was the first ex-officio Director. Later on, this Institute was merged with the Central Research Institute of Food Technology, Mysore.

Director of Agriculture, Punjab State

The Punjab was partitioned between India and Pakistan on 15 August 1947. The Government of the East Punjab appointed Lal Singh the first Director of Agriculture of the new state. The immediate problem with which the state had to grapple was the rehabilitation of millions of refugees from West Pakistan. Moreover, the land left by the Muslim evacuees who had migrated to Pakistan had to be soon ploughed up. Lal

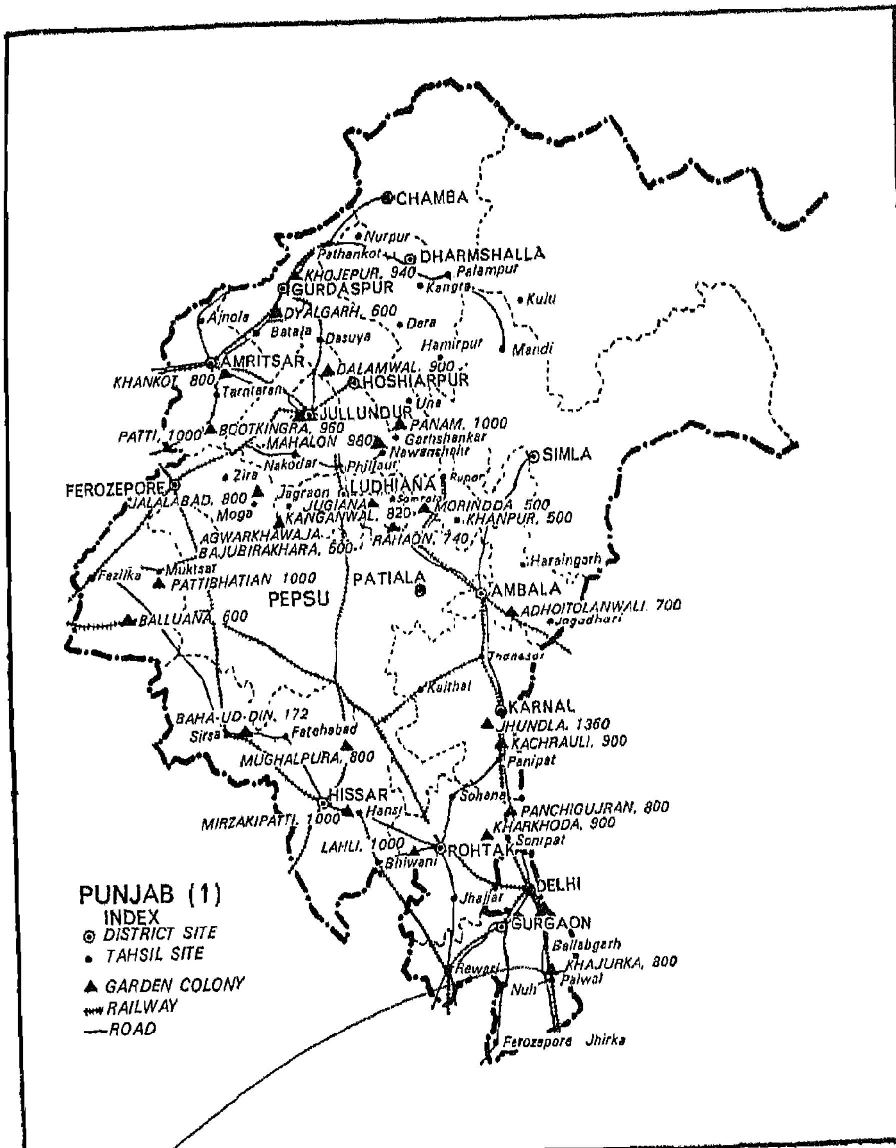


FIG. 10. To make up the loss suffered in fruit production on account of the partition of India, Garden Colonies, covering 8,094 hectares, were established in 11 districts of Punjab for the cultivation of fruit-plants. Lal Singh was the author of the scheme.

Singh was appointed the Additional Director-General, Rehabilitation, to assist Sardar Tarlok Singh, the Director-General of Rehabilitation.

It was fortunate that Lal Singh returned to Punjab at that juncture when a group of conservative agricultural officers had taken hold of the Department. One of them even went as far as to suggest that there was no need of any research station in Punjab, as the results of agricultural research carried out at the Indian Agricultural Research Institute, New Delhi, could be used equally usefully for the Punjab area!

Co-operative Garden Colonies in Punjab, 1950

It is not only the fertile canal-irrigated areas which the Indian section of the Punjab lost, but most of the orchards too. The cultivation of oranges in East Punjab was virtually unknown. The greatest service Lal Singh rendered to horticulture in East Punjab was by formulating the Scheme of Co-operative Garden Colonies. He surveyed the evacuee area and suggested the establishment of two such colonies in each district. For this purpose, chunks of land, each 500 to 600 acres (200 to 242 ha), situated on pucca roads, were selected. Thus as much as 20,000 acres (8,093 ha) in 11 districts was earmarked for planting fruit-trees in 22 Garden Colonies (Fig. 10). The burden of implementing this scheme fell on me as the Additional Director-General and later on as Director-General of Rehabilitation. During this period, I read in *Marg*, an art magazine, published from Bombay by Dr Mulk Raj Anand, an illuminating account of the garden colonies established in Israel by the Jews. I felt that here was an opportunity of building a new pattern of agri-horticulture in the new Punjab. Among the refugees were a number of graduates in agriculture. They had the experience of growing orchards in the western Punjab. They were anxious to make a start. The first task to which I gave attention was the consolidation of land in these colonies. The revenue staff were asked to demarcate blocks of 10 to 20 acres (4 to 8 ha) as well as the road system. These blocks of land were further divided into one-acre (0.404-ha) plots. When this task had been accomplished, we made a selection from among the progressive farmers who had applied for allotment of land in the Garden Colonies. A committee selected the allottees. Nurseries were also established to supply fruit-plants. The new task was to provide irrigation. Loans were given to the allottees for sinking tube-wells. I was firmly of the view that rural electrification, coupled with the sinking of tube-wells, holds out the promise of a rapid change in agriculture. Next, I got after the Department of Electricity and asked the engineers to energize the tube-wells sunk in the Garden Colonies. Loans were also provided for the planting of saplings of fruit-trees. It was also proposed to start cold stores and to arrange for the spraying of fruit-plants on a co-operative basis. Tractors were also purchased on a co-operative basis for the cultivation of land. While the

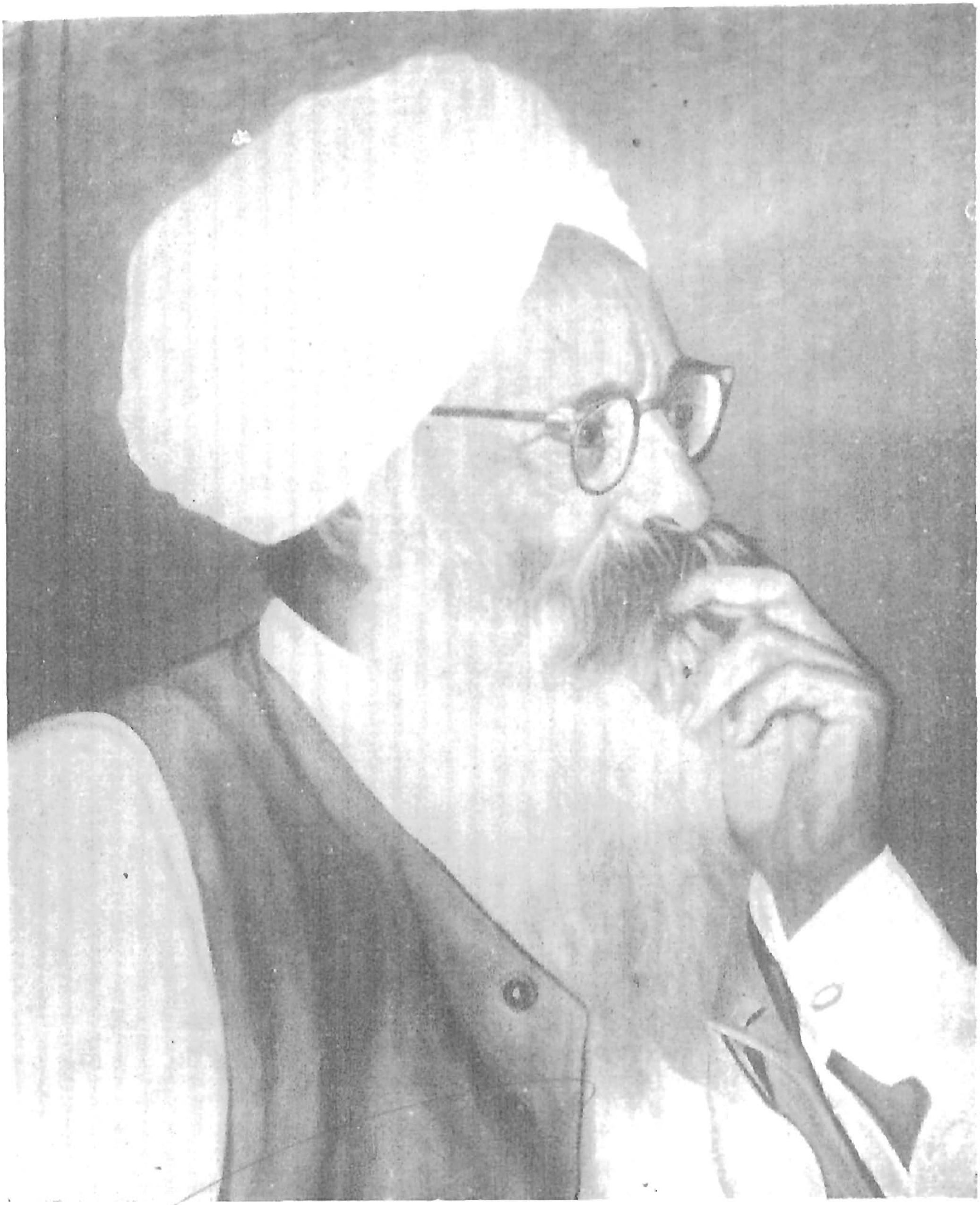


FIG. 11. Partap Singh Kairon (b. 1900, d. 1964), Chief Minister of Punjab, 1956-1964. A man with a modern outlook, he established universities at Patiala and Kurukshetra, and founded a number of polytechnics to train technicians. He introduced grape cultivation into Punjab, promoted the use of chemical fertilizers, and also founded the Punjab Agricultural University at Ludhiana. He promoted the consolidation of holding as Development Minister, Punjab, during 1953-1955. (Portrait by G.S. Bansal, Hall of Fame, Punjab Agricultural University Library, Ludhiana)

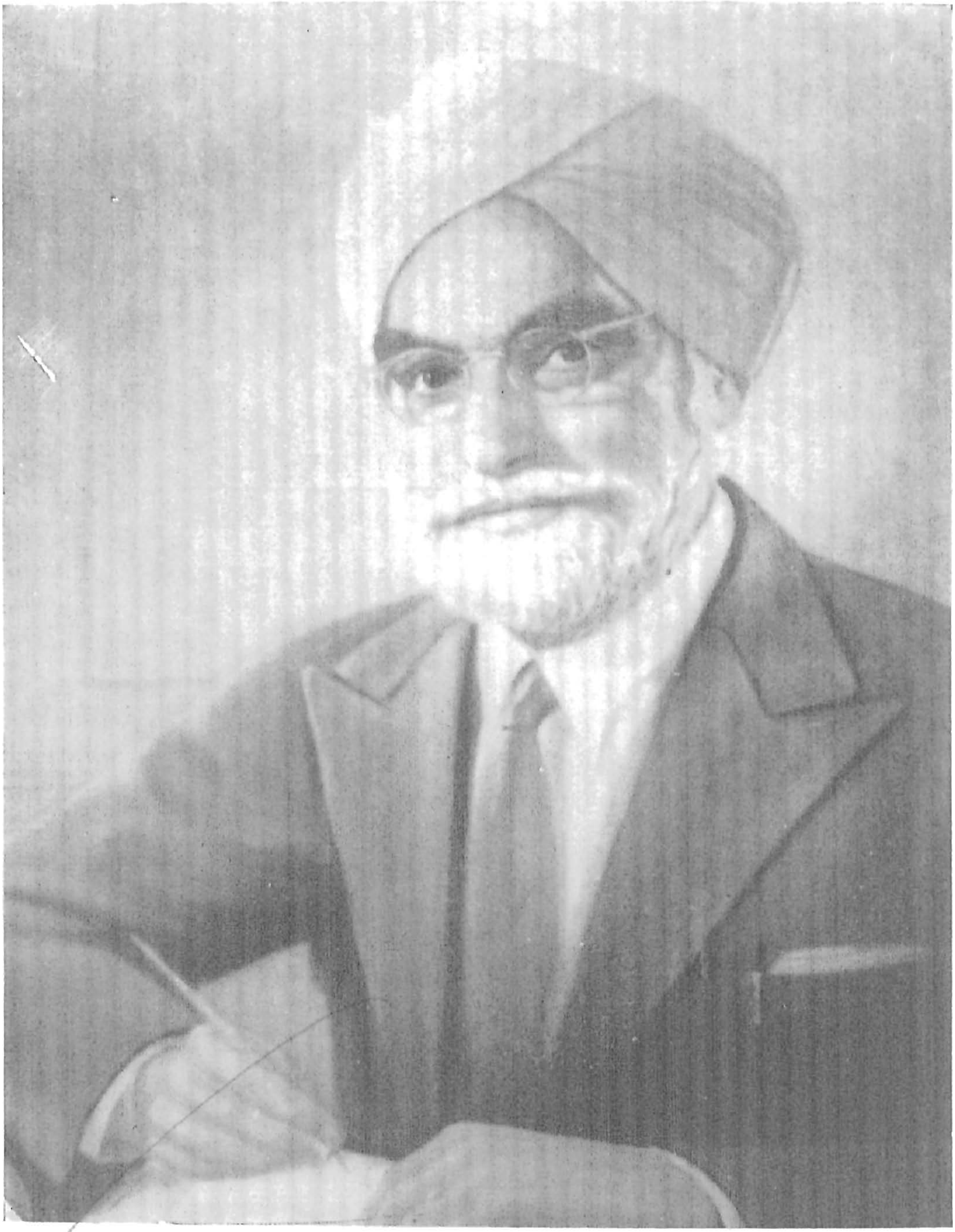


FIG. 12. Lal Singh (b. 1896, d. 1963), the first Fruit Specialist to the Punjab Government and later on Fruit Development Adviser to the Government of India. He introduced many varieties of oranges, and formulated the scheme of Garden Colonies in Punjab in 1949. (Portrait by G.S. Bansal, Hall of Fame, the Punjab Agricultural University Library, Ludhiana)

FIG. 13. A garden of oranges in a garden colony in the Ferozepur District, Punjab. The Abohar and Muktsar Tahsils in the Ferozepur District have a large area under sweet-orange.

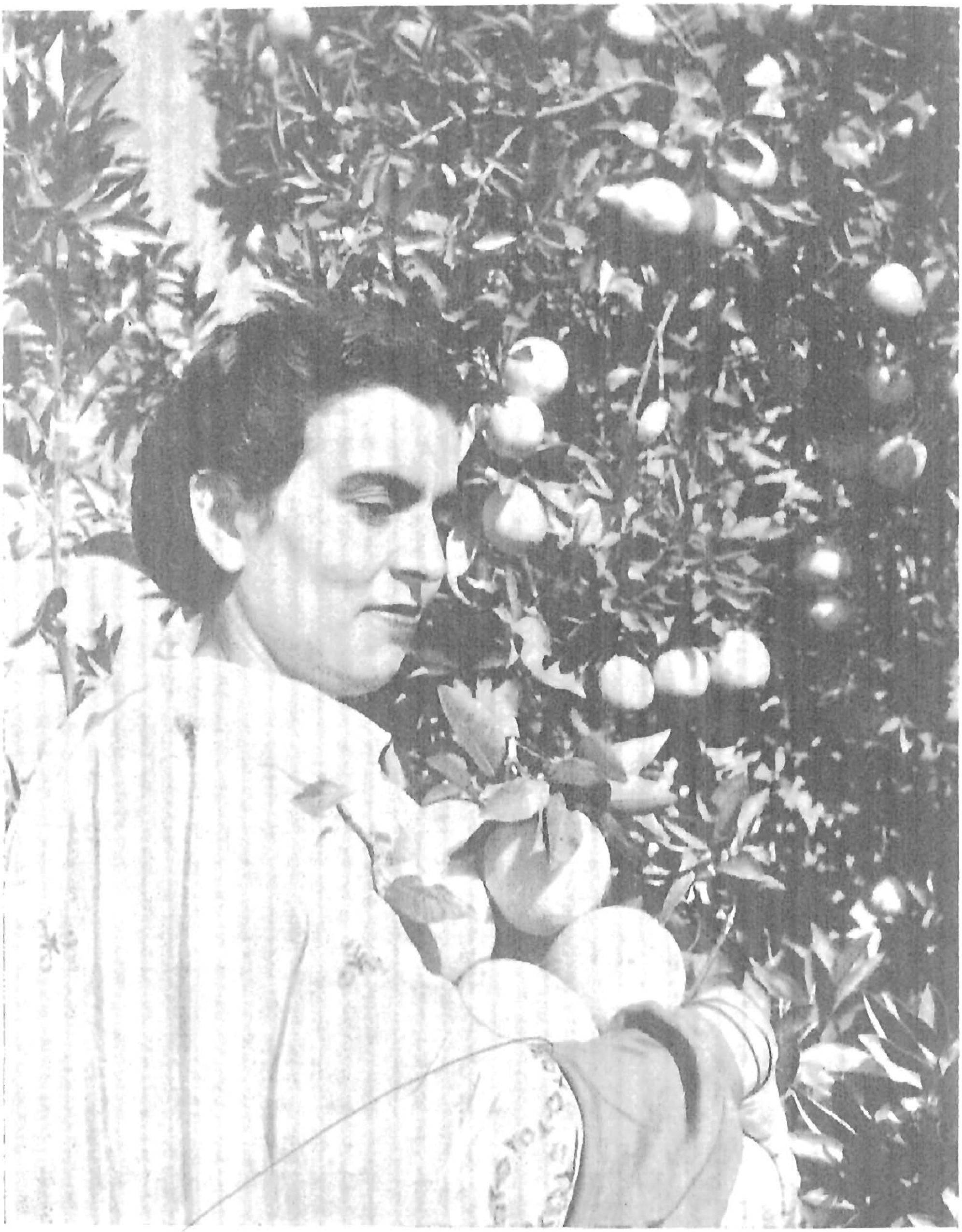


FIG. 11. The Garden-Colony Scheme promoted the cultivation of oranges in Punjab on an extensive scale. A happy gardener plucks oranges in her garden.

co-operative part of the scheme failed, the Garden Colonies succeeded on account of the initiative shown by the farmers who were allotted land. Each, according to his capacity, energy and experience, set on the job of building up a new agriculture. While the cultivation of oranges succeeded only in a few colonies, the result of the scheme was that the cultivation of vegetables and potatoes showed considerable progress. In a few years, these colonies became the models of improved agri-horticulture. The concept of the so-called package programme, which took shape in 1963, had already been proved in 1950 in East Punjab. It was demonstrated that by concentrating resources on selected areas, it was possible to force a rapid development of agriculture. If this idea had been followed and spread in other areas rather than wasting the resources over a large area merely on the pay of the staff of the Community Development Scheme, the Indian economy would have made much greater progress.

The Scheme of Garden Colonies was not merely a horticultural scheme. It was also a great social experiment. The Garden Colonies were conceived as centres of agri-horticultural advancement. Though fruit-trees have not succeeded in some of the colonies, they have developed into centres of intensive vegeculture (Figs 13, 14).

Agricultural College at Ludhiana, 1949

Another matter in which I was associated with Lal Singh was the setting up of the Agricultural College at Ludhiana. The farmers of Ludhiana had the foresight to make available the buildings of the local Khalsa High School for the staff of the Agricultural College which, like the East Punjab Government, was in search of a home and location. The next problem was to provide a permanent location through the allotment of land. At that time, politicians were busy in attracting the College to their respective districts. Lal Singh came to see me at Jullundur and asked me if I could allot to him 243 ha (600 acres) for the College. I offered him that much area in a village adjoining Ludhiana. The soil was sandy, but that was no deterrent. We knew that by proper manuring and growing of green-manure crops it was possible to improve the soil. We had in view the example of Arains (Muslim vegetable growers) of Jullundur, who had converted sandy wastes into fertile land, on which they grew their vegetables simply by careful manuring and good management. Time has shown that this was a correct decision and now the College of Agriculture has blossomed into the leading Agricultural University of India.

Legislative Measures to Promote Agriculture

Lal Singh had a firm conviction that, apart from persuasion, a certain amount of legal compulsion was necessary in agricultural development, so that the farmers could adopt improved agricultural practices on a mass scale.

With this end in view, he initiated a number of legislative measures, among which the following are worth mentioning.

(i) The Pure Seed and Seedlings Act: This Act requires the cultivators to sow specified varieties of improved seeds only in areas notified for the purpose. This Act encouraged the cultivation of long-staple varieties of cotton in the canal-irrigated areas of East Punjab.

(ii) The Punjab Conservation of Manure Act: This Act requires every farmer to store his farmyard manure in pits. Before the Act was enforced, it was a common practice with the farmers to heap manure in the form of mounds, which resulted in loss due to sun and rain. Lal Singh put his entire energy into promoting the practice of composting manure in pits. He also asked the Government to pass an Act to force the municipalities to compost their town refuse. Land was acquired for all the municipal areas for the composting of town refuse and this, in turn, promoted the cultivation of potatoes and vegetables in the suburban areas.

(iii) The Punjab Pests and Diseases and Noxious Weeds Act. Under this Act, mass campaigns were launched for the eradication of noxious weeds such as *pohli (Argemone mexicana)*.

(ix) The Punjab Reclamation of Land Act, and Land Utilization Act: In certain districts, such as Karnal, where the population consisted largely of cattle-graziers, large tracts of land were lying waste, covered with weeds and forests of *Butea monosperma*. Under this Act, the surplus land of the owners could be taken up and leased to others for reclamation. Lal Singh also realized that large belts of land, particularly in the beds of rivers, could not be reclaimed without tractors. He acquired a large fleet of these machines and asked the Punjab Government to enact legislation empowering them to recover charges of mechanical cultivation as arrears of land revenue. This Act was known as the Punjab Tractor Cultivation (Recovery of Charges) Act. Large areas were reclaimed and the results would have been more spectacular had not the members of the Legislative Assembly forced the dispersal of the fleet of tractors into their respective districts, resulting in less efficient supervision. The scheme suffered losses and the Finance Department of the State Government was highly critical of Lal Singh, little realizing the contribution that the reclaimed land ultimately made to the production of foodgrains.

The cumulative result of all these measures, followed by dynamic implementation, was that East Punjab, highly deficient in foodgrains at the time of partition, became surplus and began to export foodgrains to other parts of the country.

Lal Singh inspired a generation of agricultural scientists and horticulturists. Dr Arjan Singh, who later on succeeded him as Director of Agriculture, Punjab, was his close associate in the planning of agricultural development. Dr K.C. Naik, who was the Vice-Chancellor of the Agricultural University, Mysore, Dr Sadasivan, Professor of Botany, University of Madras, an outstanding botanist, worked with him at Lyallpur. Dr Sham Singh, who was the head of the Horticultural Section of the Indian Council of Agricultural Research, was also trained by him.

MEMBER OF PARLIAMENT (LOK SABHA)

Lal Singh retired from Government service in 1952, but it did not mean retirement from work. He decided to enter politics and was elected Member of Parliament (Lok Sabha) from the Ludhiana Constituency. Both in Parliament and outside, he took active interest in all matters relating to agriculture. He was of the view that land should be with the people, whether as owners or as tenants, who took active interest in its development. His advice was eagerly sought by the Government of India on various problems. For a while, he was the Vice-President of the Indian Central Sugarcane Committee. He was also a member of the Panel on Land Reforms, Estimates Committee of the Lok Sabha and the Agricultural Panel of the Planning Commission. He was held in great esteem by the farmers of southern India, particularly Madras and Mysore, which he visited frequently. To represent the grievances of the agriculturists, he founded an All-India Agriculturists' Federation, with a newspaper called the *Rural Voice*. As its Chief Editor he brought to the attention of the policy-makers a cross-section of farm problems from a professional angle. He created a climate for starting the first co-operative sugar-mill in Punjab, by writing articles and leading deputations to the Government. Finally, he persuaded the Punjab Government to start the Bhogpur Co-operative Sugar Mill, which is now working successfully in the Jullundur District. He was repeatedly sent on fact-finding probes to various states. He headed a team to study the possibilities of commercial exploitation of the wild loose-skinned oranges grown in Assam. For improved production, processing and marketing of sugarcane. He visited Australia twice. He was one of the founder-members of the Swatantra Party, and was on the executive of the Farmers' Forum. He was also the Founder-President of the All-India Cane-Growers' Federation, with a membership of 2,400,000. In his later years, though a victim of heart trouble, he never missed an opportunity to press his point of view forcefully. He prepared notes and papers on such issues and fought tenaciously to promote his views and he continued to do so up to the last moment.

On completing his five-year term of the membership of Parliament, he worked as a member of the Irrigation and Power Team of the Committee on Plan Projects from 1957 to 1960. In 1960, he became a Consultant with the Delhi Cloth Mills and managed their farms in Uttar Pradesh.

Lal Singh was full of energy and travelled extensively, both in the country and outside. I remember that when he was the Director of Agriculture, Punjab, he would rush from the heights of Simla to Ludhiana in a single dash, without any rest. He visited a very large number of farms in all the districts. He also travelled in the United States of America, Australia and Israel. In 1963, he was invited by the Ceylon Government for advice on the development of horticulture in that country.

Lal Singh had all the qualities of a Punjabi Jat Sikh farmer. He was outspoken and expressed his views fearlessly, whether they were palatable or not to the authorities. He generated enthusiasm among people who came into contact with him. When faced with a problem, he invariably said, 'This can be done', and never accepted defeat. He was a dedicated horticulturist and scientist, who did not live in an ivory tower, but had his feet firmly planted on the soil. He died of heart failure on 15 December 1963. In his death, India lost a dynamic agricultural leader, who played a leading role in promoting horticulture and the fruit-processing industry in the country.

GARDEN COLONIES IN PUNJAB (INDIA), INCLUDING HARYANA

District	*Tehsil*	*Name of the colony*	*Area in acres*	*Area in ha*	*Number of allottees*
		Punjab			
Ferozepore	Fazilka	1 Balluana	1,021	413.18	55
	Zira	2 Jalalabad	548	221.77	26
	Muktsar	3 Muktsar	1,233	503.98	62
Amritsar	Amritsar	4 Khankot	716	289.76	38
	Patti	5 Patti	1,038	420.06	57
Gurdaspur	Batala	6 Dyalgarh	572	231.48	32
	Gurdaspur	7 Khojepur	764	309.18	40
Hoshiarpur	Garhshanker	8 Panam	864	349.65	41
	Hoshiarpur	9 Dalamwal	187	75.68	10
Ludhiana	Jagraon	10 Bir Akhara	256	103.60	12
		11 Agwar Khawaja Baju	546	220.96	30
	Ludhiana	12 Jogiana	784	317.27	36
	Samrala	13 Rahaon	685	277.21	35
Jullundur	Jullundur	14 Boot Kingra	2,220	898.40	101
	Nakodar	15 Mahalon	970	392.46	50
Ropar	Kharar	16 Khanpur	518	209.63	28
	Ropar	17 Morinda	500	202.34	28
		Haryana			
Hissar	Sirsa	18 Baha-ud-Din	172	69.61	9
	Hansi	19 Mirza-ki-Patti	998	403.88	49
	Fatehabad	20 Mughalpura	491	198.70	26
Rohtak	Rohtak	21 Kharkhauda	600	242.81	33
		22 Lahli	435	176.04	23
	Sonepat	23 Punchhi Gujran	959	388.09	43
Gurgaon	Palwal	24 Khajurke	262	106.03	21
Karnal	Karnal	25 Jundla	2,066	836.08	110
	Panipat	26 Kachhrauli	1,304	527.71	67
Ambala	Ambala	27 Adohi Tolan Wali	1,445	584.77	71

CHAPTER 5

RECLAMATION AND COLONIZATION OF THE TARAI IN THE NAINI TAL DISTRICT, UTTAR PRADESH 1948–1958

BELOW the Siwalik Range in the Naini Tal District is a tract of land 10-15 km wide, known as *Bhabar*. It is a porous zone and is covered with a Savanna-like thorny scrub, composed of lantana bushes mixed with *Adhatoda vasica*. To the south of the *Bhabar* is another tract 15-30 km wide, the Tarai (which means wet land), covered with tall trees and elephant grass. Many small rivulets flow underground in the *Bhabar* and emerge in the Tarai. The most characteristic trees are *sal (Shorea robusta)*, *sain (Terminalia alata*; syn. *T. tomentosa)*, *haldu (Adina cordifolia)*, *dhanri (Lagerstroemia parviflora)*, *khair (Acacia catechu)*, *amaltas (Cassia fistula)* and *semal (Bombax ceiba)*. The Tarai is bounded on the west by Pargana Kashipur and on the east by the Sarda River, which separates it from Nepal. Farther south, it merges with the flat alluvial land of Rohilkhand.

CLIMATE

The climate of the Tarai differs from that of the adjoining plains chiefly in variations of temperature between day and night, which are due to the nature of the soil, and are the proximate cause of the heavy sickness which attacks the inhabitants of the tract at the commencement of the hot season and towards the end of the rainy season; the average rainfall is about 50 in. (1,270 mm). It is noticeable that the type of fever prevalent at the commencement of the hot weather is 'remittent', while that of the later months is 'intermittent'.

Tarai was a prosperous area in the Mughal period. In the reign of Akbar, it was called 'Naulakha Mahal' implying that it yielded a revenue of nine lakhs of gold *mohurs*. Till about 300 years ago, the Tarai, at least in parts, was evidently fertile and prosperous. It is not known exactly how it fell into its later deplorable condition. Many causes probably led to its decline. Water-logging, both natural and man-made, encouraged the formation of marshlands. The influenza epidemic of 1918 was the final calamity that almost decimated the already debilitated population. The influenza epidemic, plague and malaria wiped out whole villages, and the survivors fled in panic from the Tarai, never to come back. This was amply borne out from the revenue records. The maps showed that there were revenue estates all over the area.

The Tarai comprises seven parganahs: Kashipur, Bazpur, Gadarpur, Rudrapur, Kilpuri, Nanakmatha and Bilheri. The area of each parganah is estimated as follows in acres: Kashipur, 119,599 (48,400 ha); Bazpur, 71,205 (28,816 ha); Gadarpur, 44,819 (18,138 ha); Rudrapur, 97,349 (39,396 ha); Kilpuri, 83,813 (33,913 ha); Nanakmatha, 51,186 (20,714 ha); and Bilheri, 121,388 (49,124 ha).

Drainage System

The drainage system of the Tarai comprises, first those streams which flow direct from the Himalayas, and, secondly, those which are fed by springs rising in the Tarai itself. On the extreme east is the Sarda and on the west the Peli. Continuing from east to west are the Saniya, Deoha, Sukhi, East Bahgul, Kichha or Gaula, West Bahgul, Dubka, Gugi, Naiya, Kosi, Bahilla, Dhela and Phika. Most of these rivers have their sources in the hills and are subject during the rains to heavy floods. The Deoha becomes navigable for boats and rafts from near Pilibhit, but none of the others, save perhaps the Kosi, carry sufficient water to allow boat traffic. There are numerous small streams between each of these rivers which are used for irrigation. With the exception of the Sarda, they all are tributaries of the Ramganga, which falls into the Ganga in the Hardoi district. The drainage system as a whole resembles the reticulations of a leaf, the rills on the edge of the moist country unite to form a streamlet, these again form the streams which feed the arterial lines of drainage and all eventually join the great midrib stream, the Ramganga.

Canals

From the earliest times the Tarai streams were used for irrigation. The simplest and most common procedure was to construct dams where required across the streams, but the results in the end were ruinous both to the land and the climate. The soil became water-logged and gave rise to a severe form of malarial fever which carried away the majority of the inhabitants. The streams being diverted formed immense swamps and swallowed up the arable land.

The Eastern Bahgul system of canals provides for the irrigation of the Kilpuri parganah and the Maina-Jhundi portion of Nanakmatha, and is then carried on into the Pilibhit and Bareilly districts. Next comes the Kichha and Paha systems.[1]

The Tarai is excessively damp with a high water-table. Its numerous sluggish streams provided an ideal breeding-ground for mosquitoes. The thick forests of Tarai provided a sanctuary for elephants, *nilgai*, spotted deer, hog deer, sambhar, sloth-bears, pigs, leopards and tigers. Of the game birds, the peacocks, florican, black-partridge and jungle fowl are numerous.

[1]Atkinson, E.T. *The Himalayan District of the North-West Province of India*, pp. 698-700

Jim Corbett, who made Tarai world-famous by his *Man-eaters of Kumaon*, lived in the Tarai forests, where he had many encounters with tigers. In the past, pythons were also found in the Tarai. Bishop Heber mentions that these pythons had sufficient strength even to strangle a buffalo. As from distance, they appeared like logs of wood, wayfarers sometimes stepped on them, and were terrified on finding them alive.

For a long time the Tarai was a barrier between the plains and the Kumaon Hills. Bishop Heber, who travelled in these parts in 1824, records, 'I asked Mr Boulderson if it were true that the monkeys forsook these woods during the unwholesome months. He answered that not the monkeys only, but everything which had the breath of life instinctively deserts them, from the beginning of April to October. The tigers go up to the hills, the antelopes and wild hogs make incursions into the cultivated plain; and those persons, such as dak-bearers, or military officers, who are obliged to traverse the forest in the intervening months, agree that not so much as a bird can be heard or seen in the frightful solitude.'[2]

More deadly to life than the wild beasts were the mosquitoes which rose like black clouds from their breeding-places in the sunless marshes, and passed on to those whom they stung a type of malaria so malignant that thousands perished of it over the years in the tiny isolated settlements scattered over the region.

People

The only inhabitants of this area were the Tharus and Buksas—aboriginal tribes. They lived by hunting, and on jungle produce. They also practised shifting cultivation and planted small plots of land under paddy and millets. Women were more robust than men. Fishing in stagnant pools was their pastime as well as part-time occupation. Profusely tattooed, dressed in bright red, yellow and blue clothes, and their arms and ankles covered with silver ornaments, the Tharu women look picturesque. A peculiar phenomenon was noticed among them. They were liable to malarial fever up to the age of four. After that they developed immunity.

The other inhabitants of this area were herdsmen, they reared cattle in jungle clearances called *khattas* and fed the beef market in the towns of U.P. Cream was extracted from the milk of these herds by arrangements made by Keventers of Aligarh, and was transported daily by rail from Lalkuan to Aligarh to feed the dairy industry which catered for the needs of the Army.

Schemes for the Settlement of Demobilized Soldiers

The initiative for reclamation of the Tarai came from the Defence

[2]Heber, Reginald, *Narrative of a Journey through the Upper Provinces of India from Calcutta to Bombay, 1824-1825*, Vol. I, p. 454

Department of the Government of India during World War II. C.M.G. Ogilvie, Defence Secretary, early in the 1940s ordered a survey for locating sizeable chunks of waste land, with a view to reclaiming them for resettling demobilized soldiers. In U.P., Ganga khadar in the Meerut district and the Naini Tal Tarai, were identified for this work.

A detailed topographical, contoured survey of 150 square miles (388.5 km^2) in the Tarai was ordered in 1944. When it was completed, a committee was appointed in 1946 to investigate problems connected with the development and colonization from a technical and administrative point of view. One of the members of this committee has left a vivid description of the Tarai. He wrote...'life in most of Tarai villages is one of continual struggle for existence against the depredations of wild animals, the rank and vigorous Tarai vegetation, the enervating climate, malaria, bad drinking water, high death rate and infant mortality, low birth rate, bad communication and lack of amenities'. He, however, concluded with the remark that 'the country itself is most attractive and could be transformed into a beautiful settlement'. Not everyone, however, was ready to accept his opinion. Indeed, the task appeared so formidable that the timid advised against it.

Problem of the Resettlement of Refugees, 1948

In August 1947, India was partitioned, and a flood of refugees from West Pakistan entered India. Though a large number were resettled in Punjab (India), some remained without land and homes. In 1948, Kashmir was invaded by Pakistan and the army was fully occupied in tackling the problem, and hence there was no serious problem of resettling demobilized soldiers.

The initiative for the reclamation of Tarai came from Pandit Govind Ballabh Pant, Chief Minister of Uttar Pradesh (Fig. 15), who, as a Kumaoni, was familiar with the problems of the Tarai as well as with its potential. Pantji, as he was affectionately called, was ably assisted by his Food Production Commissioner, Aditya Nath Jha. Radha Kant was appointed Director of Colonization; Major Harpal Singh Sandhu was appointed Deputy Director, Colonization; Mahavir Prasad was appointed Superintendent of Works; and N N. Sen was appointed Conservator of Forests. It was this group of officers, working under the leadership of Jha, who reclaimed the Tarai and made it habitable.

The main burden of the reclamation work fell on Sandhu, the leader of the team. 'When I was asked to take charge of the reclamation work', states Sandhu, 'my only condition was that all the different Government Departments connected with the reclamation and colonization work should be put directly under my charge. This was necessary to avoid red-tape and to ensure a co-ordinated effort. To this the Government readily

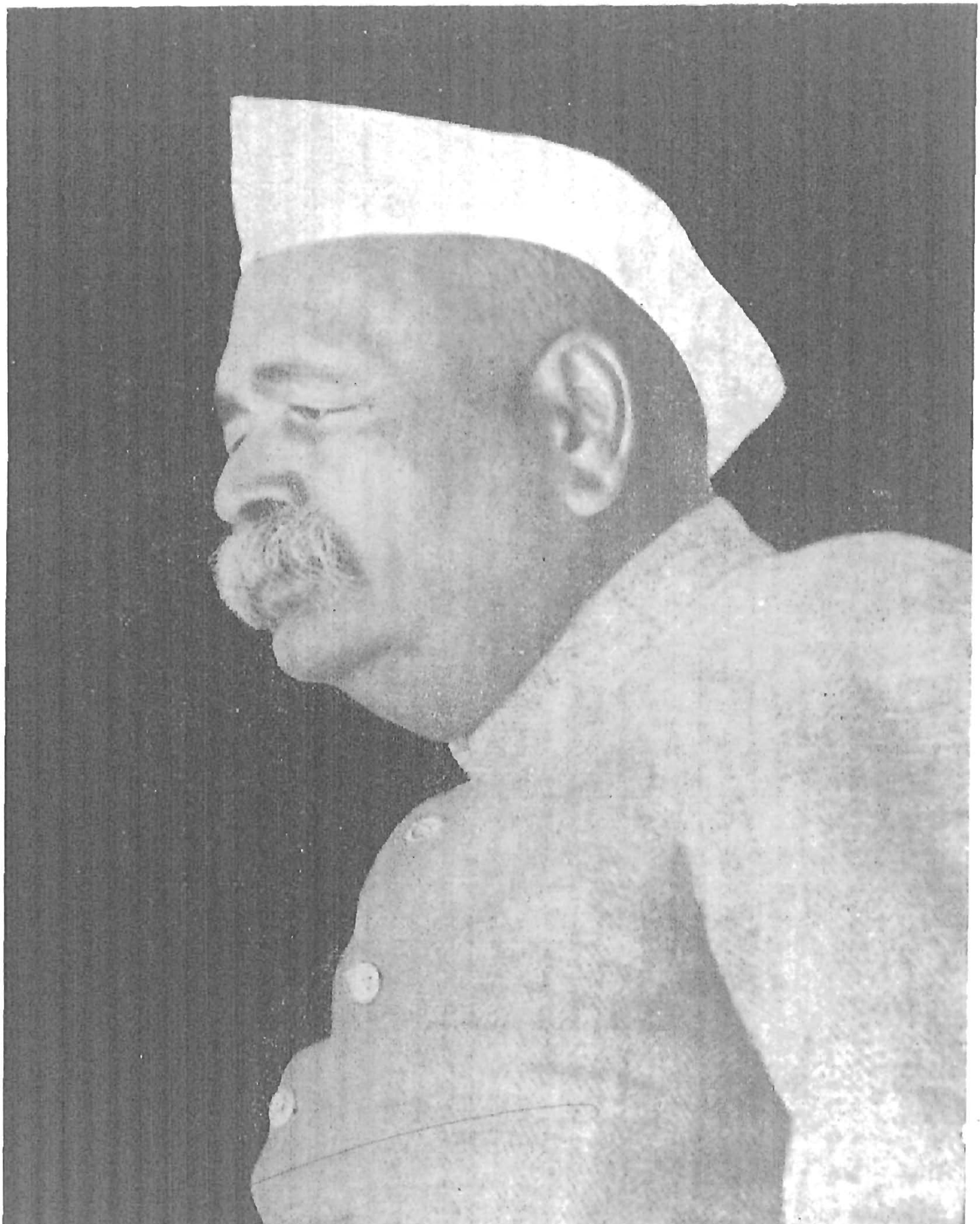


FIG. 15. Pandit Govind Ballabh Pant, who sponsored the scheme for the reclamation of Tarai of the Nainital District, Uttar Pradesh. The agricultural university at Pantnagar is named after him.

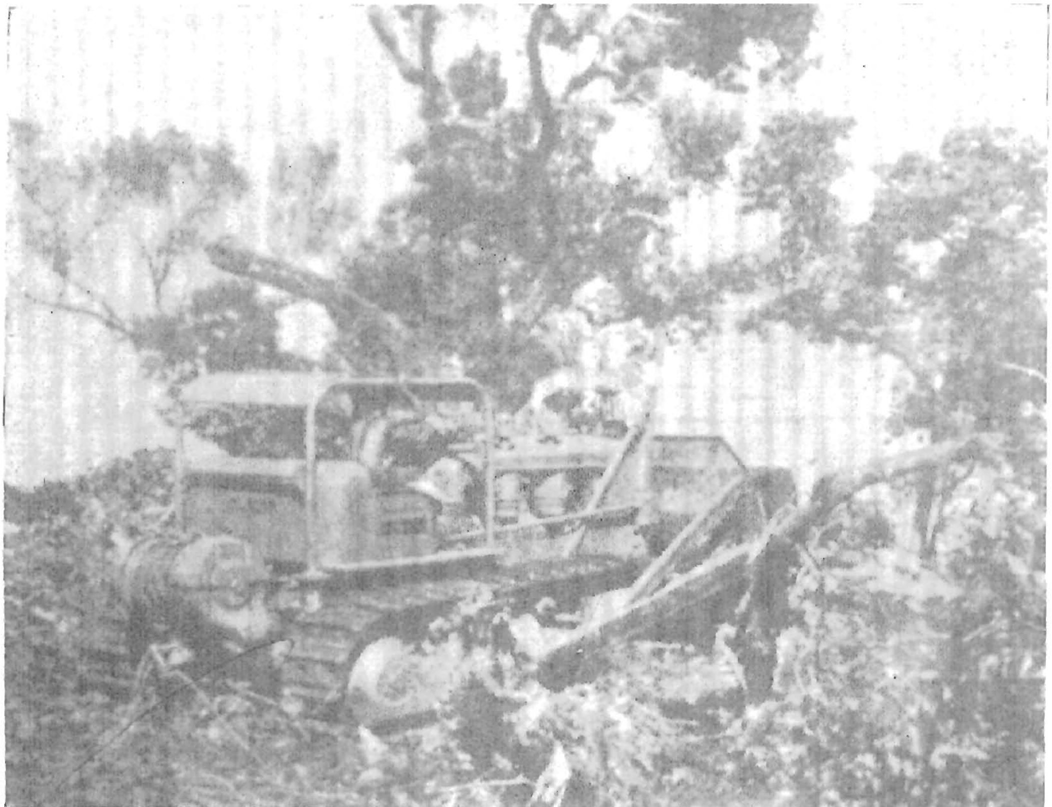
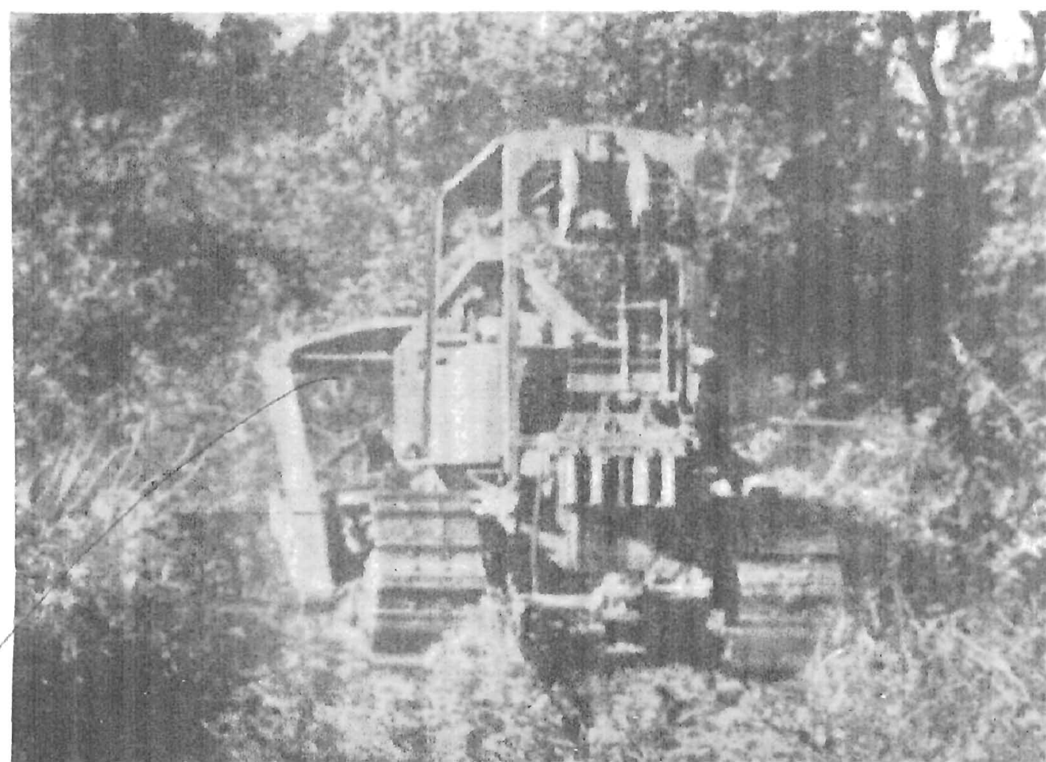


FIG. 16. *(Above and below)* Making their way through mud and crashing through tall grasses, heavy tractors started their work in the Nainital Tarai.



agreed, and both sections of the Public Works Department, Roads and Building, Power and Irrigation, Agriculture, Animal Husbandry, Co-operation, Revenue, Forest, Anti-Malaria and Reclamation Departments took directions and were answerable to me.

'It took us more than a year to build the necessary infrastructure, to recruit personnel, collect reclamation machinery, and start anti-malaria operations in the malaria-infested marshes of the Tarai.

'A good deal of dedicated effort and a war-footing approach enabled us to undertake reclamation work with effect from 4 January 1948.

'In the first season, we reclaimed 8,000 acres (3,237 ha). The reclaimed area was going a-begging, and there were no takers. The Tarai after all was a notoriously inhospitable area—the *Kala Pani*—and nobody wanted to risk founding a home in Tarai.

At a refugee camp in Hardwar, Sandhu gave a glowing account of the new life that awaited the refugees when they settled in the Tarai farms. Two hundred families responded readily to the invitation, and promised to present themselves at the railway station the following morning, where a special train had been arranged to carry them to their destination. The meeting dispersed on a note of happy confidence. Next morning, Sandhu went to the station to make sure that all details of the arrangements went smoothly. The special train steamed in alongside the platform and the staff waited in readiness to accommodate the 200 families. But not a soul turned up. The Station Master waited till the last moment when he was forced to remove the refugee train to make room for another. A bewildered Sandhu went sadly in search of his flock and found a few of them at the camp. It transpired that they had, after the previous night's meeting, made some enquiries about conditions at the Tarai and, from what they were told, decided that it would have been preferable to be killed in the holocaust of partition rather than to invite slow and painful death in 'that horrible place'.

An area of 16,000 acres(6,475 ha) was set apart from the beginning for the creation of a State Farm in which pure pedigree seed would be produced and good livestock reared for distribution to the surrounding countryside. In this portion were constructed a meteorological observatory, mobile workshops for the maintenance and repair of tractors and other farm equipment, and a modern dairy with pasteurization and processing plants. A herd of pure-bred buffaloes was established and over 3,500 acres (1,416 ha) of land developed for raising fodder and grasses for them. A poultry section was also started. A 1,000 acre (404-ha) orchard and vegetable garden was laid out. Blocks of land were set apart from afforestation and for planting fruit and ornamental trees. Facilities for colonization of the cleared portion of the Tarai were energetically put through. Well-planned villages were established and connected with roads. Comfortable homesteads with hand-pumps, kitchen-gardens and 250 deep tube-wells as well as storage tanks at suitable places were installed. Schools, a large central hospital, a mobile dispensary and anti-malaria squads were set up. All villages were provided with electricity and 20 miles (32 km) of barbed-wire fencing protected their crops from wild animals.

In spite of all these herculean efforts to transform the region, the notoriety that still clung to the Tarai made the task of attracting colonizers, even from among the refugees from Pakistan, unexpectedly difficult.

As there were no takers, Sandhu states, 'The only solution I could think of was to put this area under paddy as a Government project, and we achieved a marvellous success as nobody had ever seen such a bumper crop of paddy. I went a step further and persuade the Government to have a large Government Farm so that we could have a sizeable community of Government servants working in this area to attract settlers to the Tarai. An area, 2½ miles (4 km) wide, and 10 miles (16 km) long—16,000 acre (6,475ha)—was selected along the northern boundary of the area earmarked for reclamation. That's how the famous Tarai State Farm came into being.'

Sandhu concludes, 'If I had not enjoyed the support of Pantji and A.N. Jha and the Punjabi refugees had not come to the area with their courage and capacity for hard work, the Tarai would not have become the granary of Uttar Pradesh, which it is today. When you drive from Kashipur to Khatima, a distance of over 70 miles (112.6 km), you can always pick out the fields managed by the Punjabis from those of other settlers. There is no comparison. Fields of the Punjabis are the product of dedicated and devoted hard work. Hundreds of East Bengal refugees also have been settled in this area but they have not taken to the soil like their Punjabi neighbours.

'In the initial stages we allotted 15 acres (6 ha) of land and a pucca house to each settler. The house was given on loan-basis and the cost was recoverable by easy instalments. Lush crops on this fertile reclaimed area, and success with anti-malaria operations, attracted a large number of settlers. As the allotment was confined only to refugees, political sufferers, and ex-servicemen, we could not accommodate these eager farmers. Fortunately, there was a strip of 'banjar' land in Rampur State, adjoining the Tarai Reclamation Project, and I was able to persuade the Nawab of Rampur to allot land to these eager Punjabis, and we helped them by offering custom reclamation service at cheap rates. This enabled us to add nearly 30,000 acres (12,140 ha) along the southern boundary of the Naini Tal Tarai. In the Bareilly District, along the Tarai belt, zamindars sold land to eager settlers. Now the Naini Tal Tarai success story spread to the northern portion of the Pilibhit and Lakhimpur districts to the east, and Bijnor and Saharanpur districts to the west.

RECLAMATION

'Before starting actual reclamation operations, we experimented blasting trees with dynamite, felling them by manual labour, and using heavy machinery for clearing jungle, and we came to the conclusion that only heavy tractors could effectively clear the jungle and were also cheaper in the long run.'

USE OF HEAVY TRACTORS FOR JUNGLE CLEARANCE

The accounts of early stages of the jungle-clearing operations read like despatches from a battlefield. 'On 4 January 1948, the first fleet of heavy tractors moved into this part of the world in a bid to clear 1,90,000 acres (76, 890 ha) of virgin soil. Making their way through mud and water, crashing through tall grasses and weeds, these machines started their work (Fig. 16). Accidents were frequent, for hidden crevices were veritable traps for the machines. Dense patches were cleared by a cable towed by two tractors and the tall grass was trampled down by the giant machines in order to make land-breaking possible. Two tractors would drag a heavy anchor chain to topple trees, and a third tractor with a bulldozer would follow in the rear to topple the trees which resisted the pull of the chain. The trees were felled in east-west direction and were wind-rowed across the slope to check erosion.

'We were further helped by a sheer accident', states Sandhu. 'On the first day we had felled a few dozen trees in a marsh where we could only move about in gum-boots. Lo, and behold! when we returned the following day for further operations the marsh had drained away! I immediately decided to study the soil profile, and discovered that the top 9″ (23 cm) was leafmould, and underneath was the most fertile virgin soil, and below that at between 10″ and 14″ (25 and 35 cm) of the top soil there was a thin layer of clay which acted as a seal and did not permit the percolation of surface water. We immediately decided to send out bulldozers to fell a few trees at random between each two streams which abound in the Tarai. The clay seal being thus broken, drainage was further helped by the gravel layer about 4 ft (1.22 m) below the surface, and the marshes miraculously disappeared. That made our work easier and spelled the death knell of the mosquitoes and other biting insects.'[3]

Simultaneously with the clearance of land started the battle against malaria. Larvae were destroyed by spraying Paris-green over stagnant pools and sluggish nullahs. This together with other measures almost eradicated malaria from the Tarai. The next step was to lay down pucca roads before colonization could begin. By 1953, 43 miles (63 km) of tarmacadam and 50 miles (80 km) of fair-weather roads had opened up

[3]Personal Communication from H.S. Sandhu, 23 October 1980

165 square miles (427 km²) of the tract where only four years earlier movement was possible only on elephant-back. Bridges were constructed over the streams that crossed these roads. Subsoil drainage was essential and had to be accomplished over the entire erea. A large number of tube-wells were sunk so that pure drinking-water could be made available. In three years, 2,460 familes of displaced persons and landless individuals were settled on the Tarai and faced the future with 'faith and confidence'.

In the reclamation and colonization of the Tarai, the Central Tractors Organization played a key role in the work of clearing the land and making it fit for settlement.

To open up the area and to improve communications, 70 miles (112 km) of *pucca* roads was built, the Railway Department opened a railway station and the Civil Aviation Department, an airport.

In 1960, the Govind Ballabh Pant University of Agriculture and Technology was established on the reclaimed area. The Pantnagar farm has 4,095 ha under crops and it has 159 tractors and 30 combines. The farm is irrigated by 39 artesian wells, 50 tube-wells and 40 open wells. By its research and its extension to the farmers, the University has transformed the Tarai. Tractors, threshers and tube-wells are a common sight. The Tarai now produces bumper crops of rice and wheat, and is one of the Green Revolution areas of India.

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CHAPTER 6

COMMUNITY DEVELOPMENT AND NATIONAL EXTENSION SERVICE PROGRAMME 1952-1956

PANDIT Jawaharlal Nehru, Prime Minister of India, following in the footsteps of Mahatma Gandhi, turned to the villages in 1952 in a new effort to galvanize national economy. This is a landmark in the history of India, as it was for the first time that the Government of India showed determination to tackle the rural problem in all its aspects, undaunted by its magnitude. For the first time, the village became important, and the villager acquired self-respect. The limelight of the press and publicity was switched on to the village, and the villager, so far despised and neglected, suddenly became the object of regard and sympathy. Officials and publicmen from the middle classes felt honoured in working with the villagers.

S. K. DEY (B. 1906), ADMINISTRATOR OF COMMUNITY PROJECTS AND NATIONAL EXTENSION SERVICE

The Administrator of Community Projects and National Extension Service was S. K. Dey, an electrical engineer, scion of a farming family of Sylhet in East Bengal, now Bangladesh. He graduated from the University of Purdue, and got his M.Sc. from the University of Michigan.[1] Before Independence, he worked for 16 years in a subsidiary of the General Electric Company at Lahore. He was an inspired man who created enthusiasm even among the dull and prosaic. He built the agro-industrial township of Nilokheri in the Karnal district on waste-land to rehabilitate refugees from West Pakistan. At Nilokheri, a training centre was also started to train village-level workers.

COMMUNITY DEVELOPMENT

The programme was started on 2 October 1952, with the launching of 55 community projects, comprising 27,388 villages and a population of 16.4 million. Each project covered about 300 villages, with population of about 200,000 and a cultivated area of about 150,000 acres (60,703 ha). The project area was divided into three development blocks. A development block consisted of about 100 villages, with a population of about 60,000. Each block was divided into groups of 10 villages. Each group was the field of operation of a village level worker *(gram sewak)*.

The project was in charge of a project executive officer, who had three

[1] Dey, S.K. *Community Development*, Delhi, 1962

block-development officers and 30 *gram sewaks*. At the state level was the Development Commissioner, who was to co-ordinate the working of all development departments. Technical men, called extension officers, were provided for agriculture, animal husbandry, co-operation, village industries, and rural engineering.

NATIONAL EXTENSION SERVICE PROGRAMME (NES), 1953

The National Extension Service Programme was formulated in April 1953 and was inaugurated on 2 October 1953. It was proposed to cover the entire country by 1960-61. The National Extension Service and Community Development Programme had identical areas and functions.

FINANCE

The expenditure of each community project was 1.5 million rupees per year. The share of the Central Government was 75 per cent of the non-recurring, 50 per cent of the recurring and 100 per cent of the loan expenditure. The balance was met by each State government. The expenditure of a NES block was 750,000 rupees. The loans were to be given for productive works, e.g. irrigation, reclamation of waste-land and purchase of agricultural implements.

OBJECTIVES

Mr V. T. Krishnamachari, the Vice-Chairman of the Planning Commission, thus described the objective of the Community Development Programme:

'The objective of the movement is, briefly, to ensure that there are concerted efforts to improve all sides of village life and to mobilize local initiative and resources for the betterment of rural conditions. The basic principles on which it lays stress are three: Firstly, all aspects of rural life are interrelated, and programmes of improvement should be comprehensive, though there might be emphasis on groups of activities. Secondly, the motive force for improvement should come from the people themselves. The movement is built up on the principle of self-help; the State only assists with supplies and services and credit. The vast un-utilized energy lying dormant in the countryside should be harnessed for constructive work, every family devoting its time not only for carrying out its own programme but also for the benefit of the community. Thirdly, the co-operative principle should be applied for solving all problems of rural life.

'The directions in which change in outlook is needed and is to be worked for are: Firstly, increased employment and increased production by the application of scientific methods in agriculture, including horticulture, animal husbandry, fisheries, etc., and the establishment of subsidiary and cottage industries; secondly, self-help and self-reliance and the largest extension of the principle of co-operation; and, thirdly, the need for devoting a portion of the unutilized time and energy in the countryside for the benefit of the community as a whole.

'The movement is not an official movement. There is an administrative organization for it. This, of course, is necessary and consists of officers at all levels working as a team. But it is more than that. Alongside the administrative organization, the NES programme aims at the closest co-operation with the best non-official leadership at every stage. In essence, the organization is both official and non-official; both have to work together. Development programmes are drawn up after the fullest discussions with the people and their representatives at various levels. In the village, the Panchayat is utilized in the planning as well as in the implementation of the programme. Plans drawn up by the village are considered by advisory committees at the block level and the district level on which non-official leaders are associated. Thus, at every stage the official and non-official organizations work side by side for evolving and implementing programmes. The whole movement is based on self-help, and the active interest and support of the people has therefore to be enlisted in the task of bettering their own condition. The Central Government is assisting the movement by giving a permanent grant of half the additional cost of the staff and by organizing through the co-operative movement and other channels the short-, medium- and long-term credit required. The movement is thus essentially a people's movement. It should not be allowed to deteriorate into an agency for carrying out a series of official projects or schemes but should continue to be a dynamic movement representing the efforts made by the people to improve their own condition. The role of the official is to guide; to advise regarding the technical and other measures for increasing production; and to organize the finance, supplies and services needed. In all other matters the responsibility and initiative should be with the people themselves.

Criteria for Assessment of Results

V. T. Krishnamachari laid down the following criteria for assessment of the results of the scheme:

'Firstly, have we given a plan of improvement to every family, and are we assisting these families to implement their plans? To achieve the target of doubling the production in ten years, works of permanent improvement have to be initiated by every family for making the optimum use of irrigation facilities, for consolidation of holdings, for contour-bunding, etc. The aim should be increased empolyment not merely in agriculture but also in cottage and small-scale industries, etc.

'Secondly, is every family made fit to become a member of at least one co-operative society in its own right? The co-operative system should be integrated with the national extension movement. The important question is how the sections of the community which are not represented on co-operative societies for the reason that they do not satisfy the tests laid down for credit-worthiness can be rehabilitated and made credit-worthy. Unless such rehabilitation is achieved, the movement will be condemned as benefiting only the well-to-do families and cannot become a people's movement in a real sense.

'Thirdly, to what extent do the families utilize a portion of their time for voluntary work for the benefit of the community? The aim should be to have permanent works of public benefit like village forests, improvement of grazing grounds, drinking-water wells, roads, school buildings, etc.—constructed with people's participation. It should also be emphasized that such works as are constructed should be maintained by the village community.

'Fourthly, is there an active women's and youth movement in the villages? It is most important to bring the women and the youth into the movement fully. Only so can its usefulness be maintained.

'Unless these four questions can be answered in the affirmative for practically every rural family, the objective of the movement cannot be said to be fully achieved. Briefly the aim is to bring about a social change—an awakening in the countryside—and to release the dormant energies of the nation for the achievement of a fuller and richer life. It is by the extent to which this social change is brought about that the movement has to be judged.'[2]

Aided Self-help Programme

The Community Development Programme has been described as "aided self-help programme". The State and the people have become partners in a gigantic common enterprise for transforming the rural area, and for liquidating a vast rural slum, the inheritance of centuries of inertia. While the State provides part of the finance, and the technical know-how, the people provide land, money, and labour. A number of minor projects in villages, which were held up owing to the lack of finance, made headway on account of the financial aid provided by the Government. The success of the programme is judged by the response it evoked from the villagers, and the extent to which the people participated in the project work. Its principal objective was to better the social and economic lot of the villages.

Multi-purpose Programme

The Community Development Programme is a multi-purpose programme touching rural life in all its aspects—economic, social and cultural.

[2]Krishnamachari, V.T. Foreword to M.S. Randhawa's *National Extension Services and Community Projects in Punjab*, 1955, pp. vii-x

Rural life is an organic whole, and no improvement in any sector is possible unless an attack is made on all sectors simultaneously. Whereas the farmers were povided with facilities for growing improved crops, for rearing better cattle and poultry, and for improving cottage industries, attention was also paid to environmental hygiene. The villages were provided with paved streets, *pacca* drains, parapeted wells equipped with soakage pits, and suitable latrines and urinals, so that the villagers live in clean and healthy environment. The problem of diet is important. The farmers' diet must be nutritious as well as balanced, with adequate quantities of protective foods, such as milk, eggs, fruit, and vegetables. All these improvements would be possibe only if the farmer raised more income from the land by reclaiming waste-land, by developing means of irrigation, by sinking wells and tube-wells, wherever possible, by adopting the use of fertilizers and improved seed, by sowing the seed in rows, by cultivating fruits and vegetables, and by adopting poultry-farming and animal husbandry as side-lines. In short, 'mixed farming' was suggested to be the ideal practice.

The main items in the programme are detailed below.

AGRICULTURE AND ALLIED FIELDS

(i) Reclamation of available virgin and waste-land

(ii) Provision of water for irrigation through canals, tube-wells, surface wells, tanks, lift irrigation from rivers, lakes, pools, etc.

(iii) Provision of quality seeds, improved agricultural techniques, veterinary aid, improved agricultural implements, marketing and credit facilities, breeding centres for animal husbandry, soil research and manures

(iv) Development of inland fisheries, fruit and vegetable cultivation, arboriculture, including planting of forests and the reorganization of dietetics

(v) Key village scheme for improving milk production

COMMUNICATION

(i) Provision of link roads

EDUCATION

(i) Compulsory and free education at the elementary stage

(ii) Provision of social education and library services

HEALTH

(i) Sanitation and public health amenities

(ii) Medical aid for the ailing

(iii) Midwifery services

TRAINING

(i) Refresher courses for improving the standard of existing artisans

(ii) Training of agriculturists, extension assistants, health workers, and managerial personnel of the projects

EMPLOYMENT

Encouragement of cottage industries, medium- and small-scale industries and crafts as main or subsidiary occupations

HOUSING

Provision of improved techniques and designs for rural housing

SOCIAL WELFARE

(i) Provision of community entertainment, based on local talent and culture and sports

(ii) Provision of audio-visual aids for instruction and recreation

EMPHASIS ON AGRICULTURE

The main emphasis, however, is on agriculture. The productivity of land in India was proverbially low. If the means of irrigation are developed and the use of improved seeds, manures and fertilizers is encouraged, productivity can be increased appreciably.

Attention was also paid to education, for mass education is the keystone of the arch of rural development, and without educating the villagers no programme of development can be usefully implemented. Woman runs the home, and, if she is illiterate, progressive ideas cannot be spread. Hence women's education occupies an important place in the Community Development Programme.

Material and spiritual development must go side by side. Mere material progress, with clean houses and streets, will not spell progress. Ultimately it is the spirit of man which counts. Enthusiasm must be raised by propaganda. The cultural heritage of the people in the shape of folk-art, folk-songs, and folk-dances must be revived. This aspect of rural life is dealt with under Social Education in the Community Development Scheme. The ultimate aim was to awaken the urge for better living and for a fuller and richer life among the villagers.

The objective of the Community Development Programme was not to dig a pond that would ultimately stagnate, but to expose the springs of life, so that there is a perennial flow of pure and sparkling water and cycle of activity gets started, and the vicious circle of poverty and unemployment is ended.

Harmonizing the Country and the Town

The ultimate aim of rural development schemes launched under the Community Projects was to narrow the gap between the town and the country. The ideal was to urbanize the rural areas. The amenities which modern science has developed in the form of metalled roads, electricity, schools, and hospitals, which have so far been the monopoly of the town-dwellers, should be provided for the residents of villages also. With the extension of electrification in the rural area, many difficult agricultural operations, such as drawing water from wells, cutting fodder, crushing sugarcane, and rolling cotton, would be rendered easy. Apart from these, electricity will bring civilization to the villages; the villagers will be able to make use of their leisure time; reading habit and knitting and sewing among women would become commoner. The amenities and comforts that electrification provides would make life in the villages more comfortable, and ultimately the villager will be better off, for he would not only enjoy the comforts of the town, but would retain Mother Nature around him. He will live in surroundings free from filth, congestion, and noise, while in touch with the world and civilized areas with the aid of the metalled road and the radio and the newspaper. It is by extending the amenities which modern science has provided that the town and country would be harmonized; towns would no longer look like warts on the face of Mother Earth, and villages would also no longer remain in pristine squalor.

Evaluation of the Programme

The Community Development and National Extension Programmes started with great enthusiasm. Thousands of villagers participated in providing earthwork on village link roads. Villagers donated land, cash and labour for school buildings. Muddy streets were paved with bricks and drains were provided. During 1953-56, whereas the Government expenditure was Rs 460.2 million in these blocks, the contribution by the people was valued at Rs 261.3 million.[3] Without the new organization of the block-development officer (BDO) and the village-level worker, all this would have remained untapped. Considering the meagre resources provided, substantial work was done in the field of agriculture by providing improved seed and labour for sinking tube-wells and for purchasing improved implements. From the point of view of administration, the new set-up, viz. the Development Commissioner, Collector and Block Development Officer, provided co-ordination of all the nation-building departments at their respective points of action. The concept of the 'block' as a unit for development was a permanent contribution to development administration.

On the negative side, the main criticism of the programme is that a

[3]Rajeshwar Dayal, *Community Development Programme in India*, Allahabad, 1960, p. 167

uniform Procrustean pattern was imposed on a country in which there is so much diversity. The needs of villages in the north are different from those in the south or east. Whereas the village link roads are a dire necessity in the northern Indo-Gangetic alluvial plain, where the soil becomes muddy during the monsoon, it is not so in the rocky peninsula. Just as the plantation crops, such as coconut and arecanut, are important in Kerala, Karnataka, Tamil Nadu and Assam, it is wheat which is important in Punjab, Haryana and Uttar Pradesh. Hence greater flexibility should have been provided. Instead of dispersing the meagre funds on too many subjects, there should have been more selectivity. Some blocks near the cities could have specialized in fruit and vegetable cultivation, poultry-keeping and animal husbandry, and others could have specialized in cottage industries, such as textiles and hosiery and so on. Moreover, too much was expected from the village-level worker. He was the jack of all trades, and considering that he had to attend to the needs of ten villages, agriculture, which is a vast subject, would consume all his energies.

On the whole, the programme was useful and was appreciated by the villagers. A new administrative machinery for improvement of rural life had been fabricated and it could be improved upon and adapted to new needs as they arose. The opposition to the programme was mainly from the urban elite, most of whom do not understand rural problems and nourish traditional hostility to rural progress.

CHAPTER 7

SETTING UP OF THE PLANNING COMMISSION

GROWTH OF POPULATION AND STAGNATION IN FOOD PRODUCTION IRRIGATION AND POWER PROJECTS IN THE FIRST AND SECOND FIVE-YEAR PLANS 1950–1960

To meet the challenge of the problems of economic development in a systematic and organized manner, the Planning Commission was set up in March 1950, with Prime Minister Jawaharlal Nehru as Chairman. He was assisted by Shri V. T. Krishnamachari—an administrator of exceptional ability and with wide experience of development work—who was appointed Deputy Chairman. Krishnamachari was the Dewan of Baroda for 17 years (1927-45) and had left his mark on all aspects of life in that state. The function of the Commission was to make an assessment of the country's resources—material, capital and human—and to formulate a Plan for their effective and balanced utilization. The Commission was also required to appraise the progress from time to time.

Apart from the Planning Commission, structural changes were made to utilize the irrigation potential of the country effectively. These included the setting up of the Ministry of Irrigation and Power in the Central Government, the institution of a Central Board of Irrigation and Power and the Central Water and Power Commission.

The Ministry of Irrigation and Power

In the Government of India, the Ministry of Irrigation and Power is responsible, with the help of the Central Water and Power Commission, for examining and advising the Planning Commission on all major and medium projects that are proposed by the State Governments, whereas all minor projects are processed through the Ministry of Food and Agriculture, and Community Development and Co-operation. In the Planning Commission also, the Irrigation and Power Division, under the Member (Natural Resources), deals with major and medium irrigation projects, and the Agriculture Division, under the Member (Agriculture), deals with minor irrigation schemes.

The Central Board of Irrigation and Power

The Central Board of Irrigation, since re-named Central Board of Irrigation and Power, is run as an independent organization with financial assistance from the Central and State Governments. It is a research co-ordinating body, and provides a national forum for technical discussion, leading to improvements in technique. It, thus, establishes contact between irrigation and power engineers working under the Central Government and in the States.

The Central Water and Power Commission

The Central Water and Power Commission (CW & PC), as now constituted, is a central fact-finding and co-ordinating organization for the development of water resources in India and consists of two wings—a Water Wing and a Power Wing. It advises the Government of India and the Planning Commission on all problems relating to the development of water resources, undertakes such work of investigation as may be entrusted to it by the Central and State Governments concerned and, in particular, comments on all projects proposed by the State Governments before they are included in the Five-Year Plans. The Commission also maintains a designs organization for undertaking detailed designs of such projects as the State Governments may refer to it.

The Functions of Central and State Governments

Under the Constitution of Independent India, promulgated in 1950, irrigation continues to be a State subject, but the Central Government is charged with the responsibility for the "regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by the Parliament by law to be expedient in the public interest". The only law, so far enacted under this constitutional provision, is the River Boards Act, 1956, which authorizes the Government of India, in consultation with interested States, to set up advisory River Boards on inter-State rivers. No such Board has, however, yet been formed. As a part of the planning process, established in 1951 in connection with the Five-Year Plans, the State governments do not undertake any new major or medium projects, unless it has first been cleared by the Planning Commission and the Government of India and has been included in a Five-Year Plan. All Central assistance with respect to loan is subject to this overall condition and it enables the Central Government indirectly to influence the pattern of development.[1]

Major, Medium and Minor Projects

The State Governments have to obtain clearance from the Planning Commission and the Government of India for all new major and medium projects and work can be undertaken only on those projects which form part of the National Plan and have been approved for implementation. Under the system, irrigation projects are divided into three categories:

[1]Gulhati, N.D. *Administration and Financing of Irrigation Projects in India*, C.B.I.P., 1965, pp. 20-21

Major projects, each costing over 50 million rupees
Medium projects, each costing between 1.5 and 50 million rupees
Minor schemes, each costing less than 1.5 million rupees

The construction of all irrigation and drainage projects and their maintenance and operation are the responsibility of the State Governments. All direct revenues accrue to the State Governments and all costs of development are borne by them. The Central Government gives financial assistance, in the form of loans, and such technical assistance through the CW&PC as the State Governments may request for.

The Growth of Population, Irrigated Area and Food Production

Some idea of the vital role of irrigation in Indian economy can be had from 'Fig. 17', which shows the growth of population and the state of un-irrigated and irrigated agriculture in India from the beginning of this century. It will be noticed that while the population of the country has been increasing at a high rate since 1921, the area under un-irrigated agriculture was more or less constant between 1923 and 1947. This situation explains the stagnation in agricultural production during this period.

Dr W. Burns, in his note on 'Technological Possibilities of Agricultural Development in India' (1944), reviewed the production of major crops from 1920 to 1943, keeping in view the rise in population. He observed that population was increasing more rapidly than the production of food crops. In fact, from 1935 to 1942, food production was going down (Fig. 18). It was this situation that alarmed the British and, along with the rise of the Freedom Movement, expedited their exit from India. There was little use of chemical fertilizers for food crops, as there was no price support. The only hope lay in irrigating more of the rainfed land.

Irrigation and Power Projects in the First and Second Five-Year Plans

At the time of Independence in 1947, India was facing a severe food shortage. On account of the economic slump of the 1930s, followed by World War II, the development of irrigation had been slowed down since 1930, but the population had increased by 70 million. With the partition of the country, a large part of the irrigated area of the country went to Pakistan. The development of new irrigation facilities, thus, became an urgent necessity. A large number of new projects had already been investigated as part of the post-war reconstruction plans. Some of these were immediately taken in hand. These projects were in Orissa, Bihar, West Bengal, the United Provinces of Agra and Oudh (U.P.), Karnataka (Mysore), Maharashtra and Gujarat (Bombay Presidency).

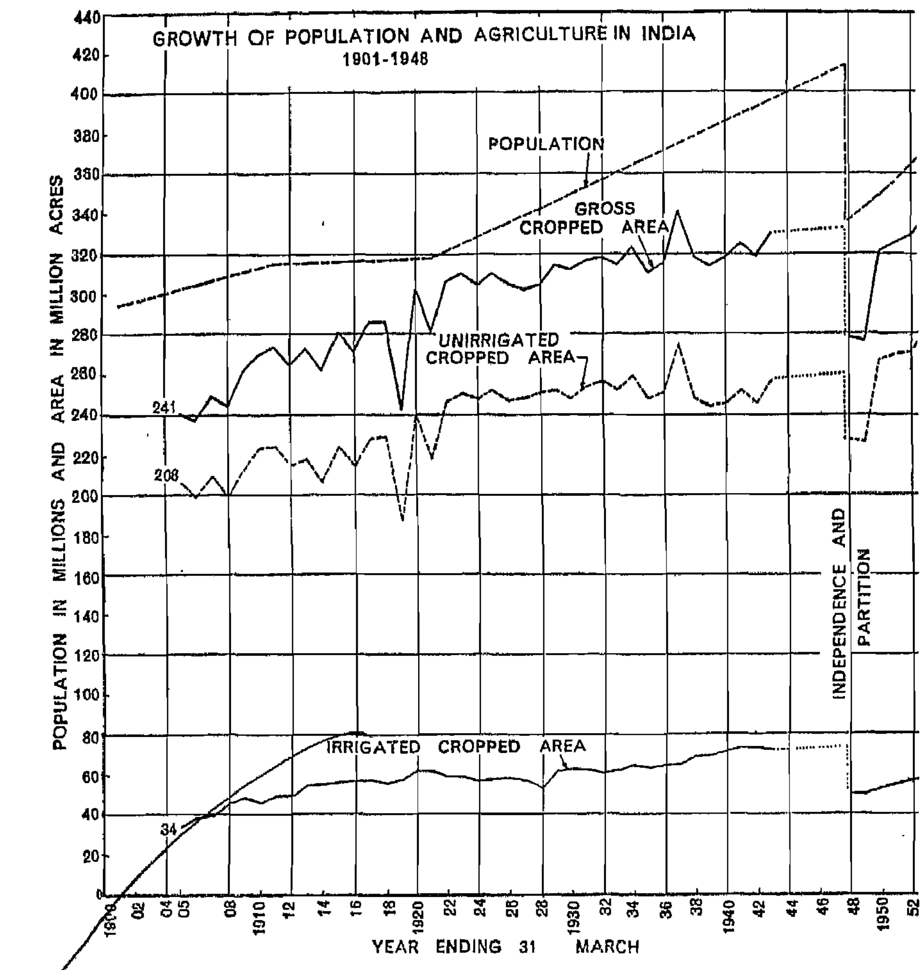


Fig. 17. Growth of population and the state of irrigated and unirrigated agriculture in India from 1900 to 1948. From 1920 to 1948, there was a sharp rise in population, but no corresponding increase in gross cropped area. (After N. D. Gulhati)

Irrigation Potential

The total estimated irrigation potential of India is about 187 million acres (75.7 million hectares). Before 1950, the total net irrigated area in India was neary 51.0 million acres (20.6 million hectares), or about 27 per cent of the total irrigation potential of the country.

The irrigation potential created during the two Plan periods was:

During the First Plan period (1951-56), 6.5 million acres (2.6 million hectares)

During the Second Plan period (1956-61), 5.2 million acres (2.1 million hectares)

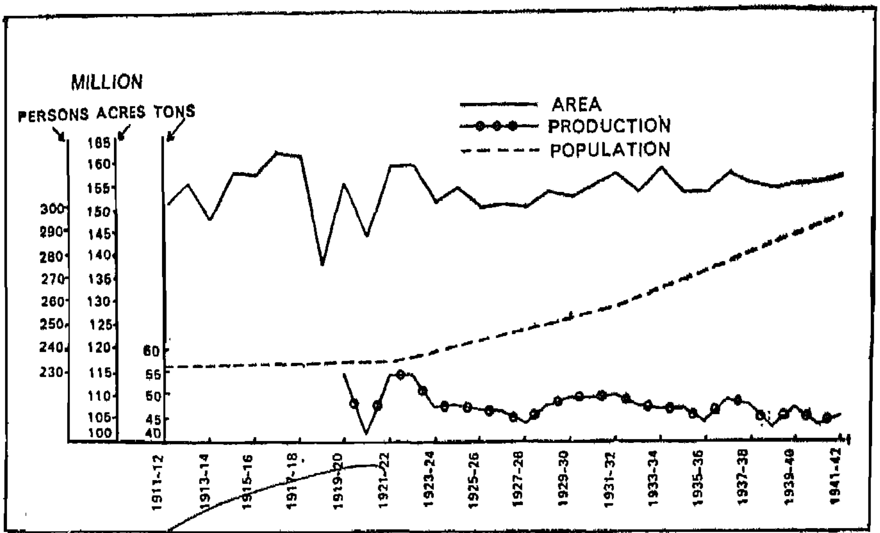


FIG. 18. The total area and production of major foodgrains (rice, wheat, barley, sorghum, pearl-millet, maize and chickpea in British India from 1911-12 to 1941-42. The production of foodgrains could not keep pace with the growth in population. (After Dr W. Burns)

MAYURAKSHI PROJECT, WEST BENGAL (1946-1956)

Near the border between Bihar and West Bengal, across the Mayurakshi River, the construction of a masonry dam at Massanjore, in Birbhum district, 155 ft (47,24 m) high, was started in 1946 and was completed in 1956 (Fig. 19). Twenty miles (32 km) down the dam, a 1,013-ft-long (309-m-long) barrage was completed at Tilpara. Two canals, each 75 miles (120.7 m) long, take off from the two sides of the barrage. The total length of the canal system is about 850 miles (1,368 km). The Mayurakshi Scheme irrigates annually over 700,000 acres (283,280 ha) in West Bengal and about 25,000 acres (10,117 ha) in Bihar.

HIRAKUD PROJECT, ORISSA (1948-1957)

The main dam is about 3 miles (4.8 km) long, with 11,980 ft (3,651 m) of rolled earth-fill and 3,768 ft (1,148.5 m) in two sections of masonry and concrete. Of the latter, 928-ft (282.85-m) length is the Power Dam Section, tied to the hill on the right flank. There are dykes on the right and left sides to close the gaps in the hills (Fig. 21) over a total length of about 13 miles (21 km). It is thus a 16-mile (25.7-km) bund across the River Mahanadi, draining at the site 32,200 square miles (82,880 km^2) of wooded and hilly country, with the flood discharge exceeding a million cusecs while at its maximum. The gross storage capacity of the reservoir is 6.60 million acre-feet (8,141 million m^3). Over 91 miles (146.5 km) of the main canal and its branches, and 460 miles (740 km) of the distributaries and minors were laid to irrigate 672,000 acres (271,949 ha) in Sambalpur, in Orissa. The construction of the dam was started in 1948 and completed in 1957, and the canal system was completed in 1959.

DAMODAR VALLEY PROJECT, BIHAR (1950-1958)

On the Damodar River and its tributaries, four dams have been constructed at Talaiya, Konar, Maithon and Panchet. These dams are meant primarily for flood control, but they provide benefits of power generation and irrigation as well. Through the construction of a barrage at Durgapur, some 1,026,000 acres (415,207 ha) was irrigated. The Talaiya Dam is 99 ft (30.18 m) above the riverbed, and is of straight gravity-type (Fig. 22). It was completed in concrete and has a storage capacity of 320,000 acre-feet (394,714,000 m^3). It has three generating units of 2,000 kW each. Its construction was started in January 1950 and was completed in December 1952.

The Konar Dam was completed across the Konar River in 1954. It is 160 ft (48.76 m) high, and has a storage capacity of 273,000 acre-feet (336,740,000 m^3). It is capable of generating 40,000 kW of electricity.

The Maithon Dam was built across the Barakar tributary of the Damodar. Unlike the concrete dams at Talaiya and Konar, the Maithon Dam is of the rolled-earth type, with a concrete spillway. Its height ranges from 164 to 182 ft (50 to 55.47 m). The storage capacity of the reservoir is 1.2 million acre-feet (1,480.18 million m^3). Though designed primarily for flood control, it also possesses a power generation capacity of 60,000 kW. Its construction was started in 1951 and was completed in 1957.

The fourth dam of the Damodar Valley Project was started in 1952 in the Dhanbad District of Bihar, across the Damodar River, and was completed in 1958 (Fig. 20). With a height of 135-157 ft (41-47.8 m), its reservoir has a storage capacity of 1,365,000 acre-feet (1,683.7 million m^3). The installed power generation capacity is 40,000 kW.

THE RIHAND PROJECT, UTTAR PRADESH (1952-1962)

The construction of a gravity-type dam was started in 1952 near the village of Pipri in the Mirzapur District of U.P. (Fig. 25). The dam is 271 ft (82.6 m) high and has a reservoir with a storage capacity of 8.6 million acre-feet (39,095.3 million m^3) and a waterspread of 180 square miles (466 km^2). Completed in 1962, it has five generating units of 50,000 kW each and provides electric power for the eastern parts of U.P. The water stored at the reservoir also makes available increased steady supplies on the Sone for extending irrigation on the existing Sone Canal System of Bihar.

TUNGABHADRA PROJECT, KARNATAKA (1945-1954)

In the Bellary District, at Hospet across the Tungabhadra River, the construction of a dam was started in 1945. It is a straight gravity-type masonry dam, 165 ft (50.29 m) high at the deepest portion and 5,942 ft (1,811 m) long, with a spillway in the centre, measuring 2,300 ft (701 m). Two saddles on the left bank are closed by an earthen dam, 450 ft (137 m) long, and a composite dam, 1,550 ft (472.4 m) long. The spillway and the sluice sections are built with granite stones in red cement mortar. The dam is composed of sections, each section being individually stable as a gravity section and free to expand or contract; copper span strips are provided to ensure watertightness at the construction joints. The rest of the dam is in lime-*surkhi* mortar.

The reservoir created by the dam has a waterspread of 145 square miles (375.5 km) and a storage capacty of 132,559 million cubic feet (3,753.6 million m^3). Two canals take off from the banks; one is 127 miles (204.4 km) long and the other, 225 miles (362.1 km). The dam went into operation in 1954. The canals irrigate 830,000 acres (335,889 ha).

KOYNA PROJECT, BOMBAY (1954-1961)

Across the Koyna, a tributary of the Krishna, at Deshmukwadi in the North Satara District of Maharashtra, the construction of a 200-ft-high (61-m-high) dam was started in 1954. The reservoir has a storage capacity of 36,045 mllion cubic feet (1,020.68 million m^3), with a water-spread of 21 square miles (54.39 km^2). Completed in 1961, it has a power-generation capacity of 240,000 kW.

PRAVARA RIVER WORKS

The 270-ft-high (82.3-m-high) masonry dam, construtced at Bhandardara in the Western Ghats, can impound 13,000 cubic feet (368 m^3) of water. This storage work protects the Ahmednagar District and irrigates nearly 60,000 acres (24,281 ha). The Nira Right-Bank Canal consists of the Lloyd Dam, constructed at Bhatgarh on a tributary of the Nira. In the Whiting Lake, 24,000 million cubic ft (679.6 m^3) of water is impounded.

KAKRAPARA PROJECT, GUJARAT (1949-1955)

At Kakrapara, some 50 miles (80.46 km) east of Surat, a weir has been constructed across the Tapti River (Fig. 27). The height of the weir is about 45 ft (13.716 m). The construction of the weir was started in 1949 and was completed in 1955. Two canals take off from the banks. The right-bank canal system has a total length of 340 miles (547.18 km), and the left-bank canal system of over 500 miles (804.67 km). The construction of the canal systems was completed in 1959. The Project irrigates 651,000 acres (263,450 ha).

IRRIGATION FROM 1948 TO 1963

The total area under irrigation has increased since Independence from 18.7 million hectares (46.7 millin acres) in 1947-48 to 25.6 million hectares (63.4 million acres) in 1962-63; an increase of about 36 per cent in 15 years. By sources, the distribution of this irrigated area was as follows:[2]

	Million hectares	*Million acres*
Government canals	9.69	23.95
Private canals	1.17	2.90
Tanks	4.73	11.70
Wells	7.66	18.95
Other sources	2.39	5.90
Total	25.64	63.40

EXPENDITURE ON IRRIGATION

The total capital outlay on State-owned irrigation projects in the whole of India during the one-and-a-half centuries from 1800 to 1950 was little under 1,000 million rupees, whereas the corresponding expenditure during the short period of ten years of the first two Five-Year Plans, from April 1951 to March 1961, was about 7,000 million rupees. During the five years of the Third Plan, another 6,000 million rupees was provided for irrigation projects, excluding flood control and drainage works. Thus, the expenditure on irrigation in one single year now is more than what was spent in a century in the past.[3]

[2]Gulhati, N.D. *Administration and Financing of Irrigation Works in India* (1965), pp. 4-5
[3]*Irrigation Development in India*, p. 101

APPENDIX I. SALIENT FEATURES OF MAJOR IRRIGATION PROJECTS COSTING 100 MILLION RUPEES AND ABOVE DURING 1951–1961

Project	*Source of water*	*Storage/non-storage*	*Capital cost (million rupees)*	*Year of completion*	*Gross area to be irrigated*		*Cost per area irrigated (Rs)*
					acres	*ha*	
ANDHRA PRADESH							
1 The Tungabhadra Project	The Tungabhadra River	Storage	335.600	1956 (dam)	672,345	27,089	504/ha; 204/acre
BIHAR							
2 Maithon	The Brakar River	Storage	133.900	1957	270,000 (under irrigation barrage)	109,265	—
3 Konar	The Konar River	Storage	99.400 (Irrig. only)	1955	104,000 (under irrigation barrage)	42,087	—
4 The Panchet Hill	The Damodar River	Storage	148.600	1959	680,000 (under irrigation barrage)	275,186	—
5 The Durgapur Barrage	The Damodar River	Non-storage	1,313.00	1955	134,400	55,390	—
GUJARAT							
6 The Kakrapara Project	The Tapti River	Non-storage	116.507	1957	651,662	263,718	442/ha; 179/acre
MADHYA PRADESH							
7 The Gandhi Sagar	The Chambal River	Storage	—	1960	—		—
MADRAS							
8 The Lower Bhawani Project	The Bhavani River	Storage	120.000	1955	207,000	83,770	1,218/ha; 493/acre
MYSORE							
9 The Ghataprabha Left Bank (Stage I)	The Ghataprabha	Non-storage	54.500	1956	1,000,000	40,469	1,346/ha; 545/acre

APPENDIX I (*Continued*)

Project	Source of water	Storage/non-storage	Capital cost (million rupeee)	Year of completion	Gross area to be irrigated acres	ha	Cost per area irrigated (Rs)
ORISSA							
10 The Hirakud Dam Project	The Mahanadi River	Storage	122.164 (irrigation)	1956	600,000	242,811	504/ha; 204/acre
PUNJAB							
11 Harike	The Sutlej River	Non-storage	872.91	1952-53	—	—	—
12 Bhakra-Nangal	The Sutlej River	Storage	988.302 (irrigation)	—	3,604,000	1,458,489	680/ha; 275/acre
WEST BENGAL							
13 The Mayurakshi (dam at Masanjore and barrage at Tilpara)	The Mayurakshi River	Storage	204.609	1955-56	560,000 (*kharif*); 50,000 (*rabt*)	22,6624 (*kharif*) 20,234 (*rabi*)	—

SOURCE: *Irrigation Development in India*

CHAPTER 8

THE BHAKRA-NANGAL PROJECT
1948–1963

In November 1908, Sir Louis Dane, Lieutenant-Governor of the Punjab, travelled by boat down the Sutlej from Simla to Nangal. He noticed the narrow gorge through which the Sutlej emerges from the Nainadevi Range of the Siwaliks, and felt that it was an ideal site for a dam. In his note, dated 8 November 1908, he proposed the construction of a reservoir at that site.

The project was first planned in 1911 and later revised in 1919. The 1919 project envisaged a 395-ft-high (120-m-high) dam at the reservoir level of 1,500 ft (457 m). In 1927, an Expert Committee to advise on the suitability of the site for the construction of a high dam was appointed by the Punjab Government. The Committee considered the site to be suitable for the construction of a gravity arch dam at a reservoir elevation of 1,600 ft (488 m).

A severe famine occurred in the south-west Punjab in the districts of Hissar, Rohtak and Gurgaon in 1937-38. The idea of constructing a dam at Bhakra was revived by Chowdhry Chhotu Ram, Revenue Minister, who represented Rohtak Constituency in the Punjab Legislative Assembly. In 1939, Ajudhia Nath Khosla and Kanwar Sen, two senior engineers, were sent by the Minister to the USA for studying a design for the Bhakra Dam with J. L. Savage, Chief Design Engineer of the US Bureau of Reclamation, Denver. Later Savage paid a visit to the Punjab in 1944 and after examining the site reported that a straight gravity dam, with a maximum reservoir level at EL 1,600, could be built, provided adequate measures were taken to confine and retain the major clay strata where such strata were covered by the dam. He prepared a programme for exploring the foundation, which was carried out in 1945 and 1946. After his visit, the work for the exploration of the foundations was taken up in the right earnest and continued for several years.

The Bhakra reservoir partly lay in the territory of the Raja of Bilaspur. He opposed a water level higher than 1,580 ft (451 m) on the grounds that the Town of Bilaspur, including his palace and the historic temples, would be submerged. On 15 August 1947, India became free, and the princely States in the hill areas were merged together to form a Union Territory. This step broke the resistance of the Raja, and he withdrew his objection to the keeping of a higher water-level in the reservoir. Eventually, a dam with the maximum water-level of 1,680 ft (512 m) was decided upon.

At that time, the country was also faced with the problem of resettling the refugees who had migrated to India from West Pakistan. It was felt that only an ambitious multipurpose project like the Bhakra Dam could help to mitigate the suffering among the refugees and to solve a rehabilitation problem of gigantic dimensions. This problem gave added importance to the Bhakra Scheme, which received the sympathetic support of Prime Minister Jawaharlal Nehru.

In December 1948, Khosla chaired a meeting of the chief engineers of the States interested in the Bhakra Project. At the meeting, an agreement was reached on the 'areas to be irrigated and the allocation of water supplies' to each State, and on various other matters connected with the execution of the Project as enlarged after Independence. This agreement was the basis of the accord on the matter later reached at the Government level. In 1948, the question of the height of the dam was reconsidered. Savage again inspected the site in February 1949 and, after considering the condition of the foundation rock and the irrigation and power requirements, advised a straight gravity dam for a reservoir level at 1,680 ft (512 m). This advice was accepted and the revised designs and specifications for the higher dam were prepared by the International Engineering Co., Denver.

Apart from irrigation, it was decided to generate power. The scope of irrigation was also increased and more areas were included for irrigation, and the proposed water allowances and intensities were also increased. It was decided to increase the water allowance on the Sirhind Canal.

Creating the Infrastructure

The period 1947 to 1952 was spent in creating the infrastructure for the construction of the dam. An all-weather metalled road and a broad-guage railway line were constructed from Ropar to Nangal and from Nangal to Bhakra in a hilly terrain. The excavation of the diversion tunnels was started. A modern colony to house about 10,000 engineers and workmen was set up at Nangal, along with guest-houses, schools, hospitals, laboratories and offices. Thermal powerhouses were installed for providing electricity for preliminary construction. Priority was given to the construction of the Nangal Dam, the Nangal Canal, the powerhouses at Ganguwal and Kotla and the Bhakra canals with a view to providing *kharif* irrigation and generating electricity from the Nangal Canal.

Mechanisation having been extended to all the major operations of construction of the dam, three modern workshops at the Nangal Township, at the site of the Bhakra Dam and at Neilla, were set up to provide adequate and readily available facilities for repairing, fabricating and manufacturing various types of mechanical assistance required at the site of the dam. The workshop at the Nangal Township was the main nucleus for meeting the demands of the construction programmes.

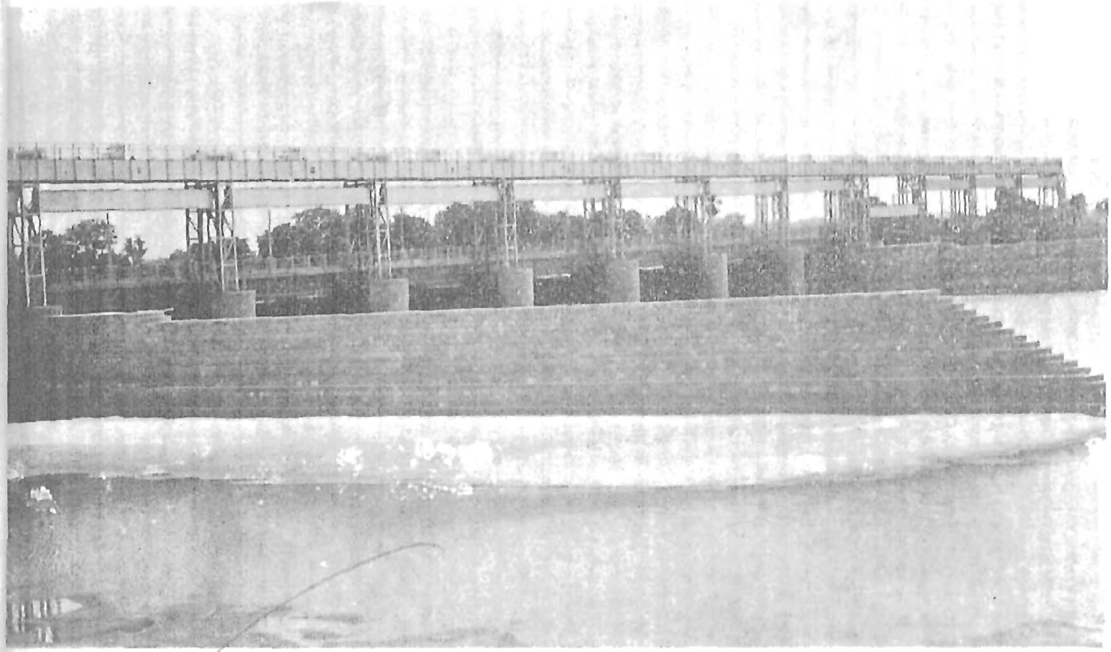


FIG. 19. The Massanjore Dam at Massanjore, Birbhum District, West Bengal, constructed on the Mayurakshi River in 1955 for irrigation, hydro-power and flood control. (PIB)

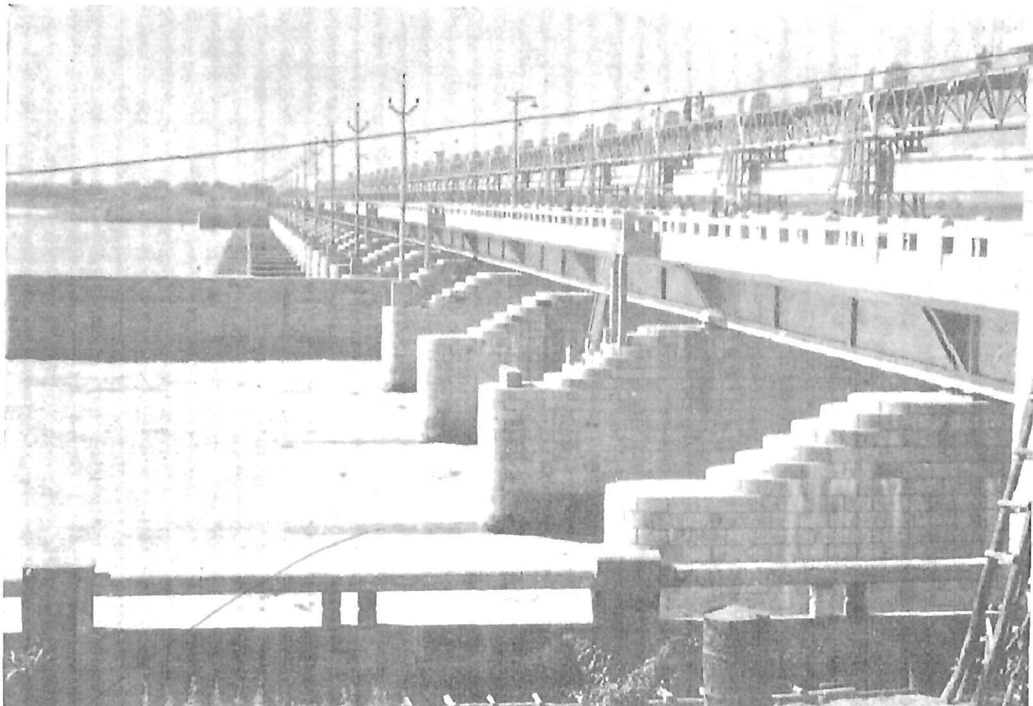


FIG. 20. The Durgapur Barrage (1952-1958) across the River Damodar in Bihar. It irrigates 54,390 hectares. (PIB)

FIG. 21. The Hirakud Dam on the Mahanadi River in the Sambalpur District, Orissa. Constructed in 1948-1957, its purpose is to provide irrigation, hydro-power and flood control. (PIB)

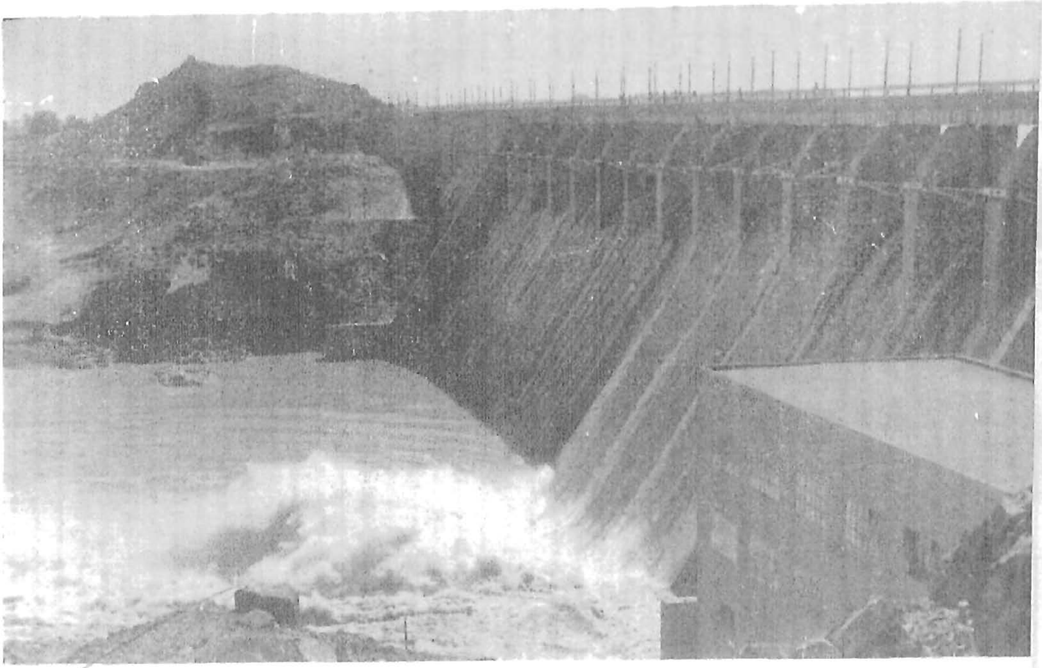
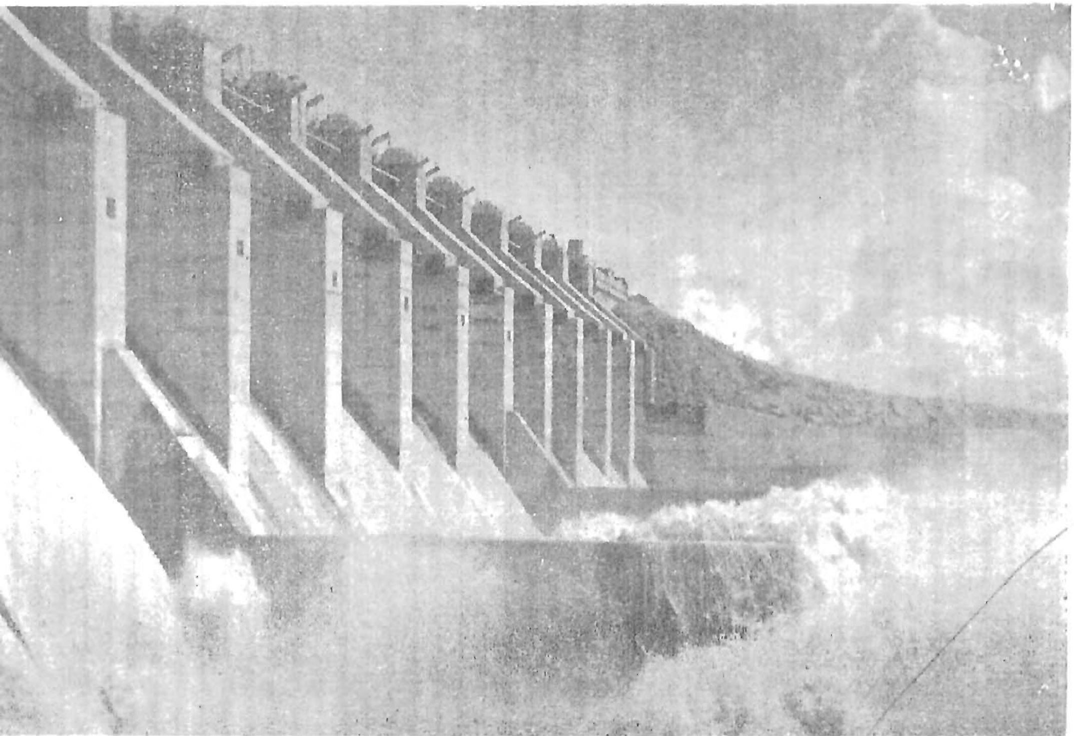


FIG. 22. The Talaya Dam on the Damodar River in Bihar, constructed during 1950-1952 for hydro-power. (PIB)

FIG. 23. The Panchet Hill Dam on the Damodar River in the Dhanbad District, Bihar, was constructed during 1952-1959 for irrigation, flood control, industrial and public water-supply. It irrigates 275,186 hectares. (PIB)



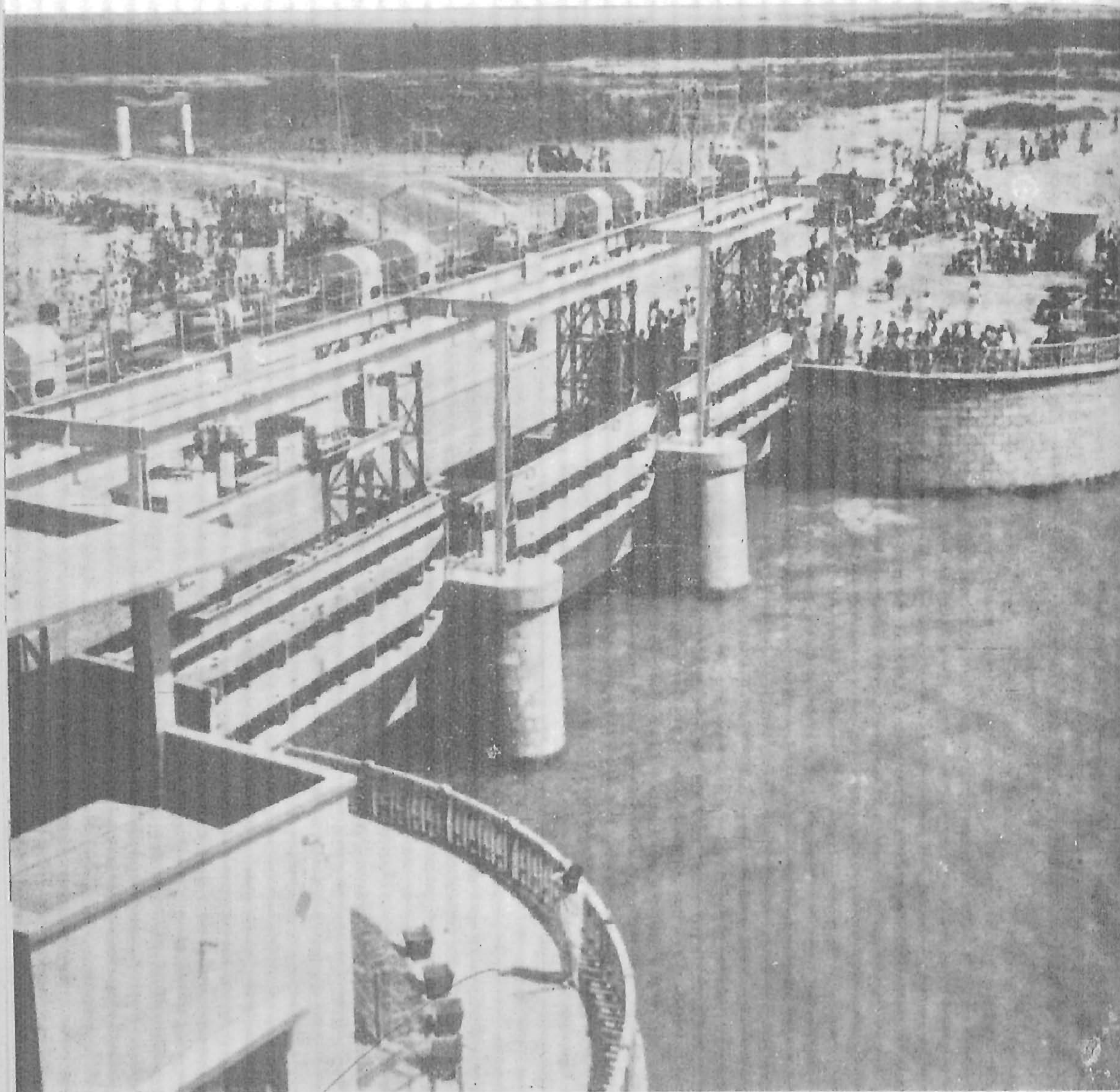


FIG. 24. The Kosi Barrage on the River Kosi in Bihar; the gross irrigated area is 577,082 hectares. (PIB)

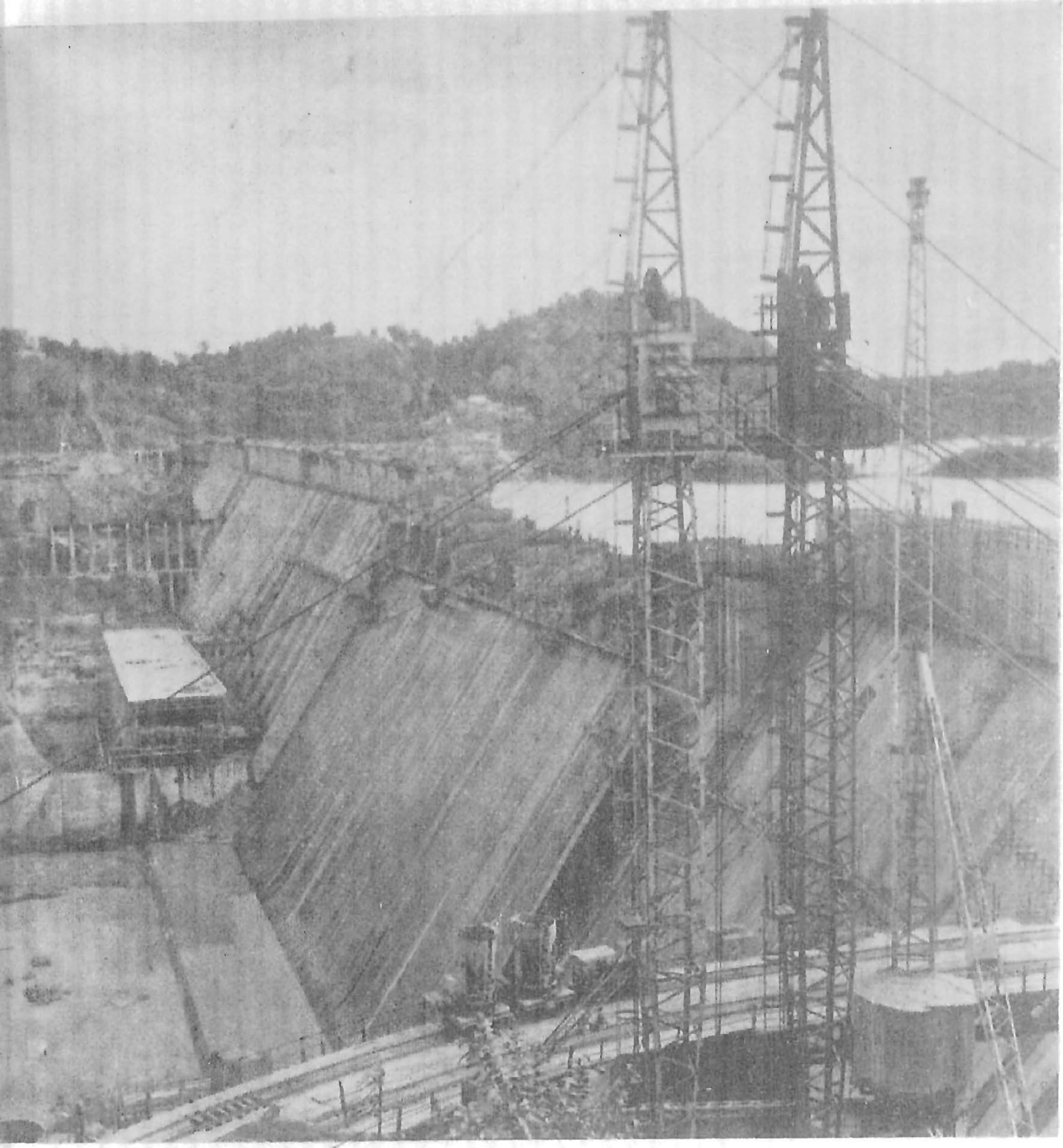


FIG. 25. The Rihand Dam at Pipri, Mirzapur District, Uttar Pradesh, on the Rihand River. It was constructed during 1952-1962 for the generation of hydro-power. (PIB)

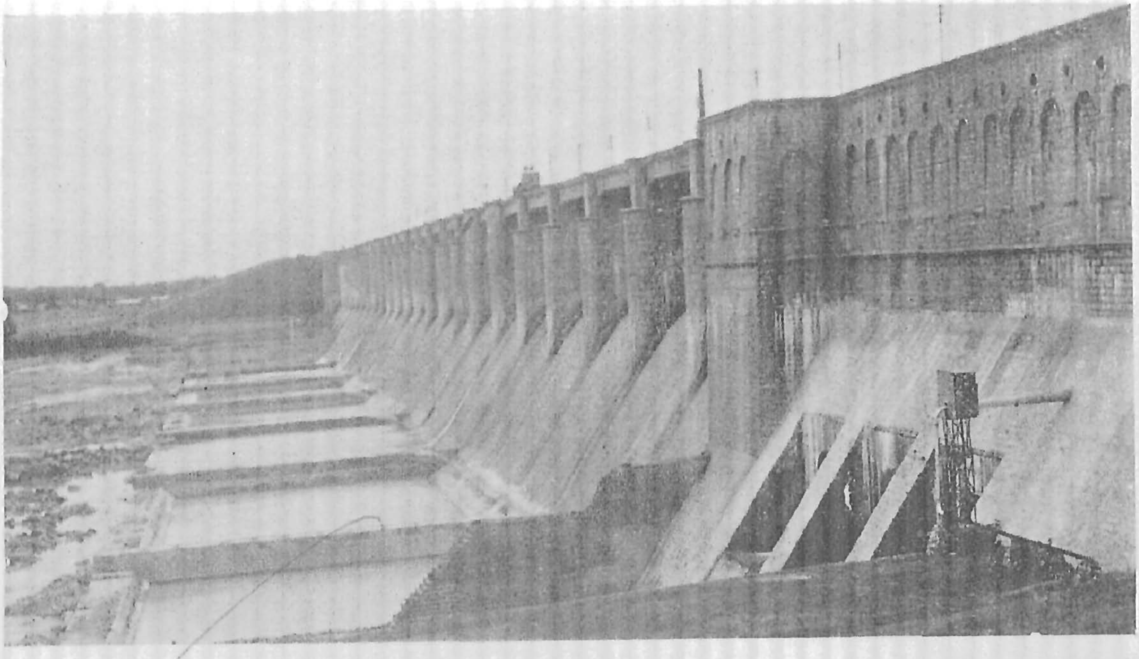


FIG. 26. The Matatila Dam, near Jhansi, Uttar Pradesh on the River Betwa. It provides irrigation and hydro-power, and was built during 1952-1958. (PIB)

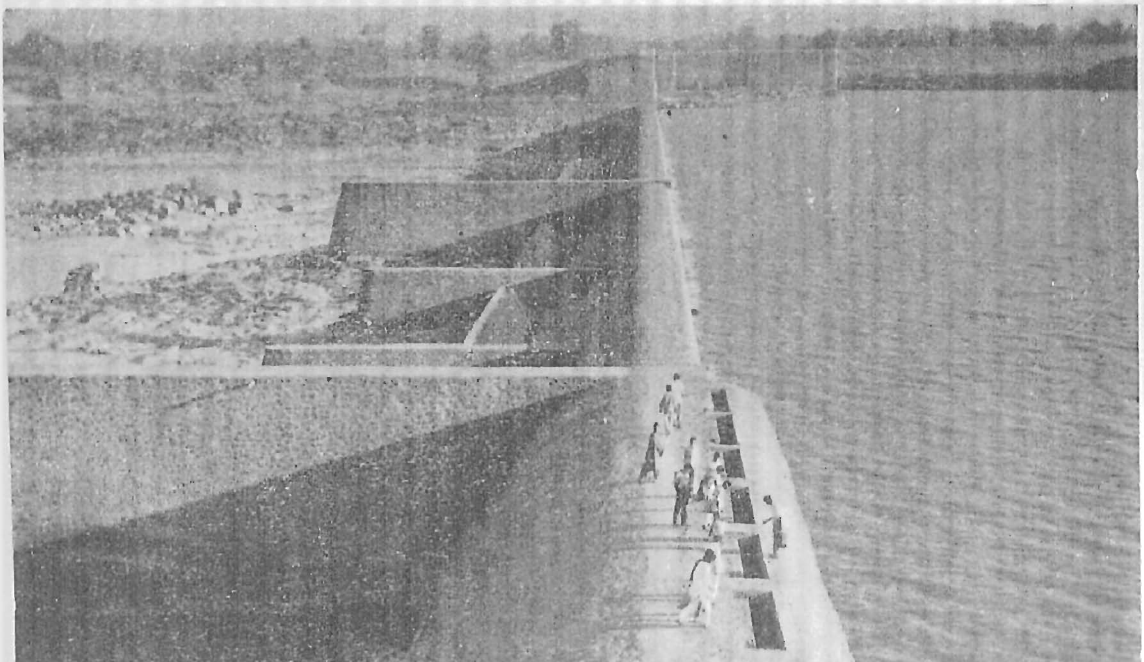


FIG. 27. The Kakrapara Barrage (1949-55) on the River Tapi in Gujarat, 80.5 km east of Surat. It is a non-storage barrage, 13.7 metres high and 521 metres long. It irrigates 270,576 hectares. (PIB)

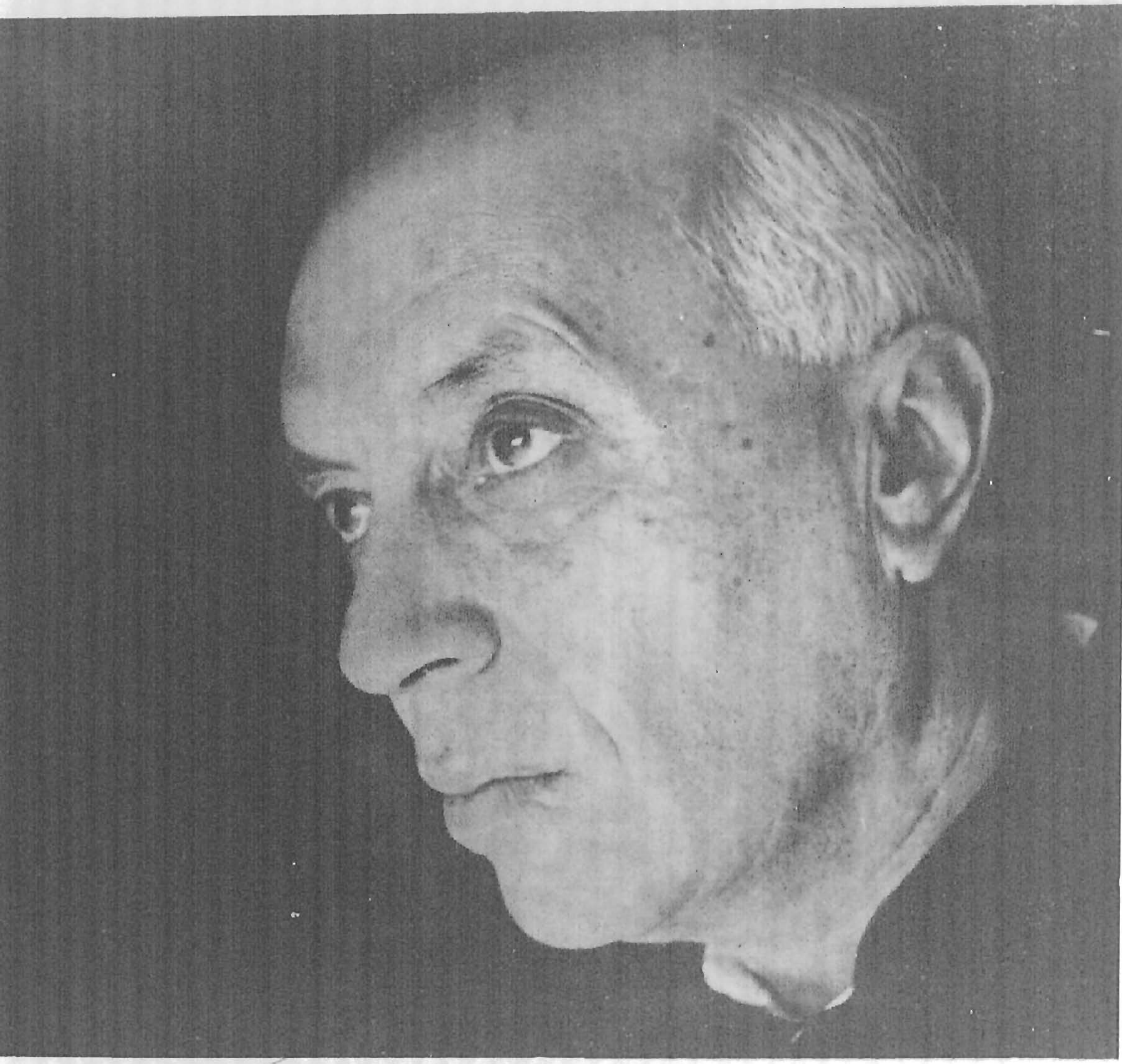


FIG. 28. Jawaharlal Nehru, Prime Minister of India (1947-1964), a great patron of science and technology; multi-purpose power-cum-irrigation schemes received his patronage. A large number of research institutes and laboratories were built all over the country while he was the Prime Minister.

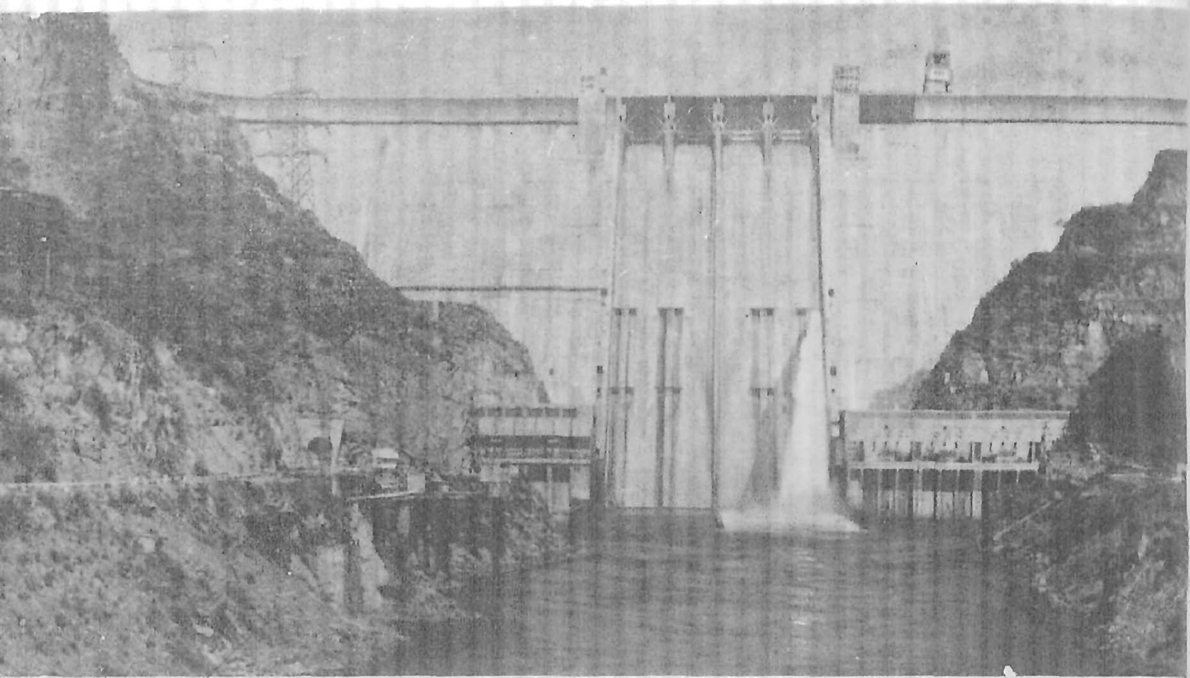


FIG. 29. The Bhakra Dam on the Satluj River, near the Village of Bhakra, Bilaspur District, Himachal Pradesh. Constructed during 1948-1963 for irrigation and power generation, it is 225.5 m high, and is the second highest dam in the world. (PIB)

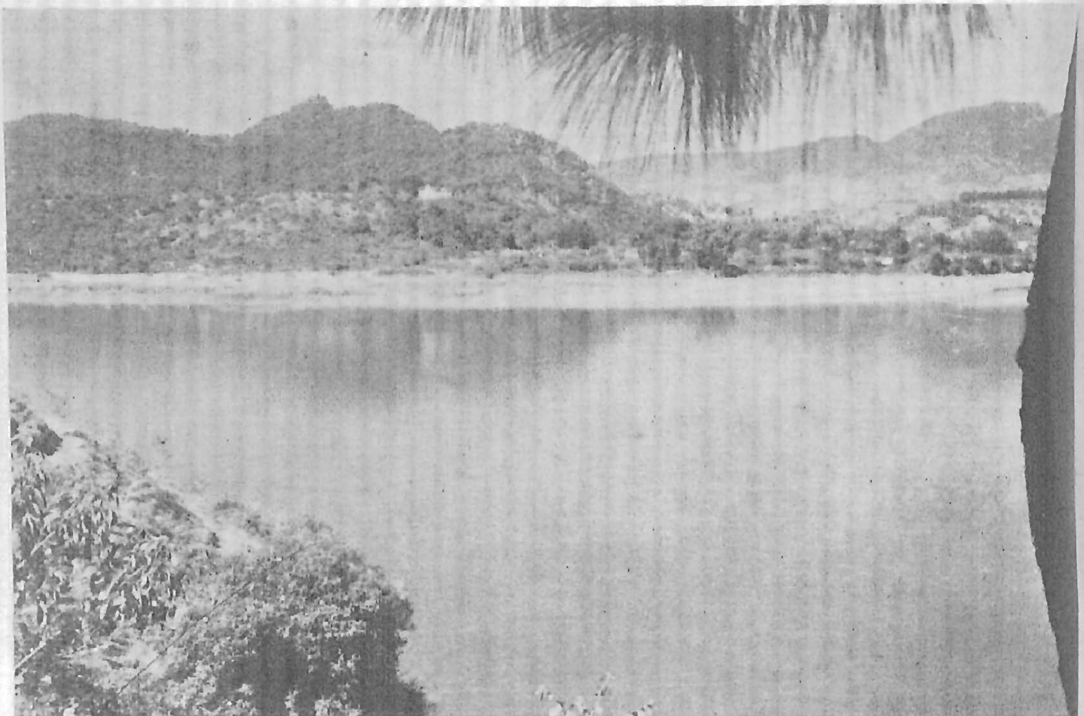


FIG. 30. The Bhakra Lake, known as Gobindsagar—upstream of the dam. (PIB)

Bhakra Dam Construction, 1952

Dr Khosla insisted that the construction of the Bhakra Dam should not be entrusted to any firm of contractors, foreign or Indian, that the entire work should be done by the Punjab State departmentally. On his advice, an American expert in constructing dams, Mr M. H. Slocum, was appointed an employee of the Project to assist the departmental construction of the Dam. Mr M. R. Chopra, later General Manager, Bhakra Dam, and Mr N. D. Gulhati were associated. This helped to train a large number of Punjab engineers and workmen in the techniques and intricacies of dam-building, and enabled them to take up another large project, viz. the Beas Project, costing about Rs 20 million without foreign technical help.

The geology of the site of the Dam presented a complex problem, owing to variations in the dip and trend of the rock strata from the lower to higher elevations, with claystone layers intervening the sandstone strata and the existence of occasional shear and thrust zones in the otherwise sound rock. The Dam is, however, located so as to rest upon a massive sandstone. A claystone stratum, approximately 30 ft (9.1 m) thick, passes in the middle of the foundation of the Dam. There are wide claystone bands, also both upstream and downstream of the Dam site. They severely limited the choice of the site. The claystone strata under the Dam and upstream of the Dam had to be excavated and back-filled with concrete. Grouting (both curtain and blanket) of the foundation and the sides of the Dam was carried out, according to an elaborate programme.

Model Tests

Extensive model tests for the various components of the Dam were carried out at the Punjab Government's Irrigation and Power Research Institute, Amritsar, and at the Field Research Stations at Malikpur under the guidance of Dr H. L. Uppal. Model tests were carried out in well-equipped modern laboratories to forecast the behaviour of the prototype in actual operation and to tackle problems which defy mathematical analysis.[1] These model experiments and research investigations saved considerable sums of money and ensured efficient and trouble-free working of several vital parts and features of the Bhakra project.

Principal Features of the Dam

The Dam is 1,700 ft (518.2 m) long at the top. The maximum height of the dam above the deepest foundation is 740 ft (225.5 m) and it is the second highest dam in the world (Fig. 29). Its designed storage capacity is 8 million acre-feet (9,867.9 million m^3) and the water-spread of the lake behind the dam is 65 square miles (168.3 km^2). The lake (Fig. 30) has been

[1]Uppal, H.L. Research for Bhakra, *Bhāgirath, XI*, Jan. 1964

given the name of Gobindsagar, after the great Sikh Guru, Sri Guru Gobind Singh, who lived in these parts for a number of years. Two hydroelectric power houses, one on the right side and the other on the left, will house 1,050,000 kW generating units. It is a straight concrete gravity dam, with a radial gate-controlled spillway and has two tiers of river outlets through the Dam, capable of passing a discharge of 106,000 cusecs (3,002 cumecs). The combined capacity of the spillway and the river outlets is 290,000 cusecs (8,212 cumecs) which can cater for a peak inflow of 400,000 cusecs (11,328 cumecs) after taking advantage of the available storage between the maximum reservoir elevation of 1,690 ft (515 m) and the normal reservoir level of 1,680 ft (512 m) for the absorption of the peak. The crest of the spillway has been designed on the principal of the path of a free-falling trajectory, with the crest surface cutting into the theoretical under-nappe to ensure a positive pressure along the crest.

The spillway carries four radial gates, 50 ft $\times 47\frac{1}{2}$ ft (15.2 m $\times$ 14.5 m), worked by a gantry crane, which runs along a reinforced concrete arch bridge over the spillway crest. The spillway discharges into a horizontal spillway apron, designed to dissipate energy by means of a hydraulic pump. The presence of a wide claystone stratum, downstream of the Dam, prevents the adoption of a bucket-type section. The spillway apron had to be designed so as to cover the entire width of the claystone stratum. The total length of the spillway is 260 ft (79.2 m), with an effective crest width of 200 ft (60.9 m) and the crest elevation of the spillway section is 1,645 ft (501.4 m), 35 ft (10.7 m) below the full normal reservoir level. The maximum discharge intensity per foot length (0.3048 m length) of the spillway is 1,160 cusecs (32.8 cumecs) against 900 cusecs (25.5 cumecs) and 894 cusecs (25.3 cumecs), respectively, of the Shasta and Grand Coulee Dams in the USA. A divide wall at the centre of the spillway facilitates inspection or repairs of half of the spillway when necessary, with the other half is discharging water over the crest.

The river outlets are designed to release water for irrigation, when the discharge through the power plant is less than the irrigation requirements and also during floods. Ten 15-ft- (4.6-m)-diameter penstocks, taking off at an elevation of 1,405 ft (428 m) and sixteen 8 ft $\times$ 8 ft (2.4 m $\times$ 2.4 m) horseshoe-shaped river outlets, fitted with jet-flow gates of the fixed wheel type, are provided in the spillway section of the Dam. The river outlets are arranged in two tiers of 8 outlets at elevations of 1,320 and 1,420 ft (402 and 432 m). The river outlets will also be used for passing density currents, containing colloidal material through the dam to the irrigated lands, where such material will be beneficial in fertilizing the soil and in maintaining its fertility.

Trash-rack structures on the upstream face of the Dam protect all the outlets through the Dam. Special bulk-head gates, with fixed wheels, are, provided for closing any two of the conduits at the intake, whenever it is desired to carry out any repairs or inspection.

In the abutment section, the downstream face of the Dam has a slope of 0.8 to 1 from the base up to the elevation level, 1,653.889 ft (504.1051 m) after which it is curved up to the top. The Dam is 30 ft (9.1 m) at the top. The upstream faces are vertical from the top up to an elevation of 1,350 ft (411.5m), after which it has a slope of 0.35 to 1.

Two towers, one on each side of the spillway, surmount the crest of the Dam. The one on the left provides access to the main elevator and the other to the hoist shaft and service elevator, all interconnected with the various galleries within the body of the Dam. These galleries have a total length of about 3 miles (4.8 km) and are provided for foundation-grouting and drainage, for the inspection of the interior of the dam and for housing the operational equipment.

DIVERSION TUNNELS

For excavating foundations and constructing the lower portions of the Dam, the river waters were diverted through two 52-ft (15.2-m)-diameter concrete-lined tunnels, one on the right and the other on the left of the Dam, each approximately ½ mile (0.8 km) long. Work on the tunnels was taken in hand in 1948 and was completed in 1953 at a cost of about Rs 36 million. The magnitude of the work involved may be gauged from the fact that 15,600,000 cu. ft (441,792 m^2) of rock had to be excavated and 578,000 cu. ft (163,528 m^3) of cement concrete was required for lining the tunnels. The construction of the tunnels was a major engineering achievement, considering the poor quality of the rock encountered during the tunnelling operations which rendered the work extremely hazardous. The tunnels were lined with 3- to 6-ft (0.9- to 1.8-m)-thick cement concrete to support the rock load and to provide a smooth surface for the high velocity of water of about 50 ft (15.2 m) per second. The process of concreting was mechanized, as far as possible.

The flow through the right diversion tunnel was controlled by two hydraulically operated temporary regulating gates and two emergency gates. These gates, weighing about 74 tons (75.2 tonnes) each, were operated from a hoist chamber located in the right abutment of the Dam.

The excavation work of the foundations of the Dam was by no means an easy job. The excavation had to be carried, at places, to a maximum depth of 210 ft (63.9 m) below the low water-level in the river. The excavation work was mechanized, as far as possible, within the restricted area of the gorge, and at peak about 270,000 cu. ft (7,645 m^3) of rock were excavated daily and transported to dump sites, a mile and a half (2.4 km) away.

Excavation for the abutments of the Dam presented some tough problems on account of the sides of the gorge being very steep, where heavy earth-moving machinery could not be employed at all places. A considerable part of excavation had, therefore, to be done through manual labour by men slung from dizzy precipices, sometimes 500 ft (152.4 m) above the ground and the river beneath. A large quantity of loose rock from the steep faces of the gorge was removed by means of 'hydraulicking', i.e. by high-velocity water jets impinging on the material to be removed.

The concreting of the dam was thoroughly mechanized. The concreting plant consisted of a 4-mile (6.4-km)-long belt-conveyor system, an aggregate-processing plant, an aggregate-cooling plant, a cement-handling plant, a batching-and-mixing plant, steel trestles, revolver cranes, cantilever cranes, diesel and electric concrete-transportation cars. The aggregate-cooling plant was the largest cooling plant in India, with a capacity for producing 1,500 tons (1,524 tonnes) of ice per day. The cooled aggregates were transported with belt-conveyors, enclosed in glass-wool chambers to avoid the chilled aggregates from regaining heat. The aggregates were chilled to 38°F (3.3°C) in order to produce concrete with a temperature of 65°F (18.3°C) throughout the year to minimize the shrinkage cracks in the concrete owing to the temperature differential.

The batching-and-mixing plant was a 118-ft (36-m-high wholly enclosed structure, housing four concrete-mixers, each having a capacity of about 4-cubic yards (3.1 m^3). All the operations of weighing, mixing and discharging concrete into buckets were fully mechanized and push-button-controlled.

For the placement of concrete, a two-stage system of trestle bridges, with two double-cantilever cranes, and three revolver cranes operating on them, was adopted. The plant capacity was 10 tons (10.16 tonnes) of concrete per minute, with a maximum capacity of 216,000 cu. ft (6,117 m^3) of concrete per day. Over 5,000 tons (5,080 tonnes) of structural steel was fabricated in the project workshops for the erection of this construction plant[2].

Contribution of Mr M. H. Slocum, 1952

The work of construction-planning for the Dam, lay-out and design of a most modern and complex plant for the concreting of the Dam, excavation for the foundation of the Dam, the diversion of the river and the construction of coffer-dams and other specialized jobs, involving the purchasing and installing of equipment were started in 1952 with the arrival of Mr M.H. Slocum on the scene. Slocum had no formal education. He could just read and write, and had risen from a semi-skilled steel-worker to the post of construction superintendent on large dams, viz. Grand Coulee and Friant in the USA, because of his outstanding ability. He brought with him a competent American engineer who had specialized in construction-planning. He also recruited a number of foremen from the USA who were

[2]*Development of Irrigation in India*, pp. 122-125

experts in various trades.

Mr S. D. Khungar, Chief Engineer of the Project, states: 'The mode of working at Bhakra was changed. Formerly, officers of Executive Engineer rank went to work for a short time and spent most of their time in offices attending to accounts and personnel matters. Office work was taken away from them and centralized under a newly opened administration office which looked after accounts and personnel matters. All engineers working on the construction were required to work in eight-hour shifts. American specialists, who were recruited for a short period, were attached to them. It must be said to the credit of Indian engineers that they picked up the work very quickly and replaced the American specialists competently.

Khungar continues, 'The role of replacing the American Engineer who assisted Slocum in construction-planning fell on my shoulders when I took over as head of the plant design office in May 1955. This was the most difficult job that I faced in my life. Slocum was a very difficult man to work with, but there was much to learn from him. Slocum believed strongly in 'hire and fire'. He was absolutely impartial and favoured none. Whenever an American failed in his duties, he was dismissed immediately. He was very sore that the Indian Government could not get rid of dead-wood. He could not compromise with inefficiency. The most outstanding quality that struck me about Slocum was that he never said "We would do this later". Many times, I knocked at his air-conditioned chamber at the hottest time of the day in summer and requested him to inspect some work. He would never say that he would go later when it would be cooler or he would do it first thing next morning. He would get up immediately, don his cap, and say jocularly 'I am ready boss'. When out in the burning sun he would say humourously 'Oh, it is going to snow!' He discussed all problems freely with me and his other assistants and encouraged us to propose solutions. 'Make as many fantastic proposals as you can', he would say, 'we will examine them one by one and adopt the best'. His conduct in the meetings of the Bhakra Control Board was just the opposite. If any-body opposed his proposal, he would shout him down, saying, 'I have built dams and not you'.[3] The contribution of Slocum to the construction of the Dam was really outstanding'.[4]

One of the most modern and complex concreting plants was put up at Bhakra and the concreting of the Dam was done in a very successful manner. It goes to the credit of the Indian engineers that with the help of a few Americans they could install and run such a plant so successfully. The progress achieved per month compares favourably with that achieved in the case of large American dams and the quality of concrete is of very high order.

[3]Personal communication from Mr S.D. Khungar

[4]Sachdev, M.R. Lessons from Bhakra, *Bhagirath*, Vol. XI, January 1964

FAILURE OF HOIST CHAMBER AND PLUGGING OF RIGHT DIVERSION TUNNEL, 1958

The most heroic job done at Bhakra was the repairs of the hoist chamber. The Bhakra canals were completed in 1954 and with a view to supplying them with stored water as early as possible, a special scheme for early irrigation was formulated. The scheme comprised the installation of regulation gates in a plug in the right diversion tunnel. A chamber, about 30 ft (9.144 m) wide and 60 ft (18.29 m) high, called the hoist chamber, was carved out of solid rock above the tunnel to house the gate controls for the interim period till the river outlets in the Dam started functioning. The hoist chamber regulated the water releases for early irrigation during 1958 and 1959, till it collapsed on 21 August 1959, when the reservoir was at an elevation of 1,431 ft (436 m). The failure caused a leakage flow of 9,000 cusecs (255 cumecs), partly through the diversion tunnel and partly through the Dam. Water was flowing at a tremendous speed of 100 ft (30.48 m) per second through the galleries of the dam. The left powerhouse was inundated and the electrical machines under installation were completely submerged. The control over the river was lost completely. There was a depth of 300 ft (91.44 m) of water on the mouth of the big tunnel and it looked also an impossible task to stop the leakages. A number of foreign specialists were invited for advice but none could suggest a solution.

Slocum proposed that the hillside near the upstream portal of the tunnel be blasted to close the tunnel. Khosla turned down the proposal as dangerous. The Indian engineers at Bhakra preferred to adopt the traditional methods (i.e. dumping the required quantity of clay with the earth-moving equipment); they felt that the heavy blast proposed by the American expert was likely to damage the foundations of the dam. Khosla supported the proposal of the Indian engineers of the project and it was carried out successfully. Later, F.A. Nickell, the engineering geologist on the Bhakra Consulting Board, who could not be consulted immediately after the mishap, stated during a visit to Bhakra that the heavy blast, if it had been carried out, would certainly have damaged the foundations of the dam.[5]

The hydraulic model test on a large model of the tunnel and the Bhakra dam were carried out by Uppal, Gulhati and Gajinder Singh. Methods to plug the tunnel at the mouth, the size of the crate, the point of launching the crates, the total number of crates, etc., were carried out after determining the average drift of the crates. The leakage was taken care of by installing syphons. Ultimately, by February 1960, the tunnel was closed. The closing of the tunnel and of the hoist chamber was a great engineering feat.

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[5]Gulhati, N.D. *Dr Ajudhia Nath Khosla Diamond Jubilee Souvenir, Roorkee*, 1976

BHAKRA CANALS SYSTEM

The Bhakra Canals System has been planned to serve the arid tracts of Punjab and a part of the Bikaner State (now a part of Rajasthan), which are proverbially famine-stricken.

The Bhakra Canals System comprises the following distinct schemes:

(i) The construction of the Bhakra Canals, fed by the 12,500-cusec (354-cumec) hydel channel

(ii) Enlarging the capacity of the old Sirhind Canal by over 3,500 cusecs (99 cumecs) by remodelling the Rupar Headworks and the old canal

(iii) Constructing the Bist Doab Canal, taking off on the right bank of the River Sutlej at the Rupar Headworks, with a discharge of 1,401 cusecs (39.6 cumecs)

Thus the whole system utilizes a discharge of about 18,000 cusecs (509.7 cumecs), with a length of 690 miles (1,110 km) of the main canal and branches and 1,100 miles (3,379 km) of the distributary channels. The total area benefiting from the above-mentioned three parts of the project is nearly 10 million acres (4 million hectares), out of which about 6 million acres (2.4 million hectares)cover the new areas. The construction on the canal system was completed in 1954, but it started taking restricted supplies for *kharif* irrigation from 1952 onwards (Fig. 31).

REMODELLING OF THE RUPAR HEADWORKS AND THE SIRHIND CANAL

The existing headworks at Rupar was remodelled by providing the right portion of the weir with undersluices and the rest of the weir was converted into a barrage. A 22-ft-wide (6.7-m-wide) road bridge was provided on the barrage for the free flow of traffic across the river.

The Sirhind Canal was remodelled to carry 12,500 cusecs (354 cumecs) as compared with the earlier 9,000 cusecs (255 cumecs) for the extension and improvement of irrigation facilities.

BIST DOAB CANAL

Owing to excessive irrigation from wells, and the denudation of the Siwalik Hills, the water-level in the Jullundur District had gone down alarmingly. As a result, agriculture in Jullundur District, which was known for the fertility of its soil, was suffering. In 1947, the problem in Jullundur District was to raise the water-level in the wells. Sardar Swaran Singh, who belongs to the Jullundur District, happened to be the Irrigation Minister in charge of the Bhakra-Nangal Scheme. He realized the gravity of the problem. It was he who suggested the digging of a canal to provide the Jullundur and Kapurthala districts with irrigation. It was thus that the Bist Doab Canal, with a full supply discharge of 1,601 cusecs (45.27 cumecs) which takes off from the right bank of the Rupar Headworks, was

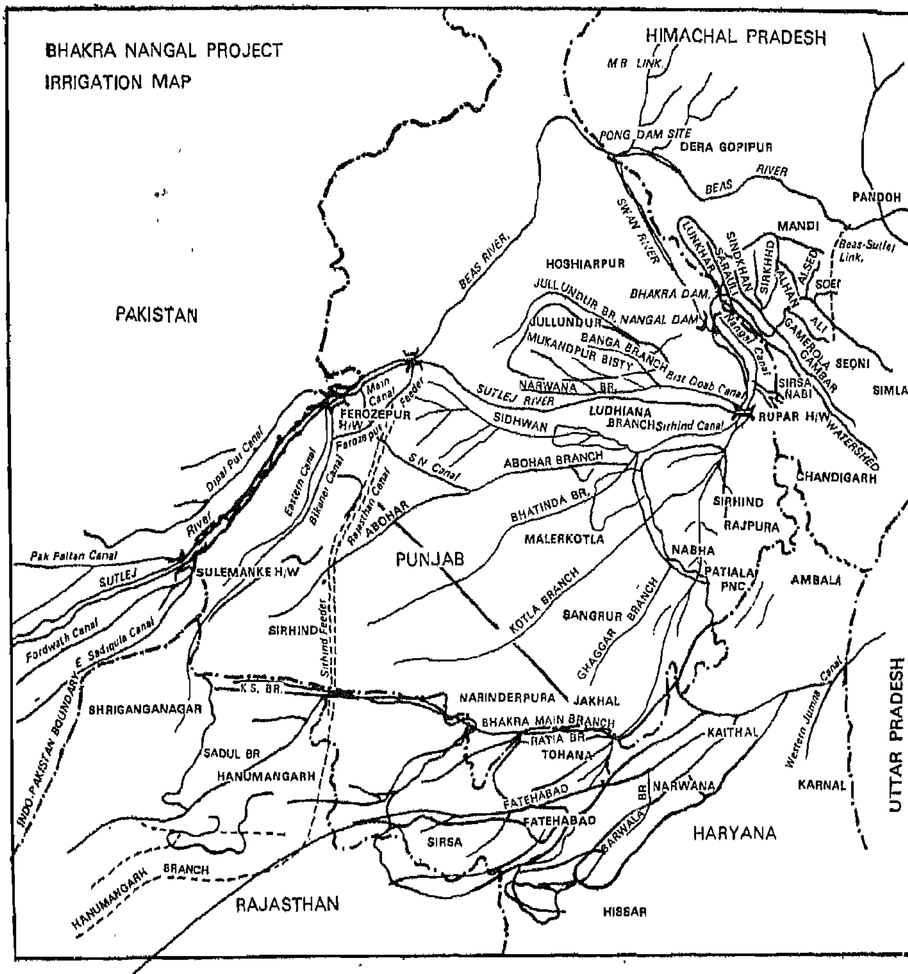


FIG. 31. The Bhakra-Nangal Project in the Punjab and Haryana irrigates 4 million hectares.

constructed. The canal irrigates 256,000 hectares (632,000 acres). By recharging the groundwater supply, this canal restored the agriculture in Jullundur District, which is now again in the forefront of agricultural development.

NANGAL PROJECT, 1948–1952

The Nangal Project was conceived to meet the acute power shortage from which Punjab was suffering during World War II. A stage was reached when even the requirements of hospitals and schools could not be met. Its construction was started in December 1946, but there was a brief interruption due to the partition of the country in August 1947. The left half

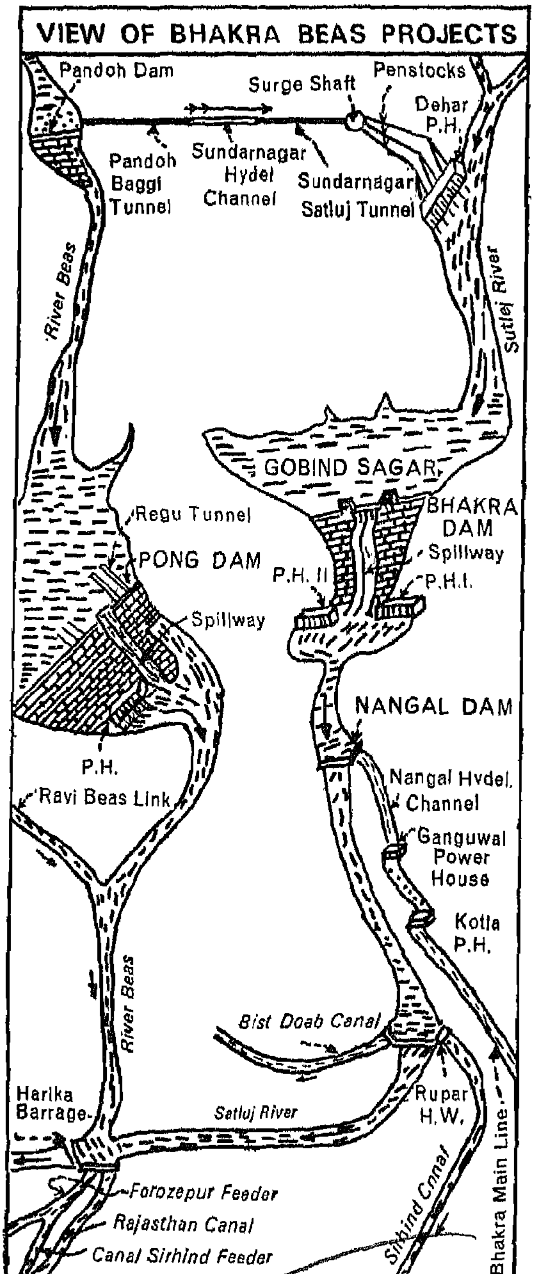


FIG. 32. A diagrammatic sketch, showing the Bhakra and the Beas Projects. To replenish supplies of water in the Gobindsagar Lake, a dam has been constructed at Pandoh, near Mandi, on the Beas River. The channel taking off from Pandoh passes through two long tunnels and, after generating electricity at Dehar, joins the Sutlej River above the Gobindsagar Lake.

of the structure was taken up first, the work on which went on till March 1949. After that, the right half was taken up and the entire work was completed in 1952. For this work, credit is due to Sardar Sarup Singh, Chief Engineer, and his team of engineers. The operation was planned well and was executed rapidly. A record flood of 310,000 cusecs (8,779 cumecs) was successfully negotiated by the new structure, as yet unfinished, on 22 August 1951. The dam came out unscathed from the very severe test.

The concrete barrage at Nangal, in the Hoshiarpur District of Punjab, is located 8 miles (12.9 km) downstream of the Bhakra Dam across the River Sutlaj, where it emerges from the outermost range of the Siwalik Hills (Fig. 34.)

The 955-ft (291-m)-long barrage has a clear waterway of 780 ft (237.7 m) provided by 26 bays of 30 ft (9.1 m) each, separated by 7-ft (2.1-m-)-wide piers. The height of the dam from the bottom of the foundations to the top of the breast wall is 91 ft (27.7 m) and the total length of the impervious floor is 338 ft (103.0 m).

Hydel Channel and Power-Stations

The Nangal Hydel Channel takes off from the left bank of the River Sutlej, just upstream of the Nangal Dam (Fig. 35). The channel serves as a feeder for the Bhakra Canal System below Rupar and for generating power at the power-stations at Ganguwal and Kotla, at 12 and 18 miles (19.3 km and 28.9 km) respectively, from the head of the channel. A third power-station is projected to be built on the hydel channel.

The hydel channel runs along the broken country and is crossed by as many as 58 hill torrents, varying in discharge from 100 cusecs to 150,000 cusecs (2.8 cumecs to 4,247 cumecs). These drainage crossings are negotiated by means of all types of structures, such as aqueducts, syphons or super passages, depending upon the relative bed levels of the channel and the crossings. Some of these cross-drainage works are impressive.

The construction of the two power-houses at Ganguwal and Kotla presented some difficult foundation problems on account of high subsoil water-levels. At Ganguwal, the foundations had to be carried as much as 68 ft (20.7 m) below the subsoil water-table and large-scale pumping had to be resorted to. Clay strata met at the foundation level had to be removed under difficult conditions to ensure the safety of the superstructure.

The installed capacity of the two power-houses is 77,000 kW each, i.e. two generating units of 24,000 kW, and one unit of 29,000 kW capacity for each power-house. The first stage of development covers only two generating units in each of the two power-houses. An interesting feature of the scheme is that, whereas the Ganguwal Power-House will be manned by the operating personnel, the Kotla Power-House, situated about 6 miles (9.6 km) downstream, will be fully controlled from the former. Another interesting feature is the installation of telemetering equipment at the Ganguwal Power-House, which enables the load-despatcher to know the load conditions on several remote sections of the power system at all times. The Ganguwal Power-House was inaugurated on 2 January 1955 and the Kotla Power-House in September 1956.[6]

BUILDERS OF THE BHAKRA DAM

The work on the dam was completed in 1963. The Bhakra site was one of the most difficult sites in the world for constructing a high dam owing to poor geological conditions and difficult terrain. It was a Herculean job to bore two large tunnels, each having a diameter of 56 ft (17 m) for the diversion of the river through the abutments in a stratum consisting of sandstones and clay and being badly shattered. The excavation for the foundation of the Dam and making the incompetent rock suitable for carrying a load of a 740-ft-high (225.5-m-high) dam required ingenuity of the highest order. There was a 100-ft-wide (30.5-m-wide) band of clay just upstream of the Dam. It was feared that the claystone would give way under the enormous loads, when the wet photoelastic tests showed that the clayband had to be excavated up to a depth of about 200 ft (61 m) below the river-bed. When such a deep excavation was started, the hillsides would cave in. The excavation was done by using the mining method through hatches. There were numerous shear zones which ran from upstream to downstream through the foundations, providing potential leakage channels. These were suitably and thoroughly treated. The abutments above the elevations of 1,400 ft (426.7 m) were badly shattered. They were consolidated in a very methodical manner. As a result of these precautions, the Bhakra Dam has behaved well, and there was hardly any leakage or structural distress.

A major project is always the result of the efforts of a large number of people, ministers, engineers, workers, and administrators. The support which Prime Minister Jawaharlal Nehru gave to this project was invaluable. Thus the project did not suffer from financial constraints. On the design side, the contribution of J.N. Savage and A. N. Khosla is great. On the construction side, Slocum made an outstanding contribution. He put his heart and soul into the work and also inspired his colleagues. Among the Indian engineers, the contribution of A.N. Khosla, who made a mission of his life to see the Bhakra Dam through, is outstanding. He is considered the architect of the Bhakra Dam. Kanwar Sen made a valuable contribution to the planning, designing and expediting the construction. Among the

[6] *Irrigation Development in India*, pp. 155-7

general managers, Sarup Singh, the first General Manager, S.D. Khungar, M. R. Chopra, B. R. Palta, R. S. Gill and S.C. Katoch made very valuable contributions. M. R. Chopra bore the brunt of heavy construction. It was his organizational capacity and indefatigable work which matched the challenge.

Benefits of the Bhakra-Nangal Project

The construction of the Bhakra Dam took 15 years to complete (from 1948 to 1963) at a cost of 49.233 million rupees. The storage reservoir, Gobind Sagar, is 96 km long, impounding 940,000 hectare-metres of water, out of which 729,000 hectare-metres is available for irrigating 350,000 hectares in Punjab, Haryana and Rajasthan and for power generation. Besides, the irrigation of 142,000 hectares in the pre-Bhakra stage by the Sirhind Canal and the Western Jamuna Canal systems was augmented. With the construction of the Bhakra Canals, agriculture in these States has undergone transformation and the area previously dependent on uncertain rains is producing high-value crops. The value of agricultural production in the three beneficiary States is estimated at well over Rs 4,000,000,000 per year. Over 4,000 million units of electricity is supplied to the partner States of Punjab, Haryana and Rajasthan and to the Union Territory of Delhi, from the two power-plants on the left and right banks. The left-bank power-plant has five machines of 90 MW each and the right-bank power-plant has five machines of 120 MW each. The power is also extensively used for industries as well as for energizing tube-wells for irrigation. The Bhakra-Nangal Project has fully justified the hopes of its designers, and in, due course, became the main prop of the Green Revolution in Punjab and Haryana.

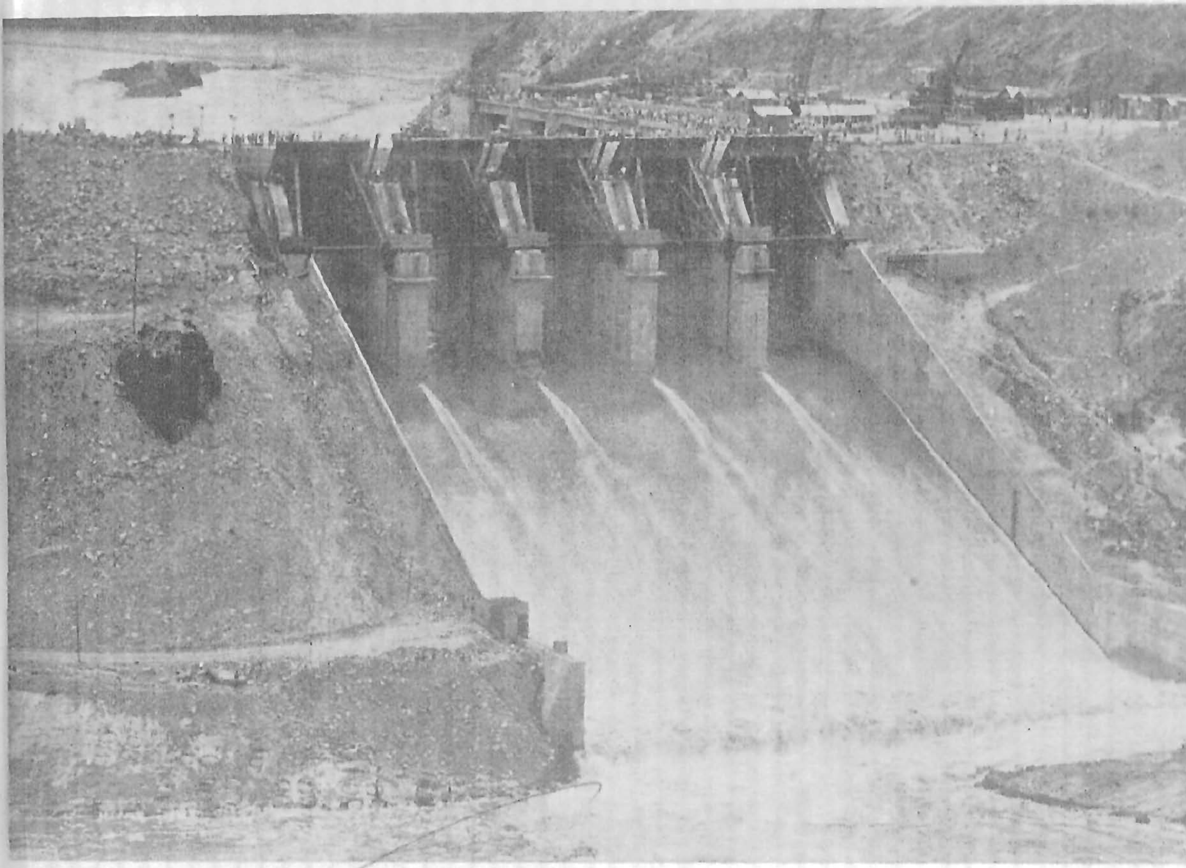


FIG. 33. The Beas-Sutlej Link Project—a view of the Pandoh-Dam Spillways on the Beas River, Kangra District, Himachal Pradesh. Constructed during 1960-1974 to firm up water storage in the Bhakra Lake and for the generation of hydro-power. (PIB)

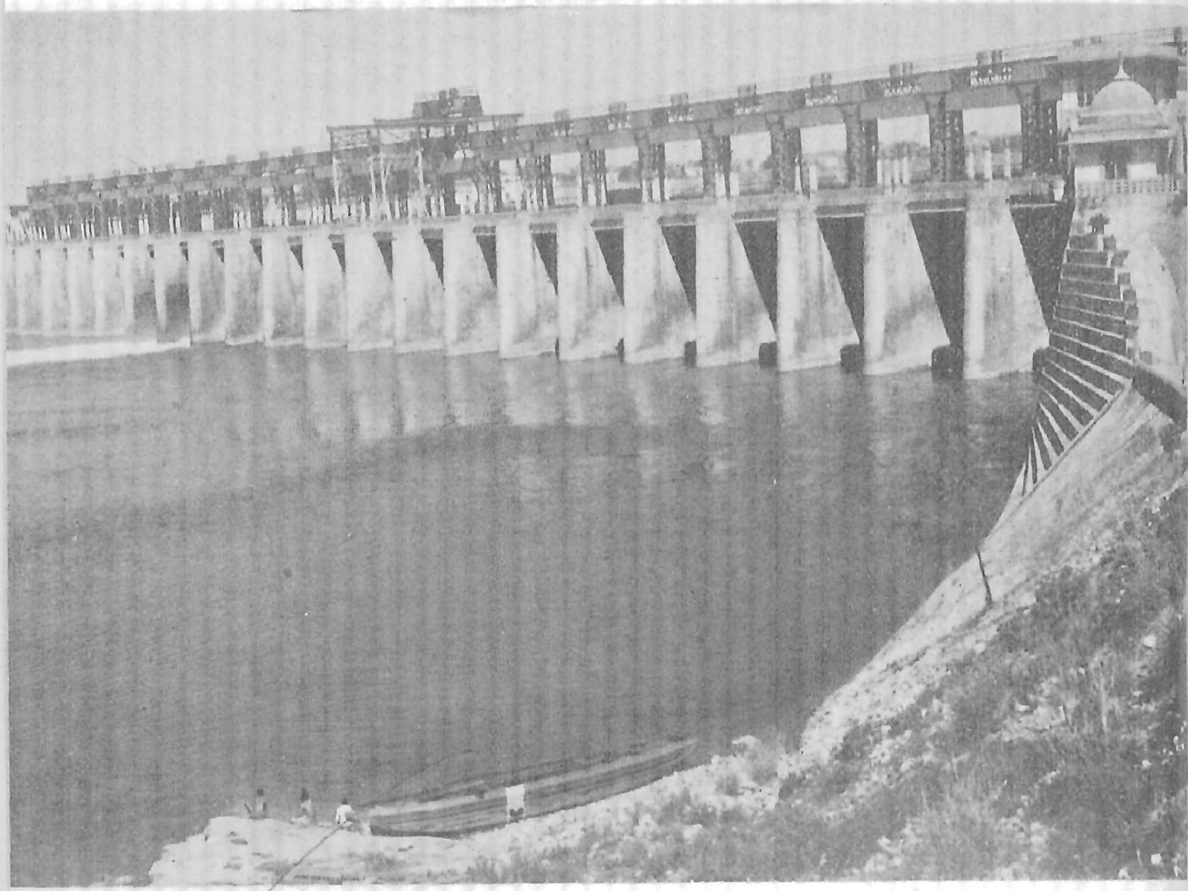


FIG. 34. The Nangal Dam on the Sutlej River, constructed during 1948-52. (PIB)

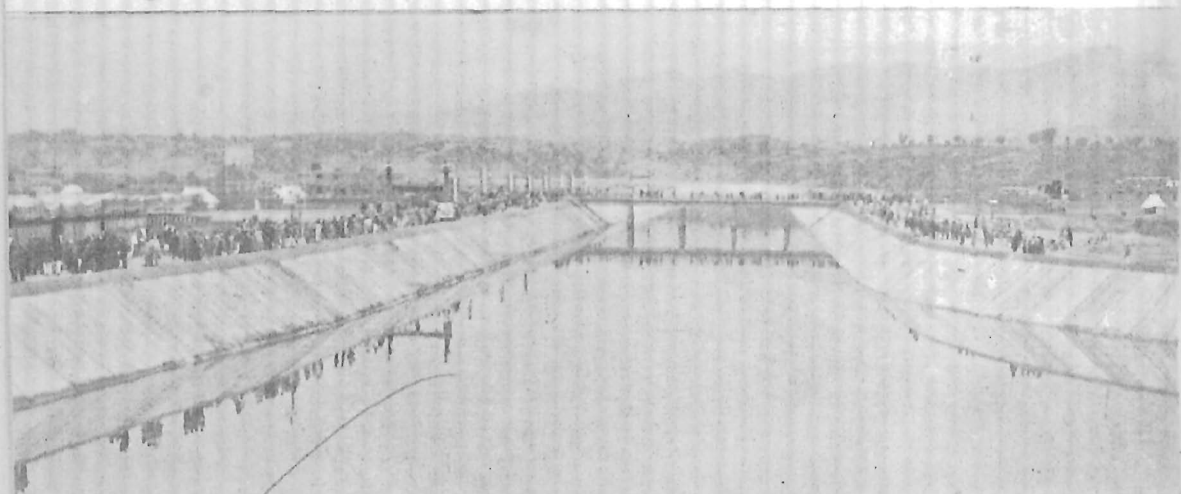


FIG. 35. The Nangal Hydel Channel serves as a feeder for the Bhakra Canal System below Ropar and generates power at Gangual and Kotla. (PIB)

CHAPTER 9

THE CHAMBAL PROJECT
1954–1967

A major tributary of the Yamuna and the only major river of India to flow from south to north, the Chambal, rises in the Vindhyas near Mhow, at an elevation of nearly 2,800 ft (853.4km). Flowing generally in a northerly direction for a distance of over 200 miles (321.8 km), it enters a deep and 60-mile (96.6-km)-long gorge near Chowrasigarh in the Mandsaur District in Madhya Pradesh. From there, it takes a north-easterly direction; then, leaving the gorge near Kotah, it sweeps majestically through the plains of Madhya Pradesh and Rajasthan, to finally join the Yamuna near Etawah in Uttar Pradesh (Fig. 36).

The Chambal River, with a large potential for irrigation and power,

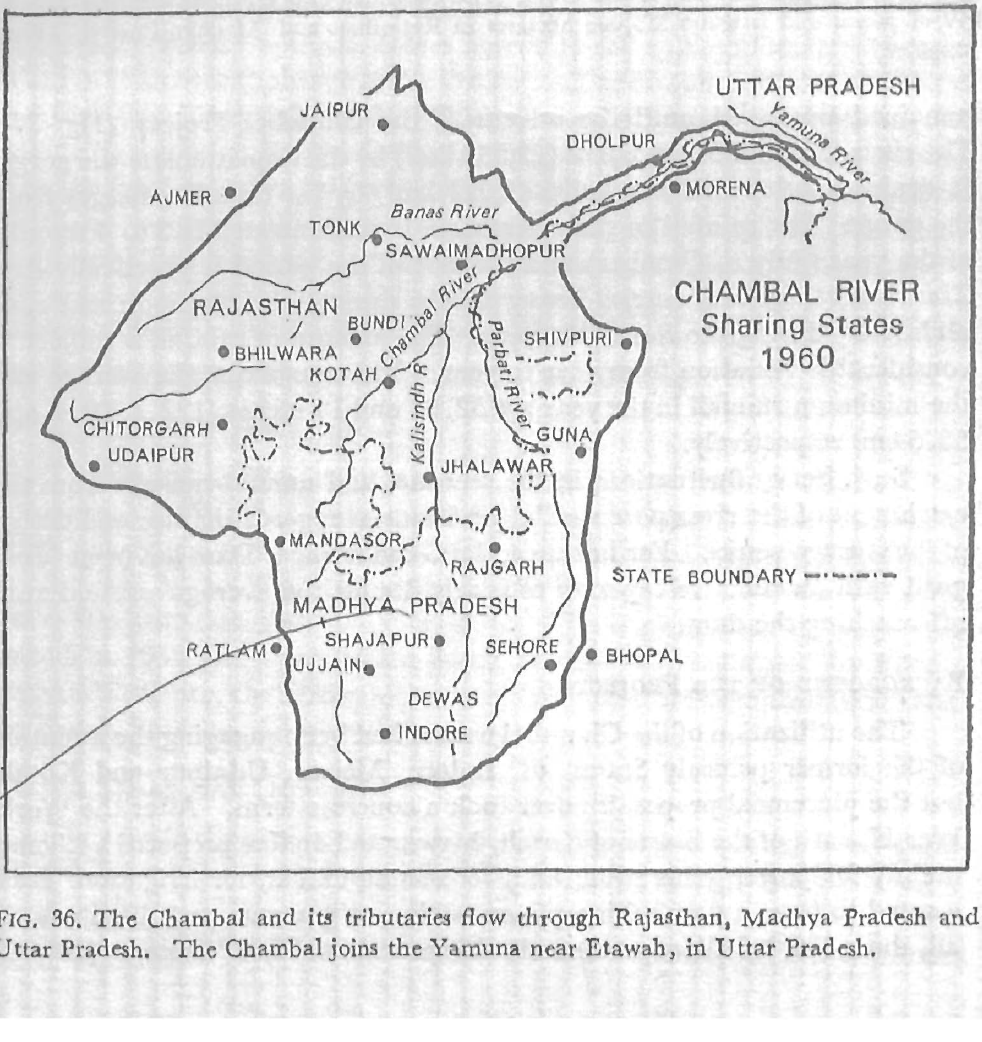


FIG. 36. The Chambal and its tributaries flow through Rajasthan, Madhya Pradesh and Uttar Pradesh. The Chambal joins the Yamuna near Etawah, in Uttar Pradesh.

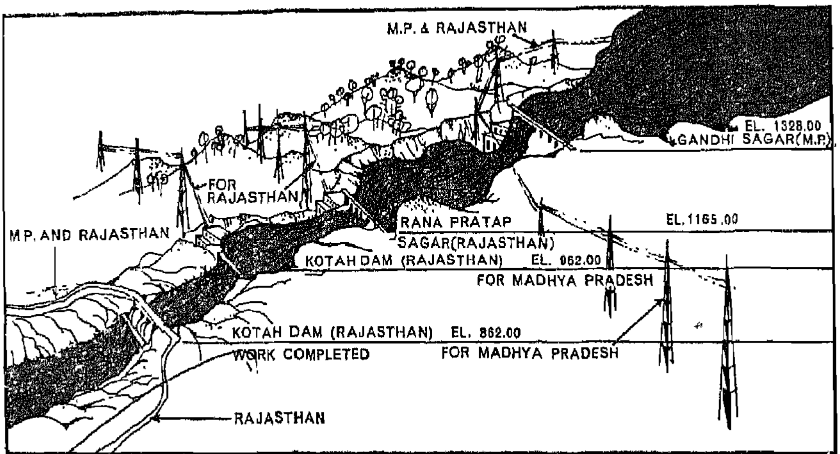


FIG. 37. The Chambal Valley Project, showing its three dams, viz. the Gandhi Sagar, the Rana Pratap Sagar and the Kotah Dam. The Chambal Valley Project develops 232,000 kW of power and irrigates 565,000 hectares in Rajasthan and Madhya Pradesh. (From *Bhagirath*)

remained untapped until the advent of the Chambal Project (Fig. 37). The river drains 8,700 sq. miles (22,533 km²) by the time it enters the gorge. It drains another 1,900 sq. miles (4,921 km²) by the time it emerges from the gorge. The rainfall in the river basin is concentrated in 3 to 4 months of the year (July to October) and the rest of the period is practically dry. The river, therefore, carries heavy floods during the monsoon and runs all but dry during the rest of the year. The amount of rainfall is subject to considerable variation from year to year. The maximum, the average and the minimum rainfall in the year are 52, 34 and 14 inches (132.1, 86.4 and 35.6 cm) respectively.

Such heavy fluctuations in the seasonal and annual run-offs from the catchment of the river pose special problems as regards the size and design of the storage works. For instance, the Gandhi Sagar Dam has been designed with an effective capacity of nearly double the average annual run-off reaching the dam.

Background of the Project

The utilization of the Chambal waters had been engaging the attention of the former princely States of Indore, Mewar, Udaipur and Kotah, but the piecemeal proposals never took a concrete form. After the World War II, each of the States of Kotah, Mewar and Indore prepared a scheme, mainly for power generation, and, to a small extent, for irrigation. Each wanted to have a dam with a power-station to generate and distribute, in all, about 150,000 kW of power and to irrigate about 80,937 hectares (200,000 acres). Among them, they could not come to an agreement on the development programme.

It was not until the different princely States came to be knit together through the genius of the late Sardar Vallabhbhai Patel that a co-ordinated scheme for developing the Chambal River could be visualized and put through. Following the merger of the Indore State into Madhya Bharat and Udaipur and other States into Rajasthan, a comprehensive scheme for the development of the river was evolved under the advice and guidance of the Government of India. The scheme, as adopted at a conference of the representatives of the two State governments, with the then Union Minister, Shri N. V. Gadgil, as president, resulted in the present Chambal Project.[1]

Chambal Control Board

One of the vitally important steps taken by the two State governments in launching this inter-State venture was the establishment of the Chambal Control Board. At an inter-State meeting, held on 25 March 1955, at which the representatives of the Central Government and the two State governments were present, both the States agreed to set up the Chambal Control Board to be in overall charge of the Project. The establishment of the Board and investing it virtually with the full powers of formulating policies and making decisions, normally vesting in the government, can be rightly stated to be the most important steps in inter-State co-operation. By convention, the State governments agreed to implement the decisions taken by the Control Board without any further examination in all matters pertaining to the execution of the Project. Without the formation of the Board, the smooth, expeditious and efficient execution of the Project might well nigh have become impossible.

Three Stages of the Project

The Chambal Project, as a whole, covers three distinct stages. The first stage comprises the construction of the Gandhi Sagar Dam near Chowrasigarh, where the boundaries of Madhya Pradesh and Rajasthan meet, the power-house at the dam site and the Kotah Barrage in Rajasthan. The total cost of the first stage was Rs 636 million. The work on the first stage was started in 1953 and the Gandhi Sagar Dam was inaugurated by Pandit Jawaharlal Nehru, the Prime Minister of India, on 19 November 1960, and the Kotah Barrage, the next day.

Gandhi Sagar Dam (1954-60)

The Gandhi Sagar Dam is a straight-gravity dam of a maximum height of 214 ft (65 m) above the deepest foundation level. The length of the dam

[1]Hathi, Jaisukhlal, Chambal—an inter-state enterprise, *Bhagirath Monograph*, New Delhi, 1960

at the top is 1,685 ft (513.5 m). The dam is constructed in random rubble masonry, i.e. in what is popularly known as red cement. The term 'red cement' is applied to a mixture of about 80 per cent portland cement and 20 per cent *surkhi*, i.e. finely ground red brick powder. The strength of the cement mortar is not adversely affected by the addition of *surkhi* to cement. On the other hand, it keeps down costs, is less liable to cracks owing to shrinkage and offers greater workability where manual labour is employed.

Another special feature of the dam is the unique location of the nine regulating gates, of size 10 ft × 25 ft (3.0 m × 7.6 m). The gates are located in the piers between the spillway gates. The piers have, therefore, had to be made sufficiently wide to accommodate the gates. This unusual arrangement has been found through large-scale models to give the most satisfactory discharge conditions when the crest gates and the regulating gates are opened simultaneously to pass down floods.

As the river at the site of the dam flowed in two distinct channels, with a natural ridge in between, it was not difficult to divert the winter flow of about 2,000 cusecs (56.6 cumecs) either to the right or to the left side for construction purposes. During the flood season, the river waters were allowed to overflow the masonry of the dam, thus obviating the necessity of having to construct any expensive diversion works.

The construction materials were hauled by means of aerial cableways, which ensured the work to continue uninterruptedly on those blocks of the dam which were not submerged during the floods.

The regulating gates of the dam, weighing about 35.6 tonnes each, had to be assembled on the dam itself and lowered into the gate slots, as there was no possibility of hauling such heavy pieces from the flanks. They were subsequently placed in position by means of about 41 tonnes travelling-gantry, specially assembled on top of the dam for the purpose.

The geology of the foundations of the dam is generally satisfactory and the foundation treatment of the dam did not present any difficult problem. The power-house is located on the downstream of the Gandhi Sagar Dam at its right extremity. The power-house is 311 ft (94.7 m) long and 59 ft (17.9 m) wide. It accommodates five generating units, each of 23,000 kW capacity.

The construction of this dam was started in 1954 and was completed in 1960.

Development of Fisheries

A scheme for the development of fisheries in the Gandhi Sagar reservoir was initiated in October 1958. Since then, up to the end of 1965-66 about 850,000 rupees were spent on three different schemes, specifically called:

(i) Fisheries Development in the Chambal Valley, (ii) Fisheries Development in the Multi-purpose River Project Scheme, and (iii) Crash

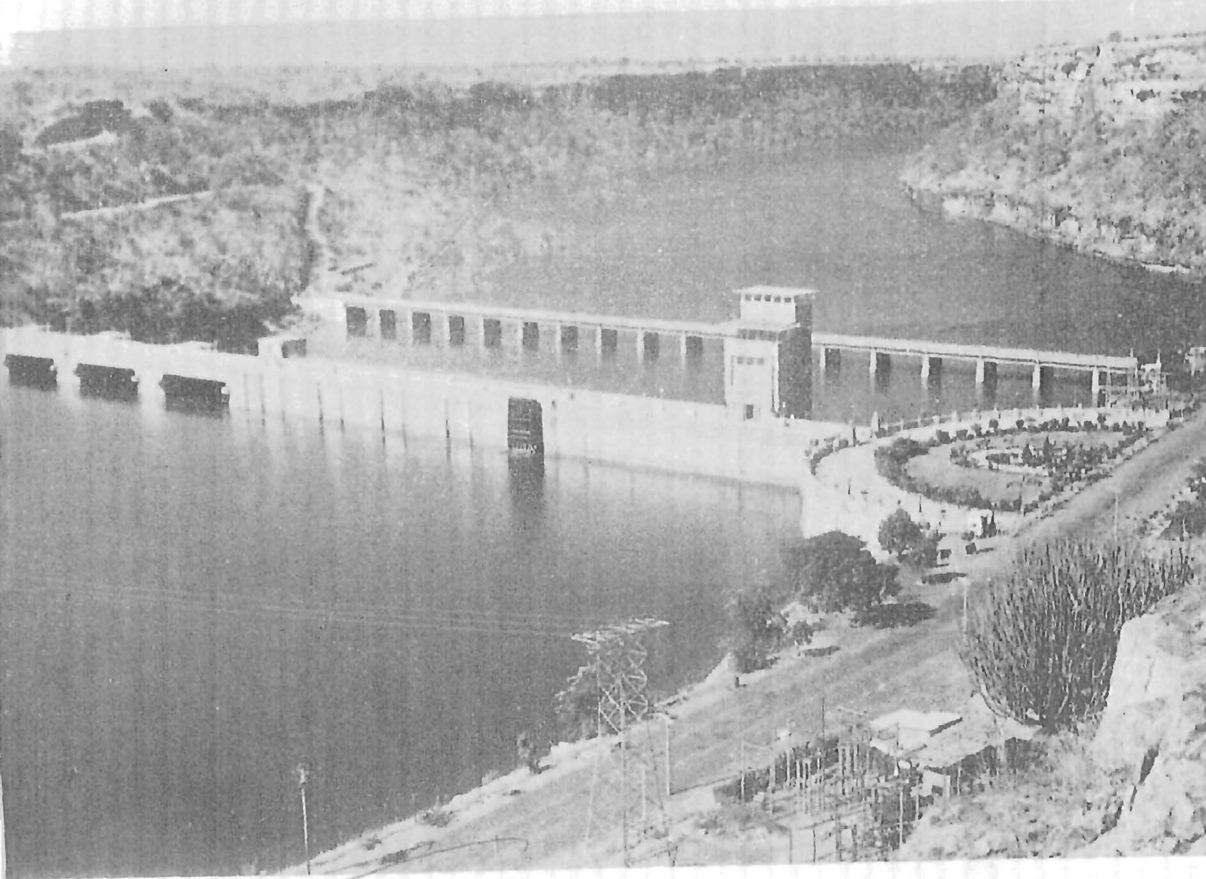


FIG. 38. The Rana Pratap Sagar Dam on the Chambal River, 51 km south of Kota, Rajasthan. Constructed during 1961-1967 for irrigation and hydro-power. (PIB)

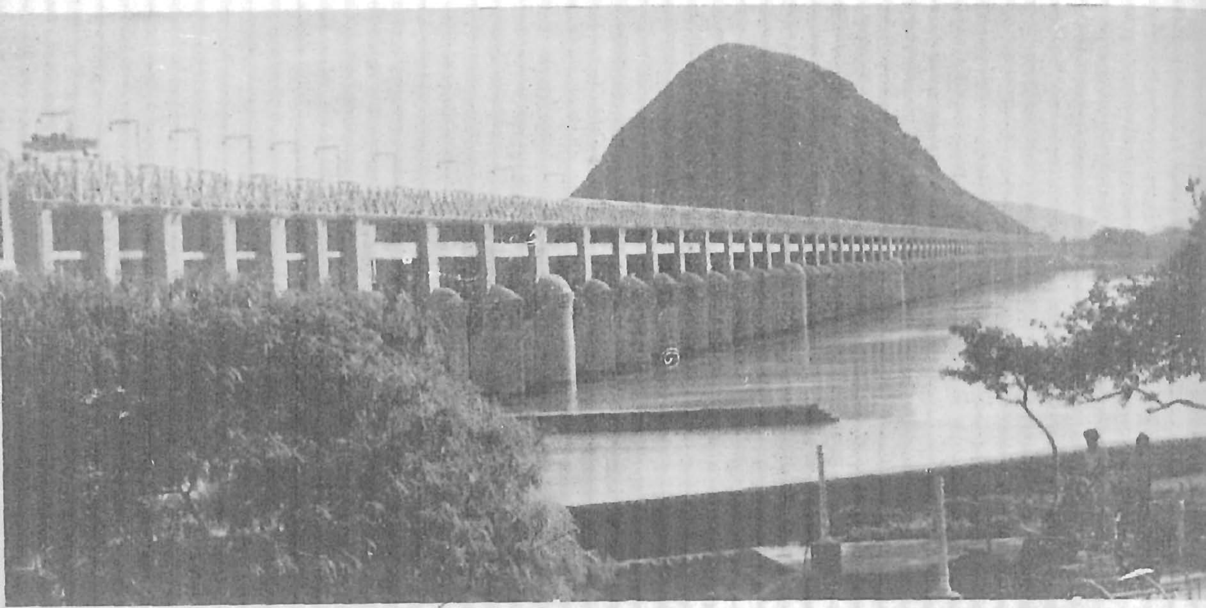


FIG. 39. The Krishna Barrage, Andhra Pradesh. (PIB)

Programme (1955-1966 only).

About 500,000 fish seeds were stocked in the reservoir during 1959-60 and 1960-61 and about 1,500,000 during the next two years, 1961-62 and 1962-63. During the following three years, 1963-64 to 1965-66, only about 800,000 fish seeds were stocked.

An ice-plant and two mechanized boats for quick transport of fish to the landing-centres have been provided under the crash programme.

The extraction of fish commenced during 1962-63, when 341 quintals of it were extracted. In the following three years, the extraction has been 642 quintals, 3,123 quintals and 3,099 quintals respectively. Four co-operative societies (two of which are registered), with a membership of about 120, are allowed to extract fish. The total revenue up to the end of 1965-66 has been 262,000 rupees.

The target with respect to fish extraction from the reservoir is 1,000 tonnes per year with an anticipated annual revenue of over 500,000 rupees. Most of the fish extracted is marketed to Delhi and Calcutta through the Central Fisheries Corporation.[2]

KOTAH BARRAGE

Situated a mile and a half (2.4 km) upstream of the Kotah-Ajmer Road, the 38-million-rupee Kotah Barrage is a part of the first stage of the Chambal River Valley Development Programme. There will be two other dams for generating hydro-power, viz. the Rana Pratap Sagar Dam in the second stage of the project which is under construction and the Kotah Dam in the third stage is located between the Gandhi Sagar Dam and the Kotah Barrage.

Two canals, the Right Main Canal and the Left Main Canal, take off from the upstream of the barrage with head discharges of 6,656 cusecs and 1,500 cusecs (188.5 cumecs and 42.5 cumecs), respectively, and between them provide an irrigation potential of 1,400,000 acres (566,000 hectares) divided equally between the two sponsoring States of Madhya Pradesh and Rajasthan.

The barrage has been completed and was formally inaugurated by the late Prime Minister, Pandit Jawaharlal Nehru, on 20 November 1960.

The Kotah Barrage is a barrage with a difference. It is the first work of its type which incorporates an earth dam as a part of the main structure across the river. The earth dam is 122 ft (98.2 m) high above the deepest foundations, with top EL. of 862.50 and the full pond level at EL. 852.00. The maximum pond level during floods has been provided at 855.00.

The earth dam is 1,970 ft (600.4 m) long at the top, and has a length

[2] A Report by the study group on Irrigation and Power of the National Planning Council on Chambal Project, 1967, pp. 35, 36

of only 600 ft (182.8 m) at the riverbed level. It has been located in the deep portion of the riverbed on the right side. The barrage proper occupies the left half of the riverbed, which is higher and where the geology of the foundations is more satisfactory than that of the right side under the earth dam.

The earth dam is a zoned earth and rockfill dam, with an upstream slope of 1 in 3 and the downstream slope varying from 2.5 in 1 to 1 in 8. The top width is 25 ft (7.6 m).

A clay blanket, 10 ft (3.0 m) thick, extending to 550 ft (164.6 m) from the upstream toe, has been provided to lengthen the path of percolation of water through the previous foundations and a filter blanket is provided at the base of the rock-fill zone, to ensure the drainage of seepage water through and under the dam without the movement of soil particles.

An interesting feature of the earth dam is the cement clay grouting, which had to be done in a portion of the dam foundations where sheet piles could not be driven owing to the presence of large boulders.

Doubts about the soundness of raising a high earthen dam on such highly permeable foundations were expressed by a number of prominent engineers. It was considered that excessive seepage through the foundations may result in the collapsing of the structure as a whole. Consultations were held with Karl Terzaghi, experts from Yugoslavia, the USA and France, besides those with distinguished engineers of the country. The final design worked out provided for clay and cement grouting of the substratum not covered by the positive cut-off wall. The injection of cement or clay or mixed grout to render faulty strata impervious to avoid uneconomic depths of cut-off walls, and to seal strata below a dam is practised in foreign countries, but the kind of work had not yet been done in India. The work of clay-cement grouting was allotted to Messrs Cementation Company Ltd, who were asked to associate with them experts in this line from France.

In November 1958, coffer dams were constructed upstream and downstream. Dewatering was started and the bed was pumped dry. The Cementation Company Ltd started the grouting operations in the third week of December 1958 and finished the work early in April 1959. The total volume of the alluvium to be grouted was estimated at 121,000 cu. ft (3,397 m^3) and the total quantity of the grout mix actually injected was 54,900 cu. ft (1,554 m^3).

The total cost of the operation was about 600,000 rupees. The cost per ton of clay and cement injected was Rs 740 (Rs 728 per tonne) and the cost per linear foot came to about Rs 450 (Rs 1,476 per m).

As a result of grouting, the permeability in the grouted areas was reduced to almost nil.

The barrage or spillway portion of the structure on the left side is 180 ft (54.9 m) long and is founded on sound rock. The crest elevation of the weir is 812.00 and it is mounted by 19 gates of size 40 ft×40 ft (12.2 m× 12.2 m). In addition, there are two sluices of size 9 ft×11 ft (2.7 m× 3.3 m). The barrage is designed for a modarated flood discharge of 750,000 cusecs (21,237.6 cumecs).

THE CANALS

The Right Main Canal, head discharge with 6,656 cusecs (188.5 cumecs), flows for the first 81 miles (130.3 km) in the Rajasthan territory and then enters Madhya Pradesh at the Parvati River aqueduct. The discharge of the canal at this point is 3,900 cusecs (110.4 cumecs) and it runs for another 145 miles (233.3 km). The estimated cost of the canal is Rs 282.1 million.

The left Main Canal, with head discharge 1,500 cusecs (42.5 cumecs), bifurcates at a distance of about 1.75 miles (2.8 km) from the head and lies wholly within the Rajasthan territory. Its total estimated cost is Rs 219 million.

There are a large number of cross-drainage works, especially on the Right Main Canal. In the first 81 miles (130.3 km), of the Rajasthan portion of this canal, there are 62 cross-drainage structures of different types, whereas in the Madhya Pradesh part of the canal there are as many as 200 such structures. A number of these cross-drainage works excel any other works anywhere by their sheer magnitude. Notable examples are the Kalisindh and Parwan aqueducts in the Rajasthan portion and the Parvati and Kurwari aqueducts, as well as the Kunu Siphon (cost 15 million rupees) in Madhya Pradesh. The Kunu Siphon is one of the largest pre-stressed concrete siphons in the world. It consists of a 20-ft (6.1-m)-diameter pre-stressed concrete pipe, of 11 in. (27.9 cm) minimum thickness and 5,860 ft (1,816 m) length.

The total culturable commanded area of both the canals is 1,945,000 acres (789,000 hectares). The area to be irrigated annually is 1,100,000 acres (445,000 hectares) in the first stage of the project, viz. before the construction of the Rana Pratap Sagar Dam, and 1,400,000 acres (566,000 hectares) in the second stage, viz. after the construction of the Rana Pratap Sagar Dam.[3]

LABOUR AND WELFARE

A notable feature of the Chambal Project is the use of manual labour, wherever possible, in order to save foreign exchange in importing construction machinery and to give employment to the unemployed.

The labour strength during the peak periods was 16,000 to 17,000 per

[3] *Development of Irrigation in India*, pp. 124-6

day. The health and welfare of the workers were attended to by camp dispensaries with a centralized dispensary at Sheopur-Kalan with mobile vans, ambulance vans and a labour-welfare centre.

All departmental employees, both regular and work-charged, were given accommodation, with free water-supply, electricity and medical aid, wherever possible.

Rana Pratap Sagar Project

The second stage of the Chambal Project, estimated to cost Rs 189.4 million, covers the construction of the Rana Pratap Sagar Dam, with a power-station at the dam site, housing four units of 43,000-kW capacity each. The project provides irrigation facilities for an additional area of 300,000 acres (120,000 hectares). In the first stage of the Chambal Project, an irrigation potential of 1,100,000 acres (445,000 hectares) was created. With the completion of the second stage, the irrigation potential increased to 1,400,000 acres (566,000 hectares). Rajasthan and Madhya Pradesh are equal partners in costs as well as in benefits, as in the case of other works of the Chambal Project.

The Rana Pratap Sagar Project was sanctioned in February 1861 at an estimated cost of Rs 172.1 million, and the preliminary works were taken in hand in 1961. This estimate was revised in 1963 to Rs 189.4 million on account of radical alterations in the original layout of the project, consequent upon the completion of detailed investigations and economic studies of various alternatives.

Rana Pratap Sagar Dam, 1961-1967

The dam is located 20 miles (32.2 km) downstream of the Gandhi Sagar Dam. It is a straight-gravity dam, built in stone masonry with red cement mortar. The right flank of the dam is a composite section, consisting of stone masonry key wall and earth section. The full reservoir elevation is 1,157.50, with a waterspread of 76.56 sq. miles (198 km^2). The maximum reservoir elevation of 1,162.00 has been provided for, with a waterspread of 84.25 sq. miles (218.2 km^2). The height of the dam above the average bed level is 130 ft (39.6 m) (Fig. 38).

The 289 ft × 60 ft (88.0 m × 18.3 m) power-house has an installed capacity of 172,000 kW, with 4 units of 43,000 kW each, one of which is a standby unit.

The construction of this dam was started in 1961 and it was completed in 1967.[4]

Kotah Dam Power Project

It is a cement-concrete gravity-section dam on the River Chambal

[4] *Major Dams in India*, C.B.I.P., New Delhi, 1979, p. 178

between the Rana Pratap Sagar Dam and the Kotah Barrage, about 16 miles (25.7 km) south of Kotah.

The dam is meant solely for hydro-power generation to meet the fast-growing demand for power for industrial development of the region. The original estimate, which was Rs 96.75 million, was revised to Rs 134.7 million.

Contribution of Engineers and Administrators

Every project is a co-operative endeavour in which engineers, administrators and workers participate. The Chambal Project had the benefit of the guidance of Jaisukhlal Hathi, Union Minister of Irrigation and Power, who was the Chairman of the Control Board. V.V. Dravid, Minister of Labour and the Chambal Project, took keen interest in labour problems. To the preparation of the design for the project, M. Hayath, Chairman of the Water and Power Commission, and K. L. Rao, P.C. Nag and Hira Lal Wadhwa effectively contributed. A. K. Achar constructed the Gandhi Sagar and Rana Partap Sagar Dams. Sivaprakasam was responsible for the construction of power-houses at the above-mentioned two dams as well as of Kotah Dam (Jawahar Sagar). In the rehabilitation of 35,000 people, who were uprooted from 200 villages which were submerged, V. Bhargava, Chief Commissioner, Madhya Bharat, played an important role.

To the construction of the Kotah Barrage, the contribution of Moti Ram and Hari Singh Chowdary, engineers of the Irrigation Department, Rajasthan, is worth mentioning. In the digging of the canals and related work, engineers J. N. Mehra of Rajasthan and Y. G. Mane of Madhya Pradesh took keen interest.

Benefits from the Chambal Project

The Chambal Valley Project is an integrated project for the development of about 232,000 kW of firm power at 60 per cent load factor and extension of irrigation to about 565,000 hectares (1.4 million acres) of arid land in Rajasthan and Madhya Pradesh. The implementation of this project had a salutary effect on the economic growth of the region. The growth had hitherto been hampered by climatic conditions and lack of power, which would now be substantially remedied. The large network of Chambal power system has reached distant load centres of Madhya Pradesh and Rajasthan, including Ujjain, Indore, Bhopal, Ratlam and Gwalior in Madhya Pradesh, and Kotah, Sawai Madhopur, Jaipur and Ajmer in Rajasthan. Great care has been taken to design the Chambal Valley Project to obtain the maximum benefits, of both irrigation and power.

CHAPTER 10

THE NAGARJUNASAGAR PROJECT, ANDHRA PRADESH

1955-1974

THE Nagarjunasagar Project in Andhra Pradesh is one of the biggest projects in India, with the ultimate command area exceeding 1.2 million hectares (3 million acres). It is based on the Krishna River, the second biggest river in peninsular India, with a total catchment area of 97,050 sq. miles (251,359 sq. km) in a length of 775 miles (1,247 km) in Maharashtra, Karnataka and Andhra Pradesh.

The traditional source of the Krishna is a spout fashioned in the image of a cow's mouth, in an ancient temple of Shiva, at the foot of a steep hill near Mahabaleshwar (Maharashtra). From this source, the river runs southwards in a rapid course, flowing through the districts of Satara, Belgaum and Bijapur. There it turns east and receives a number of tributaries, of which the chief are the Verala, the Warna, the Ghataprabha and the Malaprabha.

The river, thereafter, drops in rapids to the alluvial *doabs* of Sholapur and Raichur. The fall is as much as 300 ft (910.4 m) in about 30 miles (48.3 km). These falls are known as the Jaldrug Falls.

At Siddeswaram, a few miles east of Kurnool, the Krishna meets some ranges of hills and flows through hilly country and gorges for nearly 180 miles (289.6 km) before entering the plains of the Coromandel Coast at Pulichintala. Beyond Vijayawada, stretching away on both sides of the river is the alluvial deltaic plain formed by its silt. Through it, the river continues in a single channel of great width for another 40 miles (64.4 km) when it sends off a branch to the left and, after a course of 20 miles (32.2 km), it enters the sea.

The drainage basin of the river lies chiefly under the influence of the south-west monsoon and, therefore, from June to October, a large quantity of water is brought down, occasionally swelling into high floods. After October, the discharge of the river decreases rapidly. During the following three months, it dwindles away into a petty stream.

HISTORY OF THE PROJECT

For the irrigation of areas south of the Krishna River various proposals were put up at different times. In 1903, the Pulichintala Scheme was investigated. It envisaged the construction of a dam at Pulichintala to irrigate 600,000 acres (243,000 hectares) in the Guntur District. In 1930, the former Hyderabad State Government investigated the site for the

Nandikonda Dam and proposed a joint scheme with the Madras State. But, as the Madras Government did not participate in the scheme, the Hyderabad Government carried out investigations of the dam site and the left-side canal for irrigating land in their own territory. Again, in 1952, the Hyderabad Government made out proposals for the construction of a high dam across the Krishna River at Nandikonda for the irrigation of about 790,000 acres (319,000 hectares) in Hyderabad and 233,000 acres (94,000 hectares) in the Andhra State and for the development of 168,000 kW of power.

Earlier, in 1951, the Madras Government proposed the Krishna-Pennar Scheme to be completed in stages. The scheme, among others, contemplated the construction of two dams—at Siddeswaram on the Krishna River and at Somasila on the Pennar River, with a barrage downstream of the latter, and a link canal connecting the two reservoirs.

Before taking a decision on these schemes, the Planning Commission of the Government of India appointed a committee under the chairmanship of Dr A. N. Khosla to examine and report on the most economical method of utilizing the waters of the Krishna. The Committee, while commenting on the Krishna-Pennar Project, drew up an integrated programme. The stage I of this programme envisaged the construction of a dam at Nandikonda, with canals on both sides to provide irrigation in the State of Andhra and in the former State of Hyderabad (Fig. 39).

The Nagarjunasagar Multipurpose Project took definite shape in 1954 when a project report was prepared. The Project envisaged the construction of a masonry dam across the Krishna River at Nandikonda in the Nalgonda District of Andhra Pradesh. The generation of power was proposed at the site of the dam and irrigation through two canals on the left and right banks. The work on the Project was taken up in 1955. The Planning Commission approved the first project estimate of 911.2 million rupees in September 1960. The construction of the masonry dam, along with the spillway gates, was completed in 1974. The construction of the Right and Left-Bank Canal Systems is in progress.

The credit for the conception of the scheme goes to Dr K.L. Rao, who later on became the Minister of Irrigation and Power in the Government India. The scheme was executed by Mir Jaffar Ali, Chief Engineer of Andhra Pradesh. The Administator of the Project was G. A. Narsimharao. Pandit Jawaharlal Nehru, Prime Minister of India, inaugurated the Project on 10 December 1955. The construction of the dam was started in 1957 and was completed in 1974.

The main features of the Project are as below:

1. The Dam

(i) Masonry length	1,450 metres
Maximum height	125 metres

(ii) Earth-dam length	3,416 metres
(iii) Spillway gates	26, each of 13.72×13.42 metres
(iv) Maximum flood discharge	53,810 cumecs (1900,000 cusecs)
(v) Storage capacity:	
Gross	11,558 cumecs (9.37 million acre-feet)
Live	6,560 cumecs (4.51 million acre-feet)[1]
2. The Right-Bank Canal	
(i) Main Canal: Length	203 km
Head discharge	312 cumecs (11,000 cusecs)
(ii) Annual irrigation proposed	475,000 hectares
3. The Left-Bank Canal	
(i) Main Canal: Length	178 km
Head discharge	312 cumecs (11,000 cusecs)
(ii) Annual irrigation proposed	392,000 hectares
4. The ultimate irrigation potential	867,000 hectares

Research in Design and Material

Extensive research in the design and material for the dam was conducted at the Andhra Pradesh Engineering Research Laboratories at Hyderabad and at the site of the dam on the bank of the river at Vijayapuri. A working-model of the dam was built for finalizing the design of the spillway and a number of other major features.

Main Features of the Nagarjunasagar Dam

The Nagarjunasagar Dam takes its name after Nagarjuna, a great Buddhist saint and philosopher, who established a university at a place, now named Nagarjunakonda after him, in the second century.

The Krishna River enters a gorge, immediately after its confluence with the River Tungabhadra. The high mass of hills at the sides extends up to the Village of Chintalapalem in the north, beyond which the river widens. The dam is located in this reach of the river, about 1.5 miles (2.4 km) below the Village of Nandikonda. The width of the river gorge at the site is about 3,000 ft (914.4 m), which is sufficient to locate the powerhouse and to discharge the floods. The bed is rocky, with granitoid gneiss extending from one flank to the other.

The dam is of gravity type and straight in plan (Fig. 40). The top of the dam is 362 ft (110.3 m) above the average riverbed level. The ultimate area of waterspread of the reservoir, at elevation 590 is 110 sq. miles (284.9 km^2) and the capacity of the reservoir at that elevation is

[1] Adapted from *Major Dams in India*, C.B.I.P., New Delhi, 1979, p. 5

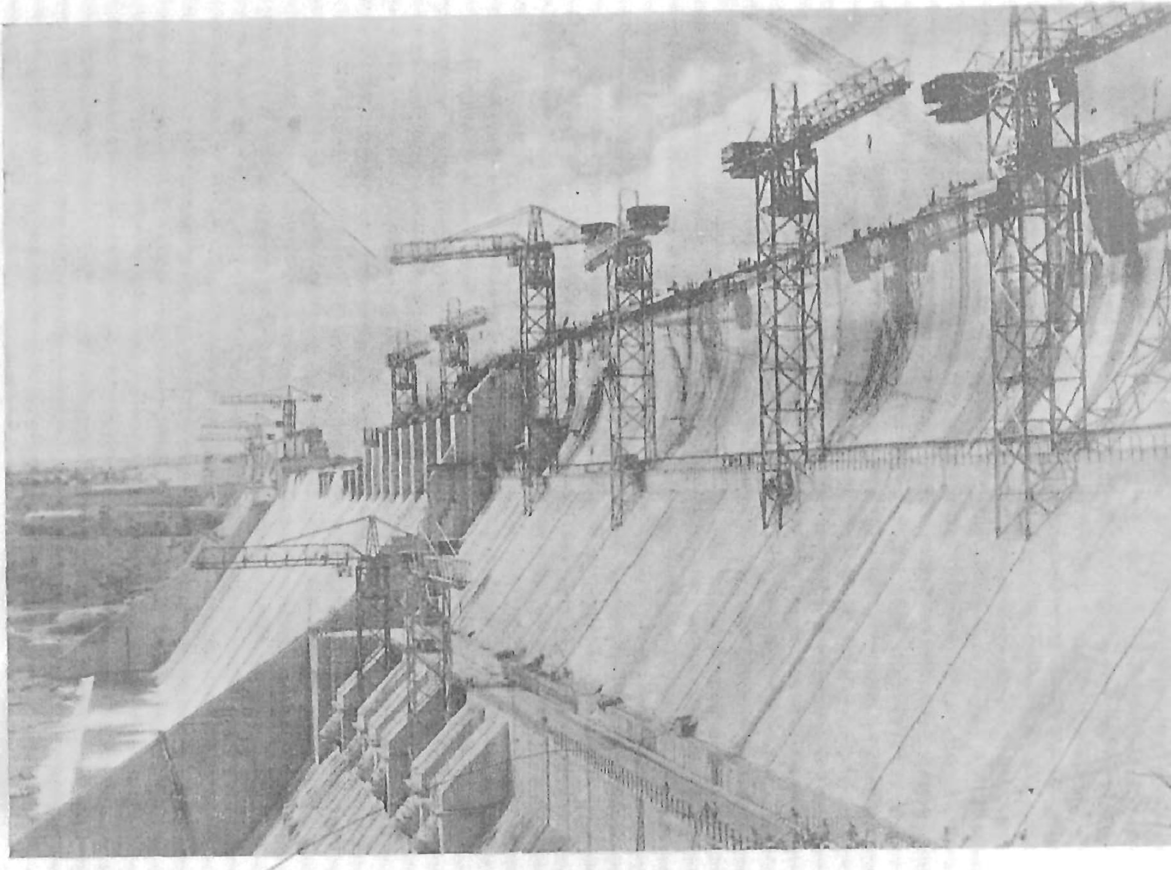


FIG. 40. The Nagarjunasagar Dam: the Village of Nandikonda, District Nalgonda, Andhra Pradesh; constructed during 1957-1974 for irrigation and the generation of hydro-power. (PIB)

FIG. 41. The Index Plan of the Rajasthan Canal Project. The Rajasthan Canal takes off from the Harike Barrage. The total length of the main canal is 685.5 km. At Stage I, it would irrigate 5,40,000 hectares. (From *Bhagirath*)

9.37 million acre-feet (11.6 T. M. cu.m.).

The dam consists of a spillway section, 1,550 ft (472.4 m) long, capable of discharging 1,709,000 cusecs (45,393.5 cumecs) over the spillway and, in addition, two sluices of 10 ft×25 ft (3.0 m×7.6 m) size, on the two sides of the spillway and a diversion-cum-irrigation tunnel 27 ft (8.2 m) in diameter are provided to discharge 85,000 cusecs (2,407 cumecs). On each side of this section is a non-overflow section totalling 3,206 ft (977.1 m) in length. The overall length of the masonry dam is 4,756 ft (1,449.6 m). In continuation, there is an earth dam on both flanks for a length of 10,570 ft (3221.7 m).

The dam serves the needs of irrigation, flood control and power.

The Right-Bank Canal

The canal on the right bank takes off through a tunnel 27 ft (8.2 m) in diameter, of a horseshoe section, for a total length of 4,135 ft (1,260 m). The designed head discharge of the canal is 21,000 cusecs (594.7 cumecs). It runs in a falling contour along the western borders of the Guntur and Nellore districts for a length of 276 miles (444 km) and falls into the Pennar River, below Somasila. The full scheme will bring under irrigation 1,858,000 acres (729,000 hectares).

The Left-Bank Canal

The Left-Bank Canal takes off from a head sluice through a tunnel, 32 ft (9.7 m) in diameter and 7,500 ft (2,286 m) in length. The designed full-supply discharge of the canal is 15,000 cusecs (424.8 cumecs). This canal will irrigate about 144,000 acres (582,000 hectares).

Besides ensuring water to 1,050,000 acres (424,000 hectares), now under irrigation in the Krishna Delta, the canal will bring under irrigation an additional 150,000 acres (60,000 hectares) of the first crop, 150,000 acres (60,000 hectares) of the second crop and about 25,000 acres (10,000 hectares) of perennial crops.[2]

Cost

The project estimate was first revised to 1,635.4 million rupees and was approved by the Planning Commission in 1969. The Project was reformulated to include the lining of the Left- and Right-Bank Canals and the latest cost is about 5,330 million rupees.

The Cropping Pattern

The research in the cropping pattern was undertaken by L. Venkataratnam and his team through soil surveys, water-requirement trials and ferti-

[2] *Development of Irrigation in India*, pp. 151-5

lizer experiments. Areas were earmarked for the growing of suitable crops, such as rice, hybrid sorghum, pearlmillet, maize, groundnut, chillies and onion. Procedures were also developed for the most beneficial use of water and fertilizers.

The additional production in 1967-68 was estimated worth 400 million rupees. When the irrigation potential of 8,033 ha (2,060,000 acres) is realized, production would increase still further. This project has made the Guntur, Nalgonda, Khammam and Krishna Districts of Andhra Pradesh most productive.[3]

[3]Venkataratnam, L. Cropping pattern in Nagarjunasagar Project, *Bhagirath*, Vol. 16, No. 1, Jan. 1969

CHAPTER 11

THE RAJASTHAN CANAL PROJECT
1956

THE Rajasthan Canal Project, one of the largest canal systems of the world, is a gigantic human effort to transform a part of the vast Thar Desert into a land of plenty and prosperity. The people of the area often have to move out with their herds of cattle, especially in years of scarcity, to places where they can find water to sustain their existence. The rainfall is scanty and varies from year to year; whereas in the Jaisalmer District, the average rainfall is 8 to 20 cm (3 to 8 in.), in the Bikaner Division, it is 20 to 30 cm (8 to 12 in.).

The surface of the area commanded by the Rajasthan Canal Project is covered with blown sand brought from the south-west of the Rann of Kutch and from Sind. This sand forms undulating sand-dunes, 20 to 200 ft (6.1 to 60.9 m) in height, with extensive stretches of flat land in between. There are very few trees in this area. However, during and after the rains, large portions become a green pasture-land. The sandstorms are a daily occurrence during the dry summer months, and the temperature rises very high in summer, touching over 50°C, whereas in winter it sometimes falls below the freezing-point. The subsoil water-table is 200 to 300 ft (60.9 to 91.4 m) below the ground level, and is often brackish and unfit for irrigation and human consumption.

The average density of population is less than 10 per square mile (3.8 per km). The population consists mainly of nomads who keep herds of cattle and flocks of sheep. Ghee, wool and leather are the main items of export. In the years of low rainfall, even the nomads leave and the land becomes totally desolate.

HISTORY OF THE PROJECT

The prospect of an irrigation project for the area was mooted in 1904. It was stated "the water was there and the land was there waiting for water, while the slope of the country was all in the right direction, and there appeared no doubt as to the feasibility of an irrigation project".

A proposal for a canal taking off from Harike on the Sutlej, just below the junction of the Rivers Sutlej and Beas, was put forward in 1948. The Central Water and Power Commission prepared a preliminary project in 1953. It indicated a definite potential for the utilization of the waters of these rivers in Rajasthan, and recommended its being taken up as a productive project. The Rajasthan Government carried out detailed surveys and the final project was prepared in 1956. Credit goes to Kanwar Sen, an eminent engineer, for the formulation of this project. The project was approved by the Planning Commission and the Government of India in July 1957, and was inaugurated on 31 March 1958 by Pandit Govind Ballabh Pant, former Home Minister, Government of India.

The project estimate amounted to Rs 667 million and the project was intended to serve 3.36 million acres (1.4 million hectares) of culturable commanded area, out of which 0.9 million acres (0.4 million hectares) was to receive perennial irrigation.

The project envisaged the construction of:

(i) The Madhopur Beas link channel to divert the surplus supplies of the River Ravi into the River Beas, and the share of the cost of the Harike Barrage;

(ii) The construction of 110.8 miles (178.3 km) of the lined Rajasthan Feeder, with a head discharge of 18,500 cusecs (523.9 cumecs); and

(iii) the construction of the unlined Rajasthan Canal, 350 miles (563 km) long, and branches and distributaries.

The Indus Waters Treaty, which was concluded between India and Pakistan in 1960 regarding the allocation of waters of the Indus Basin Rivers, provides that Pakistan shall be allowed to continue its use of the flow waters of the Ravi and the Beas during the transition period of 10 years from 1960. It has been stipulated in this agreement that, for the first five years India shall not reduce the quantum of winter supplies previously utilized by Pakistan but may reduce them during the next five years only when the replacement supplies become available. It has also been stipulated that if, on account of any reason, Pakistan is not able to complete its replacement works, it can have an extension of the transition period by another one, two or three years. Therefore the proposals, as envisaged in the 1957 estimate to get perennial supplies only for 900,000 acres (360,000 hectares) became ineffective, because, at the end of the transition period, irrigation could be extended to much larger areas.

The surplus supplies of the Ravi and the Beas cannot be utilized in full unless some storage works and diversion works are taken up. The scheme for constructing the Pong Dam for the storage of the Beas waters was, therefore, mooted and has since been finalized, and thus the availability of water for perennial irrigation over a much larger area has become feasible. In 1957 the project was accordingly revised to incorporate larger irrigation benefits from the Rajasthan Canal and also to include the share of the cost of the Pong Dam allocable to the Rajasthan Canal Project. The revised project now envisages the extending of the perennial irrigation to 3,080,000 acres (1,240,000 hectares) instead of 900,000 acres (360,000 hectares), as provided in the 1957 project.

The Rajasthan Canal takes off from the Harike Barrage. The total length of the main canal is 426 miles (685.5 km), out of which the portion of first 134 miles (215.6 km) serves exclusively as a feeder canal. The canal will irrigate the land in the Ganganagar, Bikaner and Jaisalmer districts.

Lift irrigation around Lunkaransar is also provided for. The total gross culturable commanded area of the canal is 5,000,000 acres (2,023,430 hectares). Out of this gross area, the culturable commanded area is 3,660,000 acres (1,400,000 hectares).

Soil surveys of a considerable part of the culturable commanded area have been made. About 11,000 soil samples were analysed under the guidance of the Director (Soils), Central Water and Power Commission.

The Lining of the Canal

The main canal has been lined with burnt clay tiles laid in cement mortar to prevent absorption losses in the sandy reaches. Actually, it has been calculated that the cost per cusec of the lined main canal would be less than that for an unlined one, owing to the prevention of absorption losses. Irrigation from a lined canal could also be extended to a much larger area than had the canal remained unlined.

Moreover, without lining, the danger of breaches would always be there. It would spell disaster in the arid areas served by the canal, where even drinking-water would not be available in the event of a breach. Another reason advanced in favour of lining the canal is the safety and economy of operation and the maintenance of a lined canal against the hazardous and expensive maintenance of an unlined canal.

It is estimated that there would be 60 per cent losses owing to absorption, if none of the canals or distributaries were to be lined. The losses would go down to 45 per cent if only the main canals were to be lined and to 36.6 per cent if the main and branch canals were to be lined. If the distributaries were also to be lined, the absorption losses could be cut down to 28 per cent. For the present, however, only the main canal is proposed to be lined.

Difficulties Encountered

The remoteness and the barrenness of the countryside traversed by the Rajasthan Canal make the execution of construction extremely difficult. Dust storms during summer slow down the progress of work.

The greatest hurdle in the execution of this project is the complete absence of water for drinking or construction. It is first necessary to arrange for the water for construction by means of pilot channels or pumping through long pipelines. This itself is a difficult task.

As the area through which the canal passes is sparsely populated and there are very few villages, most of the labour has to be imported from outside and arrangements for their accommodation, drinking-water, and medical and education facilities are to be provided before construction can be started. In fact, whole townships had to be constructed at various places along the alignment of the canal. The scarcity of water prevents the taking up of the construction of a canal for more than 30 to 40 miles (48.3 to 64.4 km) at one stretch.

Owing to the lack of rail or road communications, the construction materials required for lining the main canal have to be carried along *kutcha* roads through sand-dunes.

Along very long stretches of the main canal, clayey soil required for tile-burning is not available and, therefore, tiles required for lining and bricks required for masonry work have to be carried over long distances, thus entailing a heavy burden on construction. Lastly, it is very difficult to persuade skilled workers to live in the desert to operate various types of earth-moving machines employed on construction work.[1]

ORGANIZATION

At New Delhi, there was held on 7 November 1958 a conference at which representatives of the Central Government and those of the governments of Rajasthan and the Punjab were present. It was decided to set up a Committee of Direction and a Rajasthan Canal Board to ensure efficient, economical and early execution of the project. The Minister for Irrigation and Power, Government of India, was the Chairman of the Board, and the representatives of the beneficiary States were the members.

SAND-DUNE STABILIZATION, AFFORESTATION AND SHELTER-BELT PLANTATION

Scientists of the Central Arid Zone Research Institute, Jodhpur, have discovered techniques of stabilization of shifting sand-dunes. These techniques are being applied to the Thar Desert. They comprise (a) the protection of shifting dunes against all biotic interference; (b) effective micro-windbreaks on the windward side of a dune either in 5-m parallel strips or 5-m^2 chess-board design; (c) the growing of grasses or the transplanting of trees and shrub species raised in sun-dried earthen bricks on the leeward of micro-windbreaks. The suitable species for the afforestation of the shifting dunes are trees, such as *Prosopis cineraria, Prosopis chilensis (P. juliflora), Acacia tortilis, Acacia senegal, Albizia lebbeck;* shrubs *Calligonum polygonoides, Lycium barbarum, Acacia jacquemontii, Clerodendrum phlomoides* and *Ziziphus nummularia; and* grasses, such as *Saccharum bengalense, Lasiurus sindicus, Panicum antidotale, Panicum turgidum, Cenchrus ciliaris* and *Cenchrus setigerus.* In extremely arid conditions, *Acacia tortilis, Prosopis juliflora, Calligonum polygonoides* and *Acacia jacquemontii* have been found suitable.

For afforestation, a large number of species of *Eucalyptus, Acacia* and others, generally from similar iso-climatic zones of the world, were introduced. Out of different exotic tree species, *Acacia tortilis, A. aneura, A. radiana,*

[1]*Irrigation Development in India*, pp. 129-31

Eucalyptus camaldulensis, E. terminalis, Cassia phyllodenea, etc., have been found to be promising. A technique was devised for establishing shelter belts with a number of species, e.g. *Acacia tortilis, Prosopis juliflora, Tamarix articulata, Acacia nilotica* and *Cassia siamea.* These trees are fast-growing, and drought-resistant.[2]

DEVELOPMENT OF IRRIGATION

Irrigation from the Rajasthan Canal was phased in two stages. The first phase was the non-perennial stage, at which the storage supplies were not available up to about 1970-71; the second phase was the perennial stage, at which the storage supplies became available after the construction of the storage dams on the Beas and the Ravi rivers.

Stage I works comprise a 204-km-long feeder canal, 189 km of the main canal and about 3,000-km-long distribution system to provide irrigation for 540,000 hectares (1,350,000 acres) of the culturable command area, with an intensity of irrigation of 110 per cent. One of the important components of Stage I is the Lunkaransar-Bikaner Lift Canal providing irrigation for 51,000 hectares (127,500 acres) culturable command area along with drinking water supplies to the Bikaner Town and the adjoining villages. There are four pumping-stations to lift the supplies up to a height of 60 metres. The Stage I works are in advanced stage of completion with target of March 1980 for the creation of final potential. The actual annual irrigation achieved so far has been 288,000 hectares (720,000 acres).

The irrigation infrastructure items in Stage II comprise the construction of the canal system up to the outlet head, releasing water into the water-courses, leading to the farms. The entire canal system consisting of the main canal of 256 km (in continuation of Stage I of the Project) and about 3,500 km of branches and distributaries up to the irrigation outlet would be lined to conserve water in view of the pervious nature of the soils. The earthwork is planned to be executed by heavy earth-moving machinery as well as by manual and animal labour. Stage II envisages the development of 600,000 hectares by gravity. The works on Stage II of the project have been started and earthwork and lining have been completed on the main canal in 50-km and 25-km lengths respectively. A number of masonry structures and works on the branch systems are also in progress. A water-supply channel has been constructed in a length of 110 km.

An expenditure of Rs 280 million was incurred on the project by March 1978, and thereafter an outlay of about Rs 2,000 million would be needed to complete the project within the next 5-6 years.

A good deal of credit for the construction of the canal goes to Hari Singh Chowdhri, Chief Engineer of the Project.

[2]Malhotra, S.P. Combating desertification in arid zone of Rajasthan, *Bhagirath,* Vol. 24, No. 3, July 1977

THE DEVELOPMENT OF THE COMMAND AREA: 200,000 HECTARES OF STAGE I (IDA PROJECT)

A Command Area Development Project is in progress to provide all necessary project works and agriculture-supporting services to enable the full realization of the benefits from the potentials created by making huge investments in the major irrigation projects of the Pong Dam and the Rajasthan Canal. The present project covers 200,000 hectares of irrigable land in two blocks within Stage I of the Rajasthan Canal Project.

The Project includes the lining of 915 km of distributary canals, the construction of 431 km of roads, water-supplies for 100 villages, pasture development and afforestation of 35,000 hectares of high-shifting sand-dune lands surrounding the irrigated area, and the provision of 46,000 nutrient tonnes of various fertilizers to build up and restore soil fertility. The on-farm development works under the Project include the lining of 5,800 km of water-courses, the land-shaping of 32,000 hectares and the reclamation of 17,000 hectares of sodic soils. The Project will assist the farmers to complete a further 26,000 hectares of land-shaping and 17,000 hectares of soil reclamation and improve their on-farm field channels.

The implementation of the project will take six years and will use labour-intensive methods, wherever feasible. The project cost is estimated at Rs 1,390 million and a World Bank credit of Rs 680 million has been secured for this project with participation by the Government of India, the Government of Rajasthan and institutions such as the Agriculture Refinance Development Corporation and Commercial Banks.

By March 1978, the survey and planning for the on-farm development works was completed in respect of 1,000 blocks (*chaks*), covering 150,000 hectares. The construction of lined water-courses had been taken in hand in 500 *chaks*. By March 1978, the on-farm development works have been carried out on an area of about 50,000 hectares.

For the remaining 340,000 hectares of command area, the cost of these works has been estimated at about Rs 1,000 million.

The on-farm development works of Stage II include the construction of lined water-courses, field channels beyond the irrigation outlets and large-scale land development. These works will be financed by the farmers with funds either from their own resources or from the credit obtained from institutional agencies. Among these items, the lining of water courses and the large-scale development will be carried out by the Command Area Development Authority set up by the State and the cost of work will be charged to the farmers and recovered in easy instalments.

The on-farm development (construction of lined water-courses and land-shaping) will lead to greater economy in the use of water and will lead to a more intensive cropping pattern. The total area of land under various categories which needs shaping is estimated at about 94,000 hectares, of which 70,000 hectares can be levelled by the farmers themselves without any financial assistance from the Project, and 24,000 hectares will need levelling through the agency of the Project Authority.

In addition to the irrigation infrastructure and the on-farm development works, there will be complementary infrastructure works, including the village and district roads, markets, storages, agro-industries, co-operatives, health, education, and transport. These will be undertaken gradually in a phased manner as the production increases. These works are estimated to cost Rs 1,770 million. Land-shaping will be taken up on 24,000 hectares and the entire length of water-courses will be lined.

The total land-levelling is proposed to be completed in 15 years. Work with respect to 8 million cubic metres will be completed in the first eight years from the start of the on-farm development works and the remaining 16 million cubic metres during the remaining period. It has been estimated that about 20,000 km of water-courses will be lined in the command area. The work is proposed to be done manually, including the excavation of earth for the tiles and manufacturing them. The lining of water-courses for more than 250,000 hectares is proposed to be completed during the first eight years and the remainder in the next seven years.

Employment Opportunities for Labour

The Rajasthan Canal Project has been providing employment for a large number of labourers, particularly during the famine years. During March 1977, 53,300 human labour, about 8,000 camel-carts and more than 4,600 donkeys were engaged to execute the Project.

Cropping Pattern and the Estimated Production

The cropping pattern envisages the growing of wheat, chickpea, cotton, mustard, groundnut, fodder, etc. On full development, the annual production of farm produce from Stage II will be about two million tonnes of grain and about four million tonnes of fodder. In addition, all the long-staple cotton, which the country needs for its textile industry will be grown.

The cropping pattern, as envisaged under the Project, is as below:

	Crop	*Percentage of area under crop Stage I and Stage II*
A	*Kharif*	
1	Vegetables	1.00
2	Cotton	16.50
3	Groundnut	5.00
4	Pulses	7.50
5	Fodder crops	4.50
6	Pearl-millet *(bajra)*	12.50
		47.00

Crop	*Percentage of area under crop Stage I and Stage II*
B *Rabi*	
1 Wheat	30.00
2 Mustard	10.00
3 Chickpea (gram)	20.00
4 Sugarbeet	2.00
5 Berseem (Egyptian clover)	1.00
	63.00
Total for the year	110.00

ESTIMATED IRRIGATION AND FOOD AND FIBRE PRODUCTION, RAJASTHAN CANAL PROJECT

	Stage I		*Stage II*	
	Area ('000 ha)	Production of grain ('000 tonnes)	Area ('000 ha)	Production of grain ('000 tonnes)
A *Kharif*				
1 Cotton (fibre)	124	224	138	248
2 Groundnut	27	47	30	52
3 Pulses	76	113	84	126
4 Pearl-millet (*bajra*)	27	68	30	75
B *Rabi*				
1 Wheat	189	567	210	630
2 Mustard	65	84	72	94
3 Chickpea (gram)	130	259	144	288
4 Sugarbeet	10	216	12	240

SOURCE: *Rajasthan Canal Project Stage II, Water and Power Development Consulting* Services (India) Ltd, New Delhi, February 1978

CHAPTER 12

THE PUBLICATIONS OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH

BOOKS, MONOGRAPHS AND JOURNALS 1955–1962

THE need for scientific literature suited to the conditions prevalent in the country was felt for a long time, particularly in agriculture, botany and zoology. In textbooks relating to these subjects, the specimens were often foreign, and plants and animals common in this country were hardly mentioned.

In 1955, when I joined as Vice-President of the Indian Council of Agricultural Research, opportunity came for initiating an ambitious programme of publications on agriculture and botany. A minor incident sparked the programme. A delegation of Russian scientists came to the ICAR building to meet me, and there arose the question of presenting a suitable book to the members of the delegation. When I enquired what book was available, the Secretary brought Col. Ram Nath Chopra's *Poisonous Plants of India.* I felt it was not a book fit to be presented to a delegation from a friendly country. The next day, I discovered that a manuscript of a book on Mango by Ranjit Singh and S. L. Katyal, with many illustrations in colour, was ready and could be sent to the press. The publications of the Government of India were drab and poorly printed because of the tender system, according to which the press which gave the lowest quotation was entrusted with the printing of a book. This system worked to the disadvantage of quality presses, whose cost of production was higher. The problem was how to overcome this financial hurdle created by office hands who were not quality conscious. Accordingly, I got prepared a list of all the quality presses in India and classified them into three categories. In the first category were presses which did quality work, particularly in colour-printing. The second category included presses which had good types but were not specialized in colour-printing. In the third category were presses which were doing printing of average quality. When a book contained a number of colour illustrations, quotations from the first-category presses alone were invited. This procedure ensured quality, as the competition was only among the best presses.

The production of books cannot be left to presses alone, for a lot of preliminary work is necessary, such as the providing of illustrations, lay-out and editing. This meant the reorganization of the entire set-up and the setting up of a Publications Directorate with competent editorial staff, and art and photography sections. Artists were necessary for designing title covers and for preparing illustrations in black and white, I felt it was also necessary to have a library of photographs of crops, domestic animals, farmers and their houses and farms. I employed a very competent artist-photographer, H. K. Gorkha, who was my companion in my travels all over India. During those tours, I guided the photographer in the choice of subjects. Fields, villages, houses, crops, forests, garden plants, domestic animals and typical farmers, both men and women, were photographed. Thus a comprehensive library of 10,000 negatives was built up and it provided material for illustrating books and magazines.

Next came the choice of the authors and the assignment of subjects. I found there was no lack of talented men among our scientists in the research institutes. An opportunity was given to them to write on the subjects in which they specialized. There are many good scientists in the country, but there are only a few who can express themselves clearly and concisely. To overcome this problem, I was fortunate in selecting an editor having a good knowledge of English and had a penchant for editing. He knew the intricacies of idioms, grammar, punctuation, capitalization, spelling, etc. The botanical names of plants, which are changed from time to time according to the rules of botanical nomenclature, also presented a problem. For this purpose, an editor having a good knowledge of systematic botany was appointed.

The subject which attracted my immediate attention was of cereal crops, which on account of food shortages plaguing the country, deserved the first priority. An International Seminar on Rice, sponsored by the FAO, was to be held in October 1956. R. L.M. Ghose, Director of the Central Rice Research Institute, Cuttack, and his colleagues had collected material on the history, morphology, breeding and diseases of rice. This material was quickly edited and given the title *Rice in India,* and was printed in September 1956. This was the first book published under the publications programme, which I had initiated.

Horticulture, particularly the much-ignored ornamental plants, drew my attention next. After the publication of the monograph on *Mango* in 1957, I called a meeting, to which I invited the leading horticulturists and gardeners. Books on gardening contained long lists of names of plants, which included trees, shrubs and climbers and their brief descriptions. Nature has endowed our country with a great diversity of climate. This diversity enables us to grow all types of plants—from the arctic to the tropical. I felt there was a need for separate books on flowering and ornamental trees, shrubs, climbers and annuals, in which, apart from detailed description, hints on their cultivation and protection measures against pests and diseases should be given. I accepted the assignment for a book on *Flowering Trees,* and it was published in 1957. It set a new standard in publications on science and was admired

FIG. 42. Apart from the ICAR, the Indian Central Cotton Committee, the Indian Central Oilseeds Committee, the Indian Central Coconut Committee and the Indian Central Jute Committee, also published from 1956 to 1960 monographs on the crops with which they were concerned.

FIG. 43. Some of the books and monographs published by the ICAR from 1958 to 1960.

by a large number of people, including Sir C. V. Raman, the Indian Nobel Laureate in Physics, who had a passion for colour. This book served as a guide to other authors, and was briskly sold out, thus assuring the Financial Adviser of the Indian Council of Agricultural Research that there was no financial risk involved in the publications programme to which substantial funds were allocated. In fact, it became evident that a well-written book, with sound and useful information, if produced in an attractive manner, involved no financial risk, and could be a profitable investment.

Dr B.P. Pal, who, apart from being an outstanding wheat breeder, is also a lover of plants, wrote under this programme a number of books for publication, viz. *Beautiful Climbers* (1960), *Flowering Shrubs* (1967), *Rose in India* (1966), and *Bougainvillaeas* (1974).

The Commodity Committees of the Ministry of Food and Agriculture, of which I was the Chairman, were also brought within the orbit of this programme. They published monographs on *The Coconut Palm* (1956), *The Arecanut Palm* (1958), *Jute in India* (1959), *Indian Tobacco* (1960), *Cotton in India*, 4 Vols (1961), and on oilseed crops.

Monographs on Algae and Fungi

Then I started a programme of publication of monographs on various disciplines of botany. Here, I gave precedence to algae, a subject in which I was personally interested. A good deal of research on algae in India was done by the late Dr M. O. P. Iyenger and me. This work led to the discovery of a number of new and interesting plants. Information on these new species of algae was scattered in a number of research journals, but teachers and students of botany were not familiar with them. I felt that all that knowledge must be presented in a series of monographs. I called a meeting of algologists from all over India in 1956 and drew a comprehensive programme of monographs. In this work, M. O. P. Iyenger gave me much co-operation and support. Monographs on Volvocales and Siphonales were assigned to him. I agreed to write a monograph on Zygnemaceae, in which I was assisted by a new-found industrious student, G. S. Venkataraman. A monograph on *Cyanophyta* was assigned to Dr T. V. Desikachari. Both these monographs were published in 1959 and provided other assignees with guidance. M. O. P. Iyenger was an over-cautious man who was never satisfied with his work and was constantly endeavouring for perfection. I sent an artist from the ICAR to his home in Triplicane, Madras, to ink his diagrams of algae. With all this assistance, Iyenger could not complete the monographs in his lifetime. After his death, his devoted student, Desikachari, completed these monographs.

In the production of these monographs, one problem was of the size of print order. We found that an edition of one thousand was adequate for all-India and world sale. When the print order exceeded one thousand copies, it was difficult to sell the surplus.

After the publication of a couple of monographs on Algae, I called a meeting of the mycologists working in the universities as well as in research institutes, and made a publication programme of monographs on Fungi. This programme was pioneered by Dr K. S. Thind, whose *Clavariaceae of India* was published in 1962. It was followed by an excellent monograph on *Indian Hyphomycetes* by Dr C. V. Subramaniam.

Monographs on Botany

Monographs on botanical subjects are really the responsibility of the Council of Scientific and Industrial Research, but that responsibility they had not owned till then. When Dr Hussain Zaheer, a scientist with broad views, became the Director-General of the CSIR, I found there was a congenial atmosphere for initiating such a programme. A monograph on *Gnetum*, written by Dr P. Maheshwari and Vimla Vasil, was the first to be published in 1961. It was followed by four others.

All these monographs were favourably reviewed in scientific journals and were appreciated by teachers, researchers and students. The monographs were helpful in research, for they indicated the present frontiers of knowledge in the subjects they covered. Some of the monographs related to Indian plants only and a few were on global basis. The latter won recognition in many universities in foreign countries and are consulted by specialists. My object in initiating this programme of monographs was to provide material for a sound textbook of Botany, in which most of the interesting types of plants found in India could be included. Such a book still remains a dream. Now there is need of a man who can synthesize all this scattered knowledge in the form of a textbook, relevant to the flora of India.

When I look back, I realize that it was not at all a smooth sailing. When the programme of producing books on agriculture was started, it was opposed by Malcolm Orchard, an American Adviser on Extension Literature attached to the ICAR. He was even supported by some members of the ICAR staff. He was of the view that the ICAR should produce only farm bulletins, and not books. Farm bulletins produced by the Indian Council of Agricultural Research had application only to limited areas. Considering the size and the diversity of the country and its agro-climate only the State governments could take up the production of farm bulletins suited to their own conditions. This is the work which the extension directorates of the agricultural universities have taken up now in right earnest. My feeling was that both the books on agriculture and farm bulletins are necessary and each had its own place in the agriculture of the country. Ultimately, it was decided that farm bulletins could continue, but books must also be produced. After this decision, a massive publication programme, which included monographs on Algae, Fungi, and principal crops of India, reference books, technical books, textbooks, popular books and manuals was started in right earnest. Up to 1956, hardly one or two books in a year were published by the ICAR. From 1957 onwards, their number has increased. In 1959, nine books were published; in 1960, thirteen; in 1961, nine; and in 1962, fourteen.

When I think of the past, I feel a sense of satisfaction that a correct decision had been taken. The ICAR is now the biggest publisher of books on agriculture, horticulture and related subjects. Financially also, the programme of publications has proved a success, thus proving that if a book is written by a recognized authority on the subject, and is well produced, it sells. The credit for the nice get-up and printing of ICAR publications goes to Krishan Kumar, Chief Production Officer, who is a well-known specialist and a dedicated worker in his own field of specialisation.

Journals

The Agricultural Journal of India, and the *Memoirs of the Department of Agriculture in India*, published from the Imperial Agricultural Research Institute, Pusa, since 1906, were the predecessors of the current journals of the ICAR. The Inspector-General of Agriculture was the editor and he was assisted by an advisory committee consisting of the staff of the Imperial Agricultural Research Institute. The journal dealt with subjects connected with field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungal diseases, co-operative credit, management of farm stock, cattle breeding, cattle diseases, farm implements and the like. In the Memoirs, scientific work connected with agriculture, including agricultural chemistry, economic botany, entomology, plant pathology and bacteriology found a place. Separate series were issued for the chief divisions of the science concerned, and each article appeared as a separate memoir under the series into which it fell.

The Journal provided a permanent record under one cover, of the practical results of agricultural research throughout India. It was also a medium of communication among the officers of different departments and it removed some of the isolation in which they worked. It was hoped that the Journal would also appeal to the leading agriculturists in India, who would be thus kept in touch with agricultural progress in the country, and would be able to test in practice the improved methods of cultivation, and the application of science to agricultural problems, which the steady progress of knowledge of the plant life rendered increasingly available.

Journals of the ICAR

In 1931, the Indian Council of Agricultural Research started two new journals, one devoted to research in agriculture and the other to that in animal husbandry. Almost at the same time, the Council renamed the *Agricultural Journal of India* to *Agriculture and Live-stock in India.*

The Indian Journal of Agricultural Science and *The Indian Journal of Veterinary Science and Animal Husbandry* were started in 1931 to encourage the exchange of ideas among workers engaged in research in different disciplines and to encourage investigations of applied value.

Agriculture and Live-stock in India included abstracts of research in agriculture as well as in animal sciences. It continued to be published every two months for nine years. It was decided to include information in a non-technical popular style in this journal. With this change in approach, the journal was given the name *Indian Farming,* in 1940. F. M. de Mello, the Editor of this journal, gave it a popular slant, but ensured quality in the articles. The covers were, however, dull and unattractive, and the get-up and printing were rather poor. I remember I requested Sir Herbert Stewart, the Vice-President, in 1945 to agree to a change in the cover illustration, which showed a miserable dhoti-clad farmer, driving a pair of bullocks yoked to a wooden plough. He did not agree.

In 1945, Dr Usha Nath Chatterjee, a plant physiologist, joined as Editor. A new policy was adopted that *Indian Farming* should reflect the current problems of rural development and the aspirations of Indian farmers. I planned a Special Number of *Indian Farming,* viz. "Developing Village India", which dealt with the problems of rural development. The Number was widely appreciated by the national leaders as well as by others. Devendra Satyarthi the Assistant Editor, who is known for his collections of folk-songs of India, produced an excellent lay-out and provided artistic photographs from his personal collection for this Number. *Indian Farming* now looked distinctive among the drab government publications.

After Independence, the need was felt for a journal in Hindi to promote scientific farming among Indian farmers. As a result, *Kheti* was born in 1948. Devendra Satyarthi edited this journal and D.N. Paliwal looked after its production.

Under the patronage of K.M. Munshi, Minister for Agriculture, a new series of *Indian Farming* was started in 1951 and the journal acquired an altogether new look. For this change, credit goes to M.G. Kamath, the Editor. The size of the journal was changed from crown quarto ($7\frac{1}{2}'' \times 10''$) to demy quarto ($9'' \times 11''$). Good-quality art paper was used and it was profusely illustrated. The printing of the journal was taken out of the control of the Manager of Publications, Government of India, and arrangements were made for its printing at a private press. *Indian Farming,* which used to be several months in arrears, started appearing on time, and with an attractive get-up.

With the realization of the importance of statistics in agricultural research, a new journal *Statistical Newsletter* was started in 1951. The publication of *Rice News Teller,* the matter for which was provided by the Central Rice Research Institute, Cuttack, was taken over by the ICAR in 1953.

New Journals of the ICAR

On my rejoining the ICAR as its Vice-President in 1955, I started a new quarterly, *Indian Horticulture,* in October 1956 to provide latest scientific information on the cultivation of fruits, flowers and vegetables. Artistically produced, this journal had an attractive four-page central colour plate printed on art paper.

In 1959, I started two new journals, viz. the *Indian Journal of Agriculture and Veterinary Education* and the *Indian Potato Journal.* In the same year, two new editors joined the Council, viz. Dr P. Kachroo for Research publications, and P. L. Jaiswal for semi-technical and popular publications. Dr Kachroo, who was the Editor of research journals, initiated a quarterly journal *Agricultural Research* in 1961 to report on the current research activities of the research institutes of the ICAR. Jaiswal started a new quarterly, *Indian Live-stock,* in 1963 at the instance of V. Shanker, the then Vice-President. An attempt was made in this journal to explain technical material through histograms, sketches and pictures. The illustrated journal was widely appreciated.

The publications programme in Hindi also received greater support. *Pashupalan,* a Hindi counterpart of the *Indian Live-stock,* was brought out in 1963. The programme became more organized and broad-based with the joining of Dr R. G. Chaturvedi in 1964 as Editor of Hindi publications.

Dr B. P. Pal paid personal attention to the contents of the research journals, and also raised their production standard with the able assistance of Krishan Kumar, Chief Production Officer. A series of review articles by scientists of international repute were published in these journals. The refereeing of papers was made stringent, and editing was done carefully, conforming to international style and standard. As a result of these steps, there was great improvement in the quality of the papers and their presentation. The journals received greater international recognition and the inflow of articles from foreign scientists also increased.

Axeing the Journals

In 1966, the Government of India experienced financial stringency. They decided to reduce the number of journals published by various government departments. As a result of the recommendations of the Cabinet Subcommittee constituted for the purpose, a number of journals issued by the Council and Commodity Committees were thoughtlessly discontinued or merged into others, ignoring the fact that they served special interests, which required separate treatment. *Indian Live-stock* was merged into *Indian Farming* and *Pashupalan* into *Kheti*. *Statistical Newsletter* was transferred to the Institute of Agricultural Research Statistics. *Rice News Teller*, *Indian Potato Journal*, *Agricultural Research* and *The Indian Journal of Agricultural and Veterinary Education* were discontinued. This, indeed, was a retrograde step at a time when agricultural education and research were making great progress. The name of the *Indian Journal of Veterinary Science and Animal Husbandry* was changed to *The Indian Journal of Animal Sciences*. Thus only five journals, four in English and one in Hindi, survived the economy drive.

From 1970, the emphasis in the Publications Programme shifted from voluminous monographs to smaller publications on crops and agricultural topics of importance. The programme was made need-based and problem-orientated. A large number of special numbers of *Indian Farming* and *Indian Horticulture* were brought out to focus attention on the current problems in agriculture.

A new agricultural digest, *Krishi Chayanika*, was started in 1973 to meet the increasing demand of high-quality scientific literature in Hindi. It publishes the digest of important articles on agriculture in simple language. In 1980, *Phal Phool*, a quarterly, was started to meet the needs of a journal devoted to horticulture in Hindi.

CHAPTER 13

BUILDING AGRICULTURAL RESEARCH INSTITUTIONS

1947–1976

By 1950, the Government of India had by and large solved the rehabilitation problems of the refugees who migrated from West Pakistan and could now look into the problems of agricultural research. Under the leadership of Prime Minister Jawaharlal Nehru, the patron-saint of science and technology, the Ministry of Food and Agriculture embarked upon an ambitious programme of raising research institutes on crops and animals, which had hitherto received scant attention. Before Independence, India had nine research institutes and now it has thirty-three. Out of these twenty-five relate to agriculture, seven to animal sciences and fisheries and one to statistics.

As a first step the premier national research institutes, viz. the Indian Agricultural Research Institute, New Delhi, the Indian Veterinary Research Institute, Izatnagar, and the National Dairy Research Institute, Karnal, were strengthened. Crops like rice, potato, cassava and horticulture in general, which had not received adequate attention in research during the colonial period, were attended to and research institutes were founded to attend to their problems. In the wake of partition of the country certain imbalances had arisen in the agricultural economy. These were particularly acute in respect of jute and cotton, as the best growing areas of these crops were included in Pakistan. This deficiency was made up both by research and extension. Problems of soil had not received proper attention in the colonial period. To make up this deficiency, institutes and a bureau were set up for research and survey of soil, land and water-use and management. Problems of salinity and alkalinity received particular attention. Problems of the arid zone and grasslands were also attended to by establishing research institutes. Since 1975 attention has been given to the needs of far-flung areas in eastern India. Above all, research institutes were brought in touch with the problems of the growers by building up extension links. Thus the ivory-tower isolation of some of these institutes came to an end.

Indian Agricultural Research Institute, New Delhi

In 1947 the Institute was renamed the Indian Agricultural Research Institute (IARI). On the initiative of K. M. Munshi, Minister, Food and Agriculture, the Ministry decided that the Institute should take more direct part in agricultural extension. As a first step, the Institute organized the Delhi Intensive Cultivation Scheme in 19 villages. In 1959 the entire

FIG. 44. A map of India, showing the location of research institutes of the ICAR. There are 30 research institutes of the ICAR, located in the different States and Union Territories of the country.

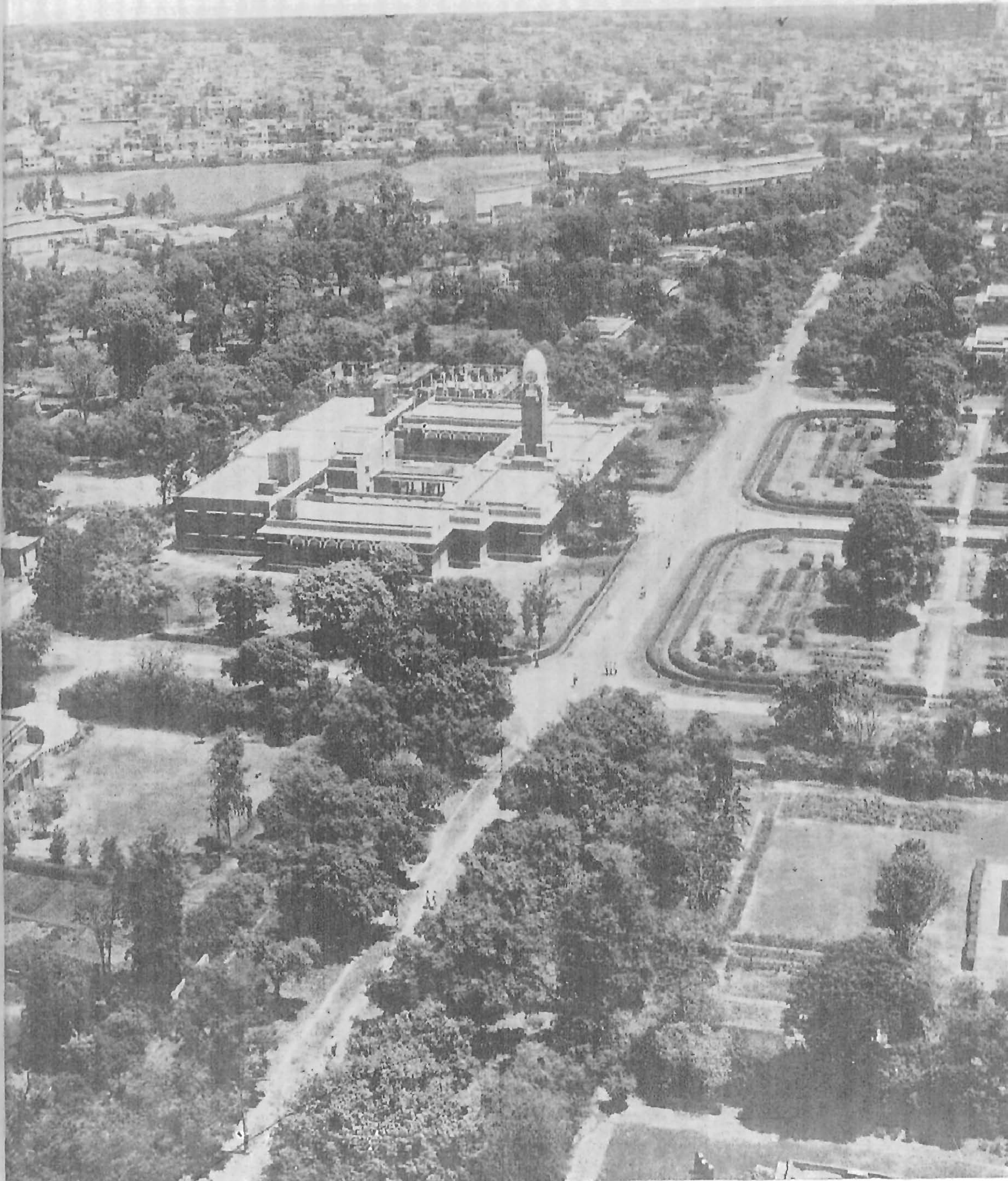


FIG. 45. The Campus of the Indian Agricultural Research Institute, New Delhi. In the centre is the Library building. The IARI was shifted from Pusa (Bihar) to its present site, mainly due to the efforts of Sir Fazl-i-Husain, Member in charge, Department of Education, Health and Lands in 1935.

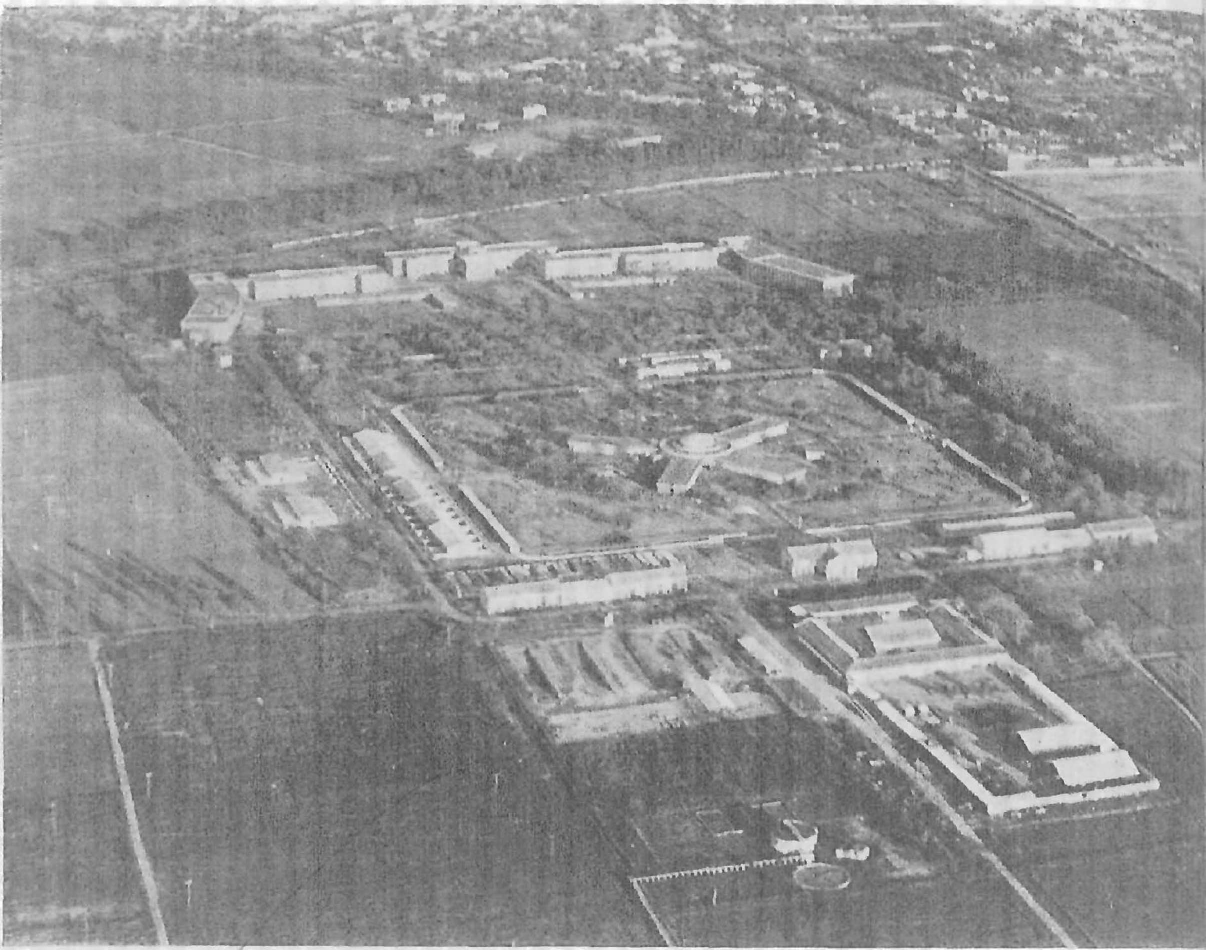


FIG. 46. The laboratories and farm complex of the National Dairy Research Institute at Karnal.

Kanjhawala Community Development Block comprising 56 villages was taken over by the Institute. The programme of extension now covers the entire Delhi State.

The original five sections were developed into five Divisions, and the Division of Agricultural Engineering was added. In 1956, the Division of Horticulture was constituted for dealing with fruits and vegetables by transferring research work on them from the parent Division of Botany. In 1970, the Division of Horticulture was further split into two, comprising a Division of Horticulture and Fruit Technology and a Division of Vegetable Crops and Floriculture.

The Plant Introduction unit of the Division of Botany was separated in 1961 and formed into a Division. In 1966, the Division of Plant Physiology and Phytotron was created out of the Division of Botany, which was renamed the Division of Genetics. The Seed Testing Unit in the Division of Genetics was developed into a Division of Seed Technology in 1968. In the same year a Nuclear Research Laboratory was set up with the general assistance of the UNDP (special fund) for affording research and training facilities for application of nuclear research techniques to agriculture. In 1960 two more divisions, viz. Agricultural Economics and Agricultural Extension, were created.

The All-India Soil Survey Scheme, started in 1956 within the Division of Soil Science and Agricultural Chemistry, developed into the All-India Soil and Land-Use Survey Organization in 1958. In 1979, the Plant Introduction Division was reorganized and expanded into the National Bureau of Plant Genetic Resources.

The IARI has 14 regional stations. Out of these, four are located at Pusa in Bihar, Kanpur in Uttar Pradesh, Sirsa in Haryana and Hyderabad in Andhra Pradesh. A regional station on Vegetable Research is located at Katrain in Kulu Valley, Himachal Pradesh. A Seed Research Products Station is located at Karnal in Haryana. There are three regional stations of Wheat Breeding, one each at Indore (Madhya Pradesh), Bhowali (District Naini Tal, Uttar Pradesh) and Tutikandi (Simla, Himachal Pradesh). A Regional Station on Plant Pathological Research is located at Flowerdale (Simla, Himachal Pradesh). A regional Station of Horticulture is located at Jutog, Simla. Besides these, there are virus research stations at Kalimpong (West Bengal) and Pune (Maharashtra).

The Project Co-ordinators and the co-ordination units of projects on pulses, maize, vegetable crops, algae, soils and tube-wells are located at the IARI.

Rao Bahadur B. Vishwanath, a distinguished soil scientist, was the first Indian Director of the IARI from 1935 to 1944. Dr Hem Singh Pruthi, who was the Director in 1944-45, was an eminent entomologist, with several enduring contributions in applied entomology. He subsequently became the first Plant Protection Adviser to the Government of India and did commendable work in locust control. Dr J. N. Mukherjee, Director during 1946-51, was an eminent soil scientist who contributed a great deal towards the growth of the discipline of soil science and agricultural chemistry. Dr B. P. Pal, who was the Director from 1952 to 1965, was an internationally famous plant breeder engaged in wheat improvement. Besides his contributions as a scientist, Dr Pal also worked hard for the growth of the Institute and it was during his directorship that the Institute was declared a deemed university in 1958 and empowered by the UGC to confer M.Sc. and Ph.D. degrees to students admitted to its Postgraduate School. Dr Pal was the first Indian agricultural scientist to receive the Fellowship of the Royal Society of England in 1970.

Dr A. B. Joshi, who was the Director from May 1965 to July 1966 and again from June 1972 to January 1977 is a well-known plant breeder, with several important contributions in the field of improvement of wheat, cotton and oilseeds.

Dr M. S. Swaminathan, who was the Director of the Institute during 1966-72, is a plant breeder of international renown. He is also well known for his contributions in mutation breeding and for his cytogenetical researches. Dr Swaminathan became the Director-General of the ICAR in 1972, after the retirement of Dr Pal. During his period as Director of the Institute, there was a remarkable growth of the research activities, staff strength and facilities. Dr Swaminathan is the second Indian agricultural scientist to have been awarded the Fellowship of the Royal Society.

Dr H. K. Jain, who succeeded Dr A. B. Joshi in February 1977, is a geneticist who believes that the key-word in the transformation of Indian agriculture from subsistence to scientific is genetic reconstruction of crop plants associated with improved agronomic management. Apart from his basic work in the field of genetic recombination, Dr Jain has been making a major contribution in preparing new blue-prints for India's crop plants of the future, plant types that will be highly efficient in utilizing water, fertilizer, solar energy and other inputs.

Central Rice Research Institute, Cuttack

In 1945 the Government of India decided to establish a central institute for rice research from its own funds to deal with all aspects of rice. Dr K. Ramiah, a well-known rice scientist, was appointed the first Director. The Chief Minister of Orissa, the Maharaja of Parlakhemundi, and the Director of Agriculture, Dr P. K. Parija, gave generous help to this Institute. In 1946 a 60-hectare farm at Cuttack was given to the Institute by the Government of Orissa.

Since Independence the Institute continued to grow in size, research activities and number of scientists under the guidance of its Directors, viz. Dr K. Ramiah (1946-51), Dr S. Ramanujam (1951-52), Dr N. Parthasarathy (1952-56), Dr R. L. M. Ghose (1956-58), Dr R. H. Richharia (1959-66), Dr S. Y. Padmanabhan (1966-76) and Dr H. K. Pande (1977-todate).

CENTRAL TOBACCO RESEARCH INSTITUTE, RAJAHMUNDRY

The Indian Central Tobacco Committee established the Central Tobacco Research Institute at Rajahmundry in Andhra Pradesh in 1947 for fundamental research on tobacco and applied research on cigarette and Lanka tobacco. During 1947-52 the Committee started Regional Research Stations at Vedasandur (Tamil Nadu) for cigar, cheroot and chewing tobacco, at Pusa (Bihar) for *hookah* and chewing tobacco, and at Dinhata (West Bengal) for wrapper and *hookah* tobaccos.

INDIAN INSTITUTE OF SUGARCANE RESEARCH, LUCKNOW

Uttar Pradesh is the main sugarcane-growing area in India. Yet it had no research institute on this crop, which is the mainstay of its economy. To fill this gap, the Indian Institute of Sugarcane Research was founded on 16 February 1952 under the administrative control of the Indian Central Sugarcane Committee. It was placed under the technical control of the Director, Indian Institute of Sugar Technology, Kanpur. A beginning was made by providing four sections, comprising Agronomy, Entomology, Mycology and Agricultural Engineering. On 1 January 1954, the Government of India, Ministry of Food and Agriculture, took over the Institute from the Indian Central Sugarcane Committee and appointed a separate Director. Dr B. K. Mukerji was the founder-Director of the Institute. He took over on 23 November 1954. In 1956 two more sections of Agricultural Chemistry and Soil Science and Physiology were added to the Institute, besides the *gur* and *khandsari* section.

On 1 April 1969 the Government of India transferred the Institute to the ICAR. Since then the Institute has been strengthened and equipped to tackle the problems facing the country and the industry more efficiently. In 1970, Botany and Breeding Section was added to the Institute to develop varieties for subtropical India, thus enlarging its research frontier and responsibilities. Two more sections—Biochemistry and Agricultural Economics and Statistics—were initiated during the Fifth Five-Year Plan. A Communication and Training Centre has also been added recently to meet the need for extension and advisory work. Isotope and residue analysis laboratories are the latest additions.

The Institute has developed a technique of companion cropping in which dwarf wheat, potato, *toria*, berseem, pulses and sugarbeet are raised in the areas in between rows of sugarcane.

Central Potato Research Institute

Potato Research Institute took shape under the guidance of Sir Herbert Stewart, the Agriculture Advisor to the Government of India and Sir Pheroz M. Kharegat, Secretary, Ministry of Agriculture. Dr B. P. Pal, Dr S. Ramanujam, Dr Pushkarnath and Dr R. S. Vasudeva participated in the formulation of the scheme and in the establishment of the Institute. Among them the name of Dr S. Ramanujam, the then Second Economic Botanist, IARI, needs special mention. He was appointed Officer on Special Duty by the Government of India in 1946 to chalk out and establish the Institute. He drew up the detailed scheme, its operational aspects, site selection, recruitment and selection of the initial team of researchers. Dr Pushkarnath was already holding the post of Botanist, with headquarters at Simla. Dr Mukhtar Singh was appointed agronomist, Dr M. J. Thirumalachar as pathologist and Dr B. P. Chaudhri as entomologist.

The Central Potato Research Institute was established in August 1949 at Patna. Later, in 1956, the headquarters of the Institute was shifted to Simla, and Patna became a regional station of the Institute. During 1956-58 new laboratory buildings and glass-houses were added. Five additional Potato Experimental and Trial Centres at Babugarh (Uttar Pradesh), Rajgurunagar (Pune, Maharashtra), Jullundur (Punjab), Shillong (Meghalaya) and Ootacamund (Tamil Nadu) were established. In 1963 a Wart-Testing Station at Darjeeling and a Nucleus Seed Production Station at Fagu (Himachal Pradesh) were started, thus expanding the infrastructure and field of activity of the Institute still further. The disease-free seed-production programme was expanded in 1969 for production of sizable quantities of disease-free seed stocks for further multiplication and making seed available to the growers. Under this scheme a second unit was added in 1969 at Jullundur, a third unit at Daurala in 1971 and a fourth unit at Kodaikanal in 1975.

Composite Regional Research Stations for Cotton, Oilseeds and Millets (PIRRCOM)

The Commodity Committees on Cotton and Oilseeds and the ICAR, which was concerned with research on millets, decided in 1956 to establish composite research stations on cotton and its rotation crops—oilseeds and millets—on a regional basis. As a result 17 composite regional stations were started at various locations in the country. The cost of running the research stations was shared by the ICAR and the two Commodity Committees. From April 1962 the cost of the project was met by the Government of India.

Central Tuber Crops Research Institute, Trivandrum

Tuber crops other thn wepotato re neglectedas so far research is concerned. Of these cassava (tapioca) is important. In fact it is this crop, which grows on poor soil, that has saved Kerala from starvation.

Realizing the importance of these crops, the Central Tuber Crops Research Institute was established in July 1963 for the intensification of research on the improvement of tuber crops (other than potato) at Sreekaryam, near Trivandrum.

The main objectives of the Institute are breeding high-yielding, better-quality, disease- and pest-resistant varieties of tuber crops, including cassava (tapioca), sweet-potato, *Dioscorea*, *Amorphophallus*, *Colocasia*, and *Coleus*, and determination of best standards of culture, manuring, soil and water management, storage etc. The Government of Kerala provided 20.64 ha of free land at the time of establishment of the Institute for an experimental farm.

M. J. Deshmukh, who was the Chief Potato Development Officer at the CPRI, Simla, joined the CTCRI, Trivandrum, on 11 July 1963 as its first Director. He obtained planting materials of different tuber crops from the University of Kerala, where a tapioca research scheme funded by the ICAR was functioning.

Indian Institute of Horticultural Research, Bangalore

India has a variety of fruits ranging from the temperate to the tropical. In spite of their importance and place in the Indian diet, there was no central research institute. On a request received from the Karnataka government, backed by a generous offer of land, the Government of India agreed to establish a central research institute in 1967. Dr G. S. Randhawa, who was then Deputy Agricultural Commissioner with the Government of India in the ICAR, was appointed the founder-Director of this Institute. The Government of Karnataka gave 24.28-ha National Hortorium at Hessaraghatta for the establishment of the Institute as its nucleus and later on gave another 202.34 ha.

Central Plantation Crops Research Institute, Kasaragod

Research on coconut and arecanut was carried on by the research institutes of the Commodity Committees concerned. But crops like cashew, pepper, tree spices, ginger and cardamom did not receive adequate attention. Hence, it was decided by the Government of India to set up a central research institute on these crops.

The Central Plantation Crops Research Institute, Kasaragod, came into existence in 1970, with the amalgamation of Central Coconut Research Stations at Kasaragod and Kayangulam and the Central Arecanut Research Station, Vittal, and its regional stations. The Institute conducts research on coconut, arecanut, cashew, cacao, oil-palm, pepper, cardamom, ginger, turmeric and tree spices.

The Institute has its headquarters at Kasaragod. It has five regional stations, at Vittal, Calicut, Kayangulam, Lakshadweep and Goa. The research centres of the Institute are located at Appangala, Hirehalli (Karnataka), Palode, Peechi (Kerala), Mohitnagar (West Bengal), Kahikuchi (Assam) and Sipighat (Andaman Islands). There are two elite seed farms at Kidu (Karnataka) for producing genetically superior planting material of coconut, arecanut and cacao, and at Shantigodu (Karnataka) for evaluation and multiplication of high-yielding cashew.

Central Arid Zone Research Institute, Jodhpur

In 1958 the Government of India requested the UNESCO to review situation in the desert regions of India and suggested the organization of desert research in the country. Mr C. S. Christian, CSIRO, Australia, was deputed as the UNESCO Adviser. He recommended the reorganization of the Central Research Farm at Jodhpur into an institute to conduct research on problems relating to aridity in arid and semi-arid tracts in the different regions of the country. Consequently, in October 1959 the Station was reorganized as the Central Arid Zone Research Institute (CAZRI). In April 1966 the administrative and technical control of the CAZRI was transferred from the Ministry of Food and Agriculture to the ICAR.

Dr P. C. Raheja (1960-66) founded the Institute on sound scientific lines. C. P. Bhimaya (1957-67) planned range management and afforestation programme of the Institute. Dr Mukhtar Singh (1968-69) and Dr T. R. Mehta (1969-70) made valuable contributions.

Dr H. S. Mann took over the charge of the CAZRI in December 1971. Under his leadership, the CAZRI has multiplied its facilities manifold. New research activities were initiated, including operational research projects entitled Arid Land Management, Arid Horticulture, Solar-Energy and Wind-Power Utilization, and Drip and Sprinkler Irrigation.

Indian Grassland and Fodder Research Institute, Jhansi

The Indian Grassland and Fodder Research Institute was established at Jhansi in November 1962 by the Government of India and administered from April 1966 by the Indian Council of Agricultural Research.

The Institute has the following research objectives: evolution of new technology for maximization of fodder production from intensively cultivated land; amelioration of forage production from marginal and submarginal lands which are agriculturally less productive; improving terrestrial and aquatic forage productivity based on improved production systems; development of silvipastoral systems and system synthesis for higher plant productivity for forage, fodder and fuel; finding out the quality of forages and their efficiency in animal production; conservation and enrichment of cellulose wastes and crop residues as feedstuff; exploitation of forage production from waste-lands characterized as saline, alkaline and desert; exploitation of weeds, shrubs and conventionally non-edible plants for livestock nutrition and the extraction and use of their chemically active principles in livestock nutrition and forage-crop growth; analysis, synthesis and modelling of forage-crop-production systems by exploitation of resources, viz. sunlight, land and water, plant types, canopy manipulation to attain the possible biological yield targets; application of natural and farm energy for pre- and post-harvesting of forage and seed production and their conservation, development of mechanical devices for conservation of natural resources like water and soil; development and application of appropriate extension methods and techniques of transfer of technology for forage production systems to the rural farming community along with imparting training and education to the concerned developmental and research workers and farmers in the field of forage production and its efficient utilization.

For conducting researches at the higher altitude, temperate, alpine and hilly regions extending from Jammu and Kashmir to Himachal Pradesh, Garhwal and Kumaon and north-eastern regions of the country, the Institute has established a regional station at Manasbal in the Jammu and Kashmir with a nucleus staff.

The Institute has identified and extended research for maximization of fodder production for varied agro-climatic conditions of the country for intensive dairy farming. Packages of production of forages (including relay cropping, year-round fodder production, insertion of fodder crops in rotations of food or cash crops) were evolved with inter-disciplinary research components on new varieties, agronomic and soil and water-management practices along with efficient utilization of fodders.

This technology has shown, on experimental basis, a rise in fodder production to 1,000-2,500 q/ha/annum of green fodder with protein level of 6-7% compared with the former level of 600-800 q/ha/annum.

During the Fifth Five-Year Plan researches were intensified in developing the concept of silvipastoral system of these lands. This provides for fuel and cattle feeding, particularly during the lean period when other green fodders are not available, and it also takes into account specific needs of sheep, goats and local cattle.

Insertion of fodder crops in between the major crops and also intercropping of fodder crops with food or cash crops, particularly legumes, has shown an additional component of fodder production and amelioration of soil fertility.

A comprehensive training programme in all facets of grassland and fodder production and its efficient utilization, and for promoting herbage production for ruminant livestock, was initiated.

Central Soil Salinity Research Institute, Karnal

The Central Soil Salinity Research Institute was established during the Fourth Five-Year Plan in 1969 at Karnal to conduct research on problems relating to reclamation, management and utilization of salt-affected soils for crop production. The Institute has a research station at Canning, West Bengal, which forms a nucleus for catering to the research needs of coastal salt-affected soils.

Dr D. R. Bhumbla was the first Director of this Institute and he remained in position from March 1969 to March 1974. It was under his leadership that the CSSRI was established and the experimental farm was laid out. Research problems that needed immediate attention were identified and several research projects initiated. Within a short period the Institute's scientists under the leadership of Dr D. R. Bhumbla brought out very useful research results on reclamation of alkali soils. Encouraged by the applicability of these research findings on reclamation of alkali soils at the farmers' fields, Haryana established the Haryana Land Reclamation and Development Corporation.

Central Soil and Water Conservation Research and Training Institute, Dehra Dun

The Central Soil and Water Conservation Research and Training Institute, Dehra Dun, came into being on 1 April 1974. This was the culmination of a series of developments starting from 1947. In May 1947, Messrs D. C. Kaith, R. J. Kalamkar, D. J. Gandhy, S. P. Raychaudhuri, A. T. Sen, M. H. Khan and A. G. Raiz were sent to the USA for one year, to acquaint themselves with the techniques of soil and water conservation and to give a report on the ways of their application under Indian conditions. These officers submitted a report entitled 'A soil conservation and land utilization programme for India' on 30 April 1948.

The late Dr J. K. Basu, one of the Directors of Soil Conservation under the Government of India, Ministry of Food and Agriculture, was primarily responsible for planning the research programme of soil and water conservation in different centres. Mr M. S. V. Rama Rao, another Director of Soil Conservation, provided guidance in drawing up the soil- and water-conservation research programme relating to engineering. Mr U.S. Madan. Director of Soil Conservation, guided in preparation of the soil and water-conservation research programme in forestry and grasslands. Dr J. S. Kanwar pushed the idea of co-ordinating research and training programmes in soil and water conservation. The scheme for providing institutional structure to soil conservation research, demonstration and training centres was also initiated by him. During the tenure of Dr D. R. Bhumbla, the Dehra Dun centre was redesignated the Central Soil and Water Conservation Research and Training Institute. Dr Bhumbla vigorously advocated the cause of soil and water-conservation research and training in India. Dr K. G. Tejwani gave practical shape to the research programmes.

NATIONAL BUREAU OF SOIL SURVEY AND LAND-USE PLANNING, NAGPUR

The National Bureau of Soil Survey and Land-Use Planning started functioning independent of the IARI with effect from August 1976. In 1978 it moved to its permanent location, Nagpur.

Till the National Bureau was established in 1976, the All-India Soil and Land-Use Survey Organization was headed by the Chief Soil Survey Officer. Dr S. P. Raychaudhuri was appointed the first Chief Soil Survey Officer in 1958. His chief contribution was in providing a sound foundation to the organization. Soil survey was relatively a new discipline. It was difficult to find trained personnel to man the tasks. Dr Raychaudhuri through his untiring personal efforts and with a few senior scientists arranged training programmes and in a short time created a band of devoted workers, most of whom are still in the organization. Dr Raychaudhuri not only started the organization with centres at distant places but also maintained a steady progress of work both in respect of quality and quantity.

With the retirement of Dr S. P. Raychaudhuri in 1961, the responsibility of the organization fell on the shoulders of Soil Correlator of the southern region, Dr S. V. Govinda Rajan. He was instrumental in starting a Training Centre at Nagpur, introducing for the first time air-photo interpretation techniques for soil surveys, revising the existing soil map of India, issuing a new Soil Survey Manual, and initiating the Rural Engineering Survey scheme. The organization derived stability during his tenure, soil-survey techniques were standardized and excellent liaison was maintained between the Central and State organizations.

On superannuation of Dr Govinda Rajan, Dr R. S. Murthy took over as the Chief Soil Survey Officer in December 1971. In 1976 he became the Director of the Bureau. During his tenure soil survey, which had the status of only a division of the IARI, assumed a national status and importance. Under his leadership, research projects of regional, national, inter-institutional, interdisciplinary and multi-disciplinary importance were undertaken, besides joint collaboration projects and consultancy work. At the same time the tempo of progressive soil surveys in different States was maintained. Modern tools including air-borne and space-borne imageries were introduced for the first time to test the feasibility of their use in soil survey. Infrastructure laboratory and field-work facilities were increased. New divisions of Pedology, Remote Sensing and Land Use were added. Two additional centres were created to cater to the heavy demand on surveys.

ICAR RESEARCH COMPLEX FOR NORTH-EASTERN HILLS REGION, SHILLONG

The ICAR Research Complex for North-Eastern Hills Region was formally inaugurated by the Union Minister for Agriculture and Irrigation, Jagjivan Ram, at Kohima, Nagaland, on 22 November 1975.

This institute took up research in all important disciplines of agriculture, animal sciences and fisheries, and was named 'ICAR Research Complex for North-Eastern Hills Region'. Its headquarters along with a research station was located at Shillong, Meghalaya. Simultaneously, research centres in Nagaland, Manipur, Tripura, Arunachal Pradesh, Mizoram, Assam, Andaman and Nicobar Islands, Goa and Lakshadweep started functioning. The research centre in Assam was located in Karbi Anglong under the administrative control of the Assam Agricultural University. Similarly, Goa and Lakshadweep centres were under the administrative control of the Central Plantation Crops Research Institute, Kasaragod.

Central Agricultural Research Institute for Andaman and Nicobar Group of Islands, Port Blair

The Central Agricultural Research Institute for Andaman and Nicobar Group of Islands was established in June 1978 for providing the research base for developing agri-horticulture, livestock and fisheries.

Central Institute of Agricultural Engineering, Bhopal

With increasing use of tractors and other agricultural machinery on account of cultivation of high-yielding varieties, a need of testing such machinery was felt. To meet this need, the Central Institute of Agricultural Engineering, Bhopal, came into existence on 15 February 1976. The idea of setting up a National Institute of Agricultural Engineering in India was conceived with the aim of applying agricultural engineering knowledge to planned development of agriculture.

Central Institute for Cotton Research, Nagpur

The Central Institute for Cotton Research was established in April 1976 at Nagpur. The station at Coimbatore in Tamil Nadu established by the ICAR in 1960 under the Project for the Intensification of Research on Cotton, Oilseeds and Millets in the region was attached to this Institute to function as southern regional station.

This Institute has been established to carry out fundamental and basic path-breaking research to meet the long-term objectives of having increased production of cotton in quantity and quality, so that the country is self-sufficient in cotton production. A number of basic studies involving long-term objectives have been envisaged for stepping up cotton production in India.

Indian Veterinary Research Institute, Izatnagar

At the dawn of Independence on 15 August 1947, the Institute had already served the country for full 57 years. For the first time the development of the enormous livestock resources of the country became a national responsibility and the name of the Institute was changed to Indian Veterinary Research Institute.

In 1947 the Institute had one Division of Pathology and Bacteriology at Mukteswar and five divisions, viz. Biological Products, Parasitology, Animal Nutrition, Poultry Research and Animal Genetics at Izatnagar. In 1963 the Division of Pathology was established at Izatnagar by reorganizing the Division of Pathology and Bacteriology as Division of Bacteriology and Virology.

With the reorganization of the ICAR, the IVRI was placed under the administrative control of the ICAR on 1 April 1966.

To keep pace with the recent advances and latest trends in animal sciences research, education, training and extension education, the resources existing in 1966 were considered to be inadequate. Therefore efforts were directed towards identifying the priority needs and filling up of the gaps in every sphere for reorienting and integrating research, education, training and extension education to meet the needs of time and interest of the nation.

In view of the important role that the Institute has played during the last 89 years or more, and is likely to play keeping in view the recent national requirements for development of livestock health, production and technology, the objectives have been reoriented:

1. To conduct basic and applied research on all aspects of livestock health, production and technology
2. To impart postgraduate education, including extension education
3. To develop the technological know-how for the production of quality veterinary biologicals
4. To provide expert advice in veterinary and animal husbandry matters including diagnostic services
5. To provide technological know-how right at the farmer's door to improve the socio-economic conditions of the rural population.

To fulfil these aims, ceaseless efforts during the Fourth and Fifth Five-Year Plan periods have culminated in the establishment of (i) 22 research divisions against 7 in 1966, (ii) four campuses at Mukteswar, Izatnagar, Makhdoom and Bangalore against 2 in 1966, and (iii) three Regional Research Stations against none in 1966. In addition, there are six special projects on livestock production research on cattle, poultry, pig, goat (for meat, milk and pashmina), sheep for mutton, and buffaloes, as participants in all-India co-ordinated projects, besides the special project on Epidemiological Studies on Foot-and-Mouth disease. An operational research project on Livestock and Fodder Improvement has also been set up at Rithoura.

Dedicated research conducted in different disciplines of animal sciences at the Institute has received international recognition and has been fruitful with the large number of proven biological products to prevent, cure and control many devastating diseases of livestock and poultry, consequently increasing the production of milk, meat, eggs and a number of animal products. Besides continuous research for making livestock and poultry industry more secure, purposeful and profitable, the frontiers of research activities have been extended to ever-broadening the areas of human health, nutrition and welfare.

The sustained research in the field of animal health has resulted in the development of highly efficacious vaccines against devastating diseases of livestock and poultry.

Recent researches on viral diseases have culminated in the development of (i) primary goat-kidney monolayer and BHK_{21} cell-culture vaccine against the foot-and-mouth disease, (ii) an effective and cheap tissue-culture rinderpest vaccine which has replaced all other vaccines, (iii) Flury's vaccine against rabies, and (iv) inactivated as well as live attenuated vaccine against sheep-pox.

NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL

There was spurt in developmental activity following Independence. Prof. H.D. Kay, Director, National Institute of Research in Dairying, Reading, was invited in early 1947 by the Government of India to review the situation in regard to dairy education, research and development in the country. Prof. Kay reiterated Dr Wright's recommendation, and suggested the early establishment of a National Dairy Research Institute, including Dairy Science College, at or near Delhi.

After 8 years, beginning with the Second Plan period, it was finally decided to set up the institute in the premises of the Cattle Breeding-cum-Dairy Farm, Karnal, which had 800 ha of land, and over 1,000 heads of pedigree cattle. The foundation stone of the Institute at Karnal was laid by the Minister of Food and Agriculture, Ajit Prasad Jain, on 7 August 1955.

In recent years the Institute has expanded considerably. It has many buildings, scientific equipment and expert staff. The annual budget, which was Rs 0.2 million in 1923-24, has gone up today to Rs 25 million. Correspondingly, there has been a growth in staff and other ancillary facilities. The scientific staff has dual responsibility of research and teaching. The inter-disciplinary interaction of the scientists showing positive impact with more assurance for a stabilized research output in areas of milk production and processing.

The work of the Institute is carried out under 14 subject disciplines grouped as: (i) *Production group:* Genetics and Breeding, Nutrition, Physio-

.ogy, Livestock Production, Fodder Production; (ii) *Processing group:* Bacteriology, Chemistry and Biochemistry, Engineering, Technology, Quality Control, Human Nutrition and Dietetics; (iii) *Management group:* Economics, Statistics, Management and Extension. There is an educational wing, Dairy Science College, a well-equipped library and Dairy Livestock Farm and Dairy Plant. The Institute and its three regional stations function under the control of the Director, who is assisted by the Heads of Regional Stations and Heads of Divisions and sections.

In 1957 Dr K.C. Sen, who held the post of Director of Dairy Research since 1946, retired and was succeeded by Dr K. K. Iya. A programme of development and expansion of the Institute was initiated, beginning with the Second Five-Year Plan.

On the teaching side, the Dairy Science College started a 4-year training course for the B.Sc. (Dairying) in 1957. The course was later bifurcated in 1961 into Dairy Technology and Dairy Husbandry, to afford specialization in these areas. The postgraduate wing of the Dairy Science College was instituted in 1961. M.Sc. courses in different branches of dairying were started and facilities were provided to conduct postgraduate research work for the Ph.D. degree of different universities. On the research side efforts were made to suitably equip the laboratories and begin research work on problems of immediate interest.

Dr K.K. Iya left the Institute in 1965 and the post of the Director was subsequently held by Dr S. N. Ray and then by Dr Noshir N. Dastur for short periods. Following the retirement of Dr Dastur in 1970, Dr D. Sundaresan, Dean of Postgraduate Studies at the PAU, Ludhiana, joined as Director.

Central Sheep and Wool Research Institute, Avikanagar, Rajasthan

The Central Sheep and Wool Research Institute was established in 1962 with the assistance of United Nations Special Fund for conducting research on sheep and wool production and wool utilization, and for imparting postgraduate training in sheep and wool sciences. The Institute started functioning in 1962 with Dr M. V. Krishna Rao as Officer on Special Duty. Subsequently 1,620 ha of land was acquired near Malpura, about 84 km from Jaipur.

Central Inland Fisheries Research Institute, Barrackpore, West Bengal

Fishes are a source of rich proteinaceous diet. India has a long coastline and numerous rivers and lakes. Before Independence, research on fishes was minimal. As a first step the Central Inland Fisheries Station came into existence in March 1947 at Calcutta. The main objective of the Research Station (now Institute) is to elucidate the scientific principles which could be applied for full utilization of all available inland waters of the country for maximizing fish production.

There are two aspects of the work of the Institute, Culture Fisheries Research, and Capture Fisheries Research. The former involves researches on culture of fish in impounded fresh and brackish-water bodies like ponds, tanks, *beels* and *bheries*; in the latter the data are drawn from the commercial fishing units operating in lakes, reservoirs, rivers and estuaries.

At the time when the CIFRI was set up at Calcutta in March 1947, S. L. Hora, the then Director of the Zoological Survey of India, was appointed the first Chief Research Officer. Dr T. J. Job succeeded Dr S. L. Hora as the Chief Research Officer in June 1947.

Dr H. S. Rao (August 1952-July 1954) assumed the office of the Chief Research Officer in August 1952. During his tenure a Fish Seed Syndicate was established for creating a centralized agency for supplying quality fish seed to the States and private pisciculturists. Transportation of fish fry under oxygen packing led to the reduction of mortality to only 4%. For conducting investigations on the fisheries of the rivers Ganga and Yamuna, a Riverine and Lacustrine Substation at Allahabad was established. A fishery training section functioned as an adjunct of the Station since 1948. Surveys to assess the fishery resources of the important riverine and estuarine systems of the country were initiated during this period.

Dr B.S. Bhimachar (July 1954-June 1966) succeeded Dr H. S. Rao in July 1954 as Chief Research Officer. Dr Bhimachar undertook the expansion of the Research Station by establishing more units and initiating new lines of research investigations. Induced breeding of Indian major carps by hypophyzation, production of fertile intergeneric hybrids and standardization of the methods of collection, preservation and use of pituitary glands were successfully accomplished for the first time in India during this period. Information on the fishery resources and status of the commercial fisheries of the Mahanadi estuarine system were gathered and sampling procedures to estimate fish production of the estuary were evolved.

With the retirement of Dr B. S. Bhimachar in June 1966, Dr V. G. Jhingran succeeded him as Director. Dr Jhingran has made significant contributions to the development of new concepts of aquaculture, which have immense practical importance and represent a major breakthrough in inland aquaculture in India.

Central Marine Fisheries Research Institute, Cochin

The Central Marine Fisheries Research Institute was established on 3 February 1947, under the administrative control of the Ministry of Food and Agriculture. Dr H. Srinivasa Rao was the first Head of the Institute.

He was responsible for the initial organization of the Institute at Madras and subsequently at Mandapam Camp and the establishment of the substations at Bombay, Karwar and Calicut on survey centres along the East and West Coasts of India. Special emphasis was given on fishery survey for the collection of catch and collection of data on an all-India basis for marine fisheries. More intensive investigations on pelagic fisheries, particularly sardines and mackerel, were initiated along with work on marine biology and in-shore hydrography.

Dr N. K. Panikkar served as the Director from 1951 to 1957. He was responsible for the future growth of the Institute at Mandapam Camp and the establishment of the substations at Waltair and Mangalore. Under his guidance the staff of the Institute undertook an all-India sample survey of fish landings, collection of exploratory fishery data by participation in deep-sea fishing operations, made significant contribution on the fishery and biology of oil sardines, mackerel, perches, marine prawns and squids.

Dr S. Jones served the Institute as the Director from 1957 to 1970. During his tenure the establishments at Tuticorin, Vizhinjam, Veraval, Kakinada, Port Blair and Minicoy came into existence. Under his guidance the Institute was able to make valuable contributions on the assessment of the resources of oil sardine, mackerel, Bombay duck, tunas and bill-fishes and prawns. Environmental studies and oceanographic investigations were greatly strengthened.

Dr S. Z. Qasim served as the Director of the Institute in 1971-73. During this period the country's marine fish production crossed the 1 million tonne mark. He initiated investigations on energy transfer in different trophic levels in selected ecosystems.

Dr E. G. Silas took charge of the Institute on 25 June 1975. During his tenure a number of inter-organizational or funded projects having an integrated approach for coastal rural development through sea-farming and integrated crop-livestock-fish systems have been initiated.

Central Institute of Fisheries Technology, Cochin

The Central Institute of Fisheries Technology was established at Cochin, in December 1957, under the Department of Agriculture of the Ministry of Food and Agriculture, with a nucleus staff for research and developmental activities in fishing craft and gear. The establishment of the Institute was the direct outcome of the zeal and enthusiasm of G. K. Kuriyan, who was appointed by the Ministry as Special Officer for the purpose. The first mechanized fishing boat, 'Pable', was built by G. K. Kuriyan, working in Madras as counterpart to the FAO Experts Mr Paul B. Zeiner, Naval Architect, and Mr G.S.S. Illugason, Gear Engineer.

Kuriyan became the Director of the Institute in September 1974.

A Highly Productive Research System

One of the criticisms made of the administration of the research institutes during the colonial period was that research was hampered by an administrative bureaucracy and by a civil service system that failed to distinguish between scientific and administrative capacity. This was true, as a number of research institutes were administered by the Secretariate of the Ministry of Food and Agriculture. In 1964, on the recommendation of the Agricultural Research Review Team, headed by Dr Marion Wesley Parker, the Indian Council of Agricultural Research was reorganized into a central agency with authority for co-ordinating, directing and promoting agricultural research in the entire country. All the central research institutes which had been under the direct administrative control of the Department of Agriculture or the Department of Food were transferred to the ICAR. The Commodity Committees were abolished and their research institutes were put directly under the ICAR. The ICAR has been headed by an agricultural scientist since 1965.

The Indian agricultural research system is one of the half-dozen significant national agricultural research systems in the world. It has been also a highly productive research system[1]. It has been conclusively shown that investment in agricultural research in a developing country is not a luxury, and it is highly beneficial for the economy. Since Independence, the Indian agricultural research system has gone through a period of consolidation and expansion in which the disparate institutions inherited from the colonial past were moulded into a national agricultural research system and new research institutes were started.

[1]Evenson, R.E. and Jha, D. "The Contribution of Agricultural Research Systems to Agricultural Production in India", *Indian Journal of Agricultural Economics* 28 (1973); Kahlon, A.S.; Saxena, P.N.; Bal, H.K. and Jha, D. "Returns to Investment in Agricultural Research in India", in *Resource Allocation and Productivity in National and International Agricultural Research*, edited by Thomas N. Arndt, Dana G. Dalrymple and Vernon W. Ruttan (Minneapolis: University of Minnesota Press, 1977), pp.124-47

CHAPTER 14

DEVELOPMENT OF AGRICULTURE IN THE UNITED STATES OF AMERICA

LAND-GRANT COLLEGES AND FEDERAL RESEARCH STATIONS
MECHANIZATION OF AGRICULTURE
INFLUENCE OF AMERICAN AGRICULTURE ON OTHER COUNTRIES

THE American continents received the overflow of surplus European population in the early seventeenth century. The English, the Scotch, the Irish, the Dutch and the French settled in North America, and the Spanish and the Portuguese settled in Central and South America. Later on, the Germans, the Scandinavians, Poles, and the Italians also settled in the USA. The first British colony in North America, viz. New England, was settled in 1620. Gradually, the population increased by growth and by the arrival of new immigrants. Most of the migrants were refugees, who were willing to try new methods and techniques. They sought an education for themselves and their children. This investment in human capital, which began as early as 1647 in the colonial Massachusetts, created a literate farm population which, through reading and schooling, absorbed the new technology developed by progressive farmers, experiment stations and other agencies of agricultural research. Both the alertness and literacy of the farmer have played important roles in the American agricultural development.[1]

Fully as important has been the farmer's relationship to the land. Although the European big-estate system was transferred with modifications to the South and with fewer modifications to the Hudson Valley, settlers in New England established a unique pattern of small farms free from the feudal restrictions of primogeniture and owned by the men who tilled them. This land-ownership and the inheritance pattern became the model for the public land legislation of the United States, beginning with the 1785 Land Ordinance and culminating in the 1862 Homestead Act and its subsequent adaptations to the needs of the arid West. As a consequence, the United States became a nation in which the land was divided into family-sized tracts which were farmed by the owners themselves who believed that manual labour was dignified and honourable.[2]

LEADERSHIP BY STATESMEN WITH AGRICULTURAL BACKGROUND

The American success in agriculture is also due to the wise leadership

[1]Oscar Handlin, *The Uprooted*, New York, 1951, pp. 3-6, 82-93

[2]Dunbar, R.G. 'The role of agricultural history in economic development'. *Agricultural History*, 1967

by men who had practical experience of agriculture. So much interest had arisen for improved agriculture in New England that complaint was made that farmers invited their guests to view their turnips in the field and animals in the stall and the sty, before visiting their families in the parlour.

George Washington, America's first President, was a business farmer who, with great industry, kept track of the 3,260 acres (1,278 ha) which he cultivated. He corresponded with Arthur Young and Sir John Sinclair, and from England sought ideas, seeds (turnips and legumes), ploughs, labourers, a manager, and in his old age, well-to-do tenants to take over his whole plantation.[3] The leaders of the American Revolution and the young Republic were determined that farming should go forward on modern lines. Resolutions recommending aid to farmers were adopted by the Second Continental Congress in 1776. In his last annual message to the Congress, in 1796, George Washington advocated the constitution of a Board of Agriculture to collect and spread information for farmers. He proposed "by premiums and small pecuniary aids to encourage a spirit of discovery and improvement". Thomas Jefferson and George Washington themselves experimented with new crops and methods. Benjamin Franklin, a scientist and diplomat, was a leader in sponsoring agricultural research.

Land-Grant Colleges, 1862

In 1862, land-grant colleges were established by the Federal Government under the Morrill Land Grant Act. Public land was provided for all these colleges. These colleges were designed to serve agriculture and to provide a sound practical education in Agriculture and Engineering. The land-grant colleges were the most important single factor in the development of American agriculture. The land-grant institutions made intensive tests of varieties of all crops, and recommended those that proved to be the best. They worked out crop-rotation systems for different types of farming. They planned breeding and feeding practices for cattle, hogs, sheep, horses, and poultry. The engineers worked out schemes for drainage and irrigation, and developed plans for farm buildings. In short, every facet of farm business was explored in a very practical way. Improved varieties of crops and improved breeds of animals were developed. Essentially, all the foundations necessary for a great agricultural expansion were laid. The traditional universities did not welcome this new development, and these colleges were contemptuously called 'Cow Colleges'. By research into problems which the farmers were facing, and by providing them with solutions to their problems, these colleges proved their usefulness to the farming community.

[3]Gras, N.S.B. *A History of Agriculture in Europe and America*, New York, 1925, p. 296

Department of Agriculture and Agricultural Research Stations

In 1872, the Federal Government created a Department of Agriculture. Later, Federal and State laws established agricultural research stations. The institutional pattern of these research stations drew heavily on the German model. This was because the American scientists who established these research stations had studied in Germany. Educational and technical assistance for farmers was provided through extension services of the land grant colleges working in co-ordination with the Federal Department of Agriculture. It took 50-70 years of innovative effort to organize a productive agricultural research and extension system in the USA. The State departments of agriculture were established first in the South—in Georgia in 1874, in Tennessee in 1875, in North Carolina in 1877, in Virginia and Alabama in 1888. In the North, they were established later—in New York in 1893 and in Pennsylvania in 1895.

MECHANIZATION OF AGRICULTURE

The use of machinery in agriculture abolished drudgery, made labour more effective, and reduced the cost of production. In the mechanization of agriculture, America has been a pioneer.

Role of Blacksmiths and Engineers

"The important inventions of the nineteenth century were not conceived by farmers clearing the land, breaking the prairie sod, or working sixteen hours a day in the harvest fields", observes Wik. Virtually, all mechanical discoveries were made by men having experience in factories, blacksmith shops, or in occupations other than farm labour. George Iles, in his *Leading American Inventors,* describes thirteen inventors, none of whom was a farmer, except Cyrus McCormick, and he seemed to be influenced more by his father's blacksmith shop than by his labour in the fields. Even in the design of farm machinery, the most creative work came from men not completely involved in farming. The big names in the plough industry were Jethro Wood, John Deere, John Lane, William Parlin, and James Oliver, all of whom were blacksmiths. Obed Hussey, an inventor of a reaper, was a draftsman. John and Hiram Pitt, who invented the first successful threshing-machines in this country, were blacksmiths. George Frick, A.B. Farquhar, John Nicholas, Meinard Rumley, and Abraham Gaar were machinists in small shops before becoming prominent manufacturers of farm steam-engines and threshing-machines. The fathers of the gasoline tractor, Benjamin Holt, Daniel Best, Charles W. Hart, and Charles H. Parr, were practical engineers.[4]

[4]George Iles, *Leading American Inventors*, Henry Holt, New York 1912

Role of Wealthy Planters in the South

Most of the inventions were made in the heavily settled regions where more capital and time were available. During the 1830s, the most advanced agrarian technology appeared in the South where wealthy planters installed the latest machinery. Frederick Law Olmsted described the Louisiana sugar-planters as the most intelligent, enterprising, and wealthy men of business in the United States. A study of Hamilton County, Iowa, in the 1880s proves that mechanical innovation occurred most frequently on the larger-than-average farm, where the owners had enough money to finance mechanical experiments. Here, the most progressive leaders were city businessmen who had tenants on the land. The families living in poverty in the old sod shanty on the plains were in the least favourable position to become mechanized.[5]

Improvement of Animal-drawn Implements—Horses Replace Oxen

About the middle of the nineteenth century, farming in America was carried on with hand-tools, such as the hoe and the scythe, supplemented by animal power provided by oxen, horses and mules, which were used for pulling wooden ploughs and other implements. American inventors such as Thomas Jefferson, Jethro Wood, and John Deere replaced the wooden plough with the cast-iron plough and then with the steel plough, which enabled farmers to more than double the amount of land that they could plough in a day. Cyrus Hall McCormick invented the reaper that displaced the cradle and increased the efficiency of harvest labour four-fold. The invention of these and other labour-saving implements was accompanied with a farm-power revolution: horses replaced the oxen of subsistence agriculture.[6]

The Combine, 1870-1891

The earliest agricultural machine developed in the USA was the combine. The combine reaps, threshes, cleans and bags the grain in a single continuous operation. Today, this machine harvests most of the grain crops in the United States and Europe. Why did this machine prove successful in the San Joaquin Valley of California in the 1870s and 1880s almost fifty years before it came into practical use elsewhere? Why did one of the most important technological breakthroughs in the history of agriculture occur in California?

According to Wik, 'The answer lies in the fact that climatic conditions in the Central Valley created unique conditions for harvesting and

[5] Wik, R.M. Some interpretations of the mechanization of agriculture in the Far West, *Agricultural History*, 1912

[6] Dunbar, R.C. The role of agricultural history in economic development, *Agricultural History*, 1967

threshing grain crops. Since virtually no rain occurred from mid-May until early November, farmers were able to harvest their grain in the field without loss from inclement weather. The hot summer air cured the wheat as it ripened, making it unnecessary to bind and stock the grain before threshing, as was the common practice in the eastern States. Since harvesting and threshing could be carried out simultaneously, the grain could be cut with a header and hauled directly to a stationary threshing-machine. Of course, if harvesting and threshing could be combined into one operation with a machine moving across the field, a great saving in time and labour would be achieved.

The principle of the combined harvester goes back to a patent in 1828 granted to Samuel Lane of Maine. Eight years later, Hiram Moore and J. Hascall of Kalamazoo, Michigan, built a horse-drawn machine which carried out this dual principle. However, the damp weather in the midwest made it difficult to thresh grain in the field, because it had not had ample time to dry out or cure. As a result, the threshed grain spoiled in the bin and became worthless for grinding into flour.

'One of the Moore combines was shipped to California in 1854, where it harvested wheat in Alameda County. F. Hal Higgins, the well-known historian of farm machinery, states that from 1854 to 1876 scores of blacksmiths and mechanics experimented in building various types of combines in the San Joaquin Valley. In 1863, William Marvin and H. H. Thurston built a combine which was improved each year until the *Stockton Independent* declared in 1867 that "this machine is considered one of the greatest labour-saving inventions ever produced". Although individuals had made combines, the *Pacific Rural Press* claimed that the Matteson and Williamson Manufacturing Company of Stockton in 1876 was the first company to manufacture a number of combines, all essentially of the same model.

'During the early 1880, prominent firms engaged in the production of combines included the Houster-Haines Company and the Shippee Harvester Works, both of Stockton. During the later 1880s, the Holt Manufacturing Company of Stockton and the Daniel Best Company of San Leandro became the most important manufacturers of combines in the Far West.

'The Holt company increased the utility of combines by investing a side-hill model in 1891, which made it possible to harvest grain on the foothills of the Central Valley and on the rolling terrain of eastern Washington and Oregon. On these combines, each wheel was mounted independently, so that they could be lowered or elevated to compensate for the angle of the side hill. These machines had cutting-bars, ranging from ten to twenty feet, and were pulled by sixteen to thirty-six horses. Today, an 1887 Holt combine resides in the Smithsonian Institution in Washington, D.C., where the exhibit represents what John T. Schlebecker termed the "final development in the heroic age of animal power".[7]

STEAM TRACTORS, 1890-1924

In 1890, an important development took place in the wheat farms of north-western United States. This was in the form of tractors which were large four-wheeled machines driven by steam and could pull as many as 40 ploughs across the field. Benjamin Holt built in 1900 a huge steam-traction engine, fitted with wide extension wheels. Although this engine had limited use, this experience evidently led Holt to think about substituting a crawler, treadmill-type track for the conventional wheels. After removing the wheels from one of his forty-horse power steam-traction engines, he installed a pair of track units and tested the machine on 24 November 1904. The result was the world's first practical track-type caterpillar tractor. In 1906, the Holt Manufacturing Company installed a gasoline motor to replace the steam-engine with results that were highly successful. When twenty-eight of the Holt Caterpillar tractors were used to help build the 233-mile (375-km) aqueduct across the Mohave Desert, to tap water in the Owens River for use in Los Angeles, the reputation of the new tractor had been established. During World War I, General E. D. Swinton, the British inventor of the military tank, announced that he had found his idea for the new weapon in the performance of a Holt Caterpillar in Antwerp in 1913. Later, the track-type tread became visible on a variety of military vehicles, as well as on the road-building equipment, bulldozers, logging machinery, and farm tractors. By 1912, steam tractors attained their peak of size and performance and by 1924 they became extinct.

GASOLINE TRACTORS, 1910-1939

The first gasoline tractor was built in 1892 by John Froelich, an Iowa farmer and blacksmith. The first practical tractor was made by E. W. Hart and C. H. Parr in 1902, but it was large and expensive (Fig. 48). In 1910, tractors with internal-combustion engines were developed. In 1918, the United States, in its second year of entry in the World War, was confronted with a severe shortage of farm labour. Mass production of tractors with internal-combustion engines was started. The introduction of small Farmall tractor by the International Harvest Company popularized the tractor. The most significant design development was the introduction of the rear-power take-off for the operation of mounted and drawn implements. Originally regarded as an alternative to the horse, the

[7]Wik, R.M. 'Some interpretations of the mechanization of agriculture in the Far West', *Agricultural History*, 1969

tractor has now come to be regarded more as a versatile source of power with a part to play in most farming operations, e.g. ploughing, harrowing, planting, cultivating, harvesting, threshing and transportation. In 1931, tractors were equipped with diesel engines which enabled these machines to work under extremely adverse traction conditions. Low-pressure pneumatic tyres first appeared on the farm tractors by about 1932. The truly revolutionary development of the pre-World War II period, the Fergusson system was introduced from the UK in 1939. With the tractor came the greater use of the combine, cotton-stripper and corn-picker.

The development of mechanical power was an incredibly rapid transformation. The reasons were the development of the automobile industry and the associated farm equipment industry plus the availability of cheap energy from oil.

Farmers' Reaction to Loan Companies and Trusts

As no arrangements were made in the nineteenth century to provide credit to the farming community, farmers were obliged to take loans at high interest from the Loan Companies to buy costly agricultural machinery. This situation caused distress among the farmers, who thus reacted to it, 'Let's raise less corn and more hell !' This is just a sample of the angry advice of Mary Ellen Lease, a spokesman for the protesting farmers in the late nineteenth century.

'The farmers of this country are the victims of villains who, like leeches, are sucking the lifeblood out of our bodies. One such is the loan shark of the East, whose agents flood the West. Out of farmers' desperate need for money to buy livestock, machinery, or land, he squeezes interest rates of twenty per cent or higher. This means that millions of Western and Southern farmers are slaving from sunup to sundown for Eastern loan companies. It means that many farmers are losing their heavily mortgaged farms to the loan companies when they cannot keep up these high interest payments. It means that more and more farmers, losing their farms, become tenant farmers or sharecroppers.

'Loan sharks claim that they have to charge farmers higher rates than manufacturers or merchants because farming is a riskier occupation. It's true that some farmers are in such a hurry to make money that they recklessly borrow too much money to buy too much land. But why doesn't the Government see to it that interest rates for farmers are fair.

'The West—and the South, too—will soon become the private property of the East. For soon our farms will be owned by Eastern corporations, just as many of our mines and cattle ranches are now. Since Eastern corporations also own most of the nation's factories, it won't be long before the whole country will be theirs.

'The huge trusts that monopolize so many of the nation's industries also are like leeches living off the farmer. With little or no competition, they charge him excessive prices when he wants to buy farm machinery, fertilizer or furniture. If the Government would only lower the tariff, such trusts might be forced to lower prices in the face of competition from European companies. But we farmers don't expect much help from the Government, since both political parties seem to favour the trusts and high tariffs.'[8]

Genetic Improvements in Crops

The first major application of the science of genetics to plant breeding was the creation of hybrid corn. The pioneers were George Hearrison Shull, of the Carnegie Institution's Station for Experimental Evolution, and Edward Murray East, at the Connecticut Agricultural Experiment Station. However, it was Donald F. Jones, working at the Connecticut Station, who carried the work to completion and produced double-cross hybrids in 1917. However, a widespread use of hybrid corn was delayed by production and marketing problems until in 1926, Henry A. Wallace in Iowa organized the first of several Midwest commercial corn companies and began to employ salesmen to sell seed-corn that was 20 per cent more productive than the open-pollinated varieties. Nevertheless, it took time to develop volume and it was not until the mid 1930s that the planting of hybrids in the Corn Belt became popular.[9]

The splurge of genetic improvements in plants and animals continues. This includes new varieties, hybridization and other ways of increasing yields of crops and livestock. Research leading to stiffer, shorter straw and stalk, enabling grain plants like wheat and rice to support the weight of much heavier stalks without breaking or bending, has increased production more than hybrid vigour alone.

Horticulture and Landscape Gardening

In the early nineteenth century, fruit-growing and landscape gardening also developed in the USA. N.S.B. Gras thus describes how it took place. 'A significant development of specialized intensive agriculture is found in horticulture, for the production of vegetables, fruits, nuts, or flowers, and shading off into landscape gardening. At first, gardening was just a part of household management, or self-sufficient agriculture. Almost every farm came to have its kitchen-garden and many had an orchard. New England and New Jersey were early noted for their fruit-trees; Maryland and Virginia were praised for their vegetable gardens. As towns,

[8]Platt, N. and Drummond, M.J. 1964. *Our Nation from its Creation, a Great Experiment*, N.J., pp. 480-1

[9]Dunbar, R.G. 'The role of agricultural history in economic development', *Agricultural History*, 1967

cities, and especially metropolitan centres developed, specialization arose as between horticulture and general agriculture, and even within the field of horticulture. We may place such growth roughly in the early part of the nineteenth century. During that period, treatises were being written in America on special parts of horticulture—fruit-growing in 1817 and landscape gardening in 1841. The eastern States set up horticultural societies—New York in 1818, Pennsylvania in 1827, and Massachusetts in 1829. Horticultural journals were started in Philadelphia in 1832, in Baltimore in 1833 and 1834, three in Boston in 1835, and one in Albany in 1846. By 1848, the new development was so strong that there were two societies disputing hegemony and enlisting the aid of the devotees of horticulture. The third development came after the Civil War when horticulture came to be localized, not only according to accessibility to great markets but according to climate, its products being handled, however, through the metropolitan marketing agencies. Florida and California are outstanding examples of this growth.'[10]

Rural Electrification

Farming was electrified in the third decade of the current century. Electric lighting came to farm houses and barns. Electric motors were installed for pumping water, grinding, milking and other tasks. This came about through government initiative, financing and technical help for the farmer electrification co-operatives. Electric power on the farms was confined to a few places near towns and in densely populated areas until the mid-1930s; then rapid electrification took place even in the vast reaches of the Great Plains. In 1935, about 10.9 per cent of the American farmers received electricity from central stations. By 1960, the percentage increased to 90.[11]

Input Industry

The transformation of commercial agriculture in the last few decades obviously has not been on the farm alone. It has included a fantastic growth of supply industries—farm machinery, the manufacturing of fertilizers, insecticides, herbicides, disease-control materials, etc., and feed-mixing. The advances in agricultural chemistry involved the development of fertilizers, weed-killers, insecticides, growth stimulants, and antibiotics and other medicines for livestock. The great upsurge in the US grain yields since World War II has been mainly the result of chemical nitrogen fertilizer produced and used in vast quantities in the USA. Accompanying the development of these agricultural chemicals was the

[10]Gras, N.S.B. *A History of Agriculture in Europe and America*, pp. 302-3

[11]Dunbar R.C. 'The role of agricultural history in economic development', *Agriultural History*, 1961

appearance of various machines, spray equipment, irrigation techniques and devices for using the new materials.

DISCOVERY OF 2,4-D, A GROWTH-REGULATOR AND HERBICIDE

The secret discovery of 2,4-D during World War II initiated a revolution in chemical weed control. In 1940, the estimated market for herbicides came to only 1½ to 2 million dollars; in 1962, the American farmers treated over 70,000,000 acres (28,328,000 ha) with this herbicide at a total cost of £270,750,000. Without doubt, 2,4-D created this phenomenon, bringing unexpected success to half a century of agricultural and botanical research.

During the early 1930s, scientists isolated three forms of growth substances. Though chemically different, they all possessed identical growth-regulating properties. In 1934, just as two scientists at the University of Utrecht reported the isolation of the third substance, F.W. Went and K. Thimann, working in California, synthesized it. Further, they found that the synthetic chemical affected the growth of plants exactly as did the plant-produced hormones. Following this discovery, plant physiologists synthesized a wide range of compounds of similar structure and tested their effect on plant growth.

In 1935, P. W. Zimmerman, F. Wilcoxon, and A. E. Hitchcock—scientists at the Boyce Thompson Institute—reported the finding of new hormone-like substances. They noted, in particular, the activity of phenyl and naphthyl acetic acids. While their work continued, in 1938, V.C. Irvine, of the University of Colorado, reported that naphthoxyacetic acid was a very active growth-regulator. Following that report, Zimmerman and Hitchcock began to examine the activity of similar compounds and soon discovered that phenoxyacetic acid was very active. By 1939, Zimmerman, Hitchcock and Wilcoxon listed 54 different substances which affected plant growth, when applied in vapour form.

While Zimmerman and Hitchcock searched for and tested even more potent growth-regulating chemicals, other plant physiologists found useful applications of research on synthetic hormones. By 1939, workers succeeded in getting apples and pears to hang on to the trees, until fully ripe, by applying very minute quantities of growth-regulating chemicals. Plant physiologists also found that some chemicals induced rooting, hastened the ripening and colouring of fruits, or even produced seedless tomatoes. The single focus of research on growth-regulators continued, leading to the discovery of more such useful applications of synthetic hormones.

In April 1942, Zimmerman and Hitchcock reported the responses that phenoxyacetic and benzoic acids induced, when applied to plants in various forms. Among these chemicals, one of the most potent for inducing seedless tomatoes was 2,4-dichlorophenoxyacetic acid (2,4-D). Indeed, when they compared the potency of 2,4-D with that of another synthetic plant hormone, viz. the then widely used indolebutyric acid, they concluded that 2,4-D was 300 times more powerful!

'In June 1944, Mitchell and Hamner made the first public suggestion of using 2,4-D —or any growth-regulating chemical—as a herbicide. They first noted the translocatory properties and the extremely small quantities of 2,4-D required to kill bean plants. Then they suggested that in view of its specificity, 2,4-D might be "of some importance" in connection with the differential killing of weeds.

'The tests in 1944 provided dramatic proof that E. J. Kraus, of the University of Chicago, had been right in 1941 when he envisaged the use of growth-regulators as herbicides. Further, the secrecy that covered the early work did not extend to the agricultural applications that scientists found. Indeed, with the decision in 1944 by several chemical companies to market 2,4-D commercially in 1945, it would have been impossible to prevent publicity about the new herbicide. Franklin D. Jones, of the American Chemical Paint Company, had worked for several years on growth regulators, before he announced in 1944 that he would seek a "use" patent for 2,4-D as a herbicide. Accordingly, in May 1945, Jones applied for a patent on 2,4-D and the Patent Office granted it in December under the title, "Methods and Compositions for Killing Weeds". Also in that year, the American Chemical Paint Company marketed the first systemic herbicide produced on a commercial scale under the brand name "Weedone".

'The market for 2,4-D increased rapidly. In 1945, the first year of public testing when only limited amounts of 2,4-D were available, the total production in the United States came to 917,000 pounds (416,000 kg). In 1946, its production climbed to 5,466,000 pounds (2,479,334 kg)—an increase of nearly 500 per cent. By 1950, its annual production exceeded 14,000,000 pounds (6,350,300 kg). The years following 1950 confirmed the trends already begun. The production of 2,4-D rose to 36,000,000 pounds (16,329,300 kg) in 1960 and then increased rapidly to 53,000,000 pounds (24,040,400 kg) in 1964. Further, the herbicide-manufacturers built upon their own successes. The growing market stimulated the producers to develop better and more types of herbicides. These improved products attracted even greater attention and thus increased the total market. By 1962, the companies marketed about 100 herbicides in 6,000 different formulations. The increased specificity for particular weed problems in certain crops under differing soil and climatic conditions accounted for the bewildering selection'.[12]

[12]Pertersen, G.E. 'The discovery and development of 2,4-D', *Agricultural History*, Vol. XLI, 1963

Price Support

Modern agriculture with the use of machinery, fertilizers, weedicides, insecticides and fungicides is a costly business. Unless the farmer is assured that he will recover his costs and also earn some profit, he hesitates to invest. With the enactment of the Agricultural Adjustment Act of 1933, the Congress began to develop price-support programmes which took much of the price uncertainty out of farming and encouraged farmers to make greater investments in their business.

Credit and Marketing

The Federal Farm Loan Act of 1916, the Agricultural Credit Act of 1923 and the Farm Credit Act of 1933 created financial agencies adapted to the needs of the farmers. Still other laws, including the Capper-Volstead Act of 1922, encouraged the formation of marketing and purchasing co-operatives.

Contribution of European Nations to the American Agriculture

The USA is a melting-pot of nations. The resources of three continents were pooled; Africa gave its labour; America, its land; and Europe, its talent and capacity to exploit. It is the people from Europe who made the plans and introduced innovations. Gras thus describes the traits of different European nations which settled in the USA and the type of agriculture in which they specialized.

'The English contributed much to American animal husbandry. Whereas the English and the Scotch are good all-round livestock people, the Danes and the Swiss are excellent dairymen, the Danes taking to butter-making, the Swiss to cheese. Generally, the Scandinavians are progressive, with high ideals for improving their houses as well as their barns. They readily adapt themselves to their environment and see to it that their children obtain education so that they will not all have to remain on the farm. The Germans are industrious, inclined to save, with a propensity to field-gardening and land-ownership. Their barns are likely to be better than their houses. In one community of the yankee farmers along the upper Mississippi, the Germans came in and gradually bought up the farms. The Yankee women did not labour in the fields, as the German women did. The Yankees sold what they did not eat, while the Germans ate what they could not sell. The Yankees lived for the present, while ther Germans saved for the future. Accordingly, the Germans crowded the Yankees out, and still hold their land. The Germans have a capacity for taking pains. They care for their cattle and their machinery. They use all the soil available and get the last grain from the harvest. The French have never been progressive in America, though in their homeland they cannot be called poor farmers. They are in some parts more inclined towards horticulture than towards agriculture, and have more children than cattle. The Irish are shiftless farmers, unprogressive like the French, careless of detail, and unsuccessful with livestock. On the other hand, they are often outstanding in local political and administrative work and in the social life of their community. The Poles have large families and work long hours. They have ousted many American onion- and tobacco-growers in New England. In Wisconsin, they have taken leftover farms in the sandy regions of the centre and the north. The Poles seem to be making good in American agriculture, but their progress is not striking and their numbers are not large. The Finns in many parts have poor land, but by industry and skill in dairying, they have attained some material success. They are a suspicious people, clannish, and unsanitary. Like the Germans, they are musical, a rather uncommon trait in rural America. The Italians have settled in New Jersey, New York, the coastal plain of the Gulf, and in Wisconsin. They do best in communities of their own people. Loving agriculture, they are successful in maintaining soil fertility or even improving it further. Usually, their farms are small and carefully worked with hand-tools.'[13]

The Countryside in America: no Villages but only Homesteads

A visitor to the USA will notice that there are no villages, and only scattered homesteads dot the countryside. This is the result of large-scale mechanization. No doubt, to start with the villages were established, but they grew into towns, where trading, shipbuilding, fishing and the like, took place. The village was unable to compete with the isolated farm-stead. 'In the passing of the infant village', Gras observes, 'America suffered a great social loss, for close proximity in Europe and elsewhere has meant daily social life, conversation, story-telling, singing, and dancing. So imbued was the emigrant from Europe in settlement days with the saving grace of economy that he did not hesitate to sacrifice the social advantages of the village group to the managerial advantages of the isolated farm. But above all was the fact that the farms in America were too large to be compressed into a village organization.'[14]

One result of this type of development was that America failed to develop a rural culture. From purely economic standpoint it was a great accomplishment, but from the social angle it was a disaster.

Large Commercial Farms

A modern American farm uses little labour but is highly capitalized. The average investment in a top commercial farm in the Midwest State

[13]Gras, N.S.B. *A History of Agriculture in Europe and America*, pp. 385-6
[14]Gras, N.S.B. *A History of Agriculture in Europe and America*, p. 287

of Iowa at the end of 1975 was about $400,000. This typical farm of 120 hectares would have machinery and equipment valued at about $40,000, an inventory of livestock and feed worth $60,000 and land and buildings worth about $300,000. The farmer relies on off-form businesses, part of the agribusiness complex, to provide him with production supplies, marketing services and sometimes entire "custom" operations, such as the combine-harvesting of soybeans or planting and weed-control for maize.

There is a strange parallelism in the development of large mechanized farms in the capitalist USA and in the Communist USSR. The large State farms and collective farms in the USSR resemble the American commercial farms in the use of heavy tractors and combines. This parallelism exists because both these countries have large arable areas and relatively scanty manpower.

One evil result of this change has been that a large number of people were uprooted and migrated to the cities bursting with people and polluted by smoke. Crime is also rampant. Farming is not merely an economic enterprise, but also a way of life—a healthy way of life. The social costs of this change cannot be quantified in terms of money. The day may come when the Americans, tired of urban squalor, will trek back to the countryside.

Influence of American Farming on other Countries

The USA has the most productive agriculture in the world. This success is due to the combination of many factors, e.g. a favourable land-man ratio, good soil and the grassland climate, which is suitable for the cultivation of cereals, and the government price-support programmes. The farmers are also educated and readily apply the findings of scientific research to their agriculture. Above all, the organization of education, research and extension in agriculture as a unit is a major innovation. Other important contributions of the USA to world agriculture are in the invention of the combine and the tractor, and the discovery of the herbicide 2,4-D. American agriculture had an impact on Japan in the Meiji Era (1868-1917) and on Mexico after 1930. From 1955 onwards, it has also influenced Indian agriculture. Its concept of integration of teaching, research and extension was accepted in India, and this led to the development of agricultural universities. By providing seeds of high-yielding varieties of wheat, rice, maize and millets, it laid the foundation of the Green Revolution.

CHAPTER 15

AGRICULTURAL UNIVERSITIES

GENESIS AND GROUNDWORK
REPORTS OF THE FIRST AND SECOND JOINT INDO-AMERICAN TEAMS
CUMMING'S COMMITTEE REPORT ON AGRICULTURAL UNIVERSITIES, 1960-65
THE REPORT OF THE EDUCATION COMMISSION 1964-66

HIGHER education in Agriculture had a low status before Independence. The best students were attracted by the professions of Medicine, Engineering, and Law, which were more remunerative. Thus, with a few exceptions, only those who were left out joined agricultural colleges. In 1948, there were only 17 agricultural colleges in India and facilities for training in postgraduate research in agricultural sciences were available for only 160 students.

Agriculture and education are allocated to the States. Thus all agricultural colleges were under the immediate supervision and control of the State departments of agriculture, whereas the veterinary colleges were responsible to the State veterinary departments or State departments of animal husbandry. All agricultural and veterinary colleges were affiliated to a traditional type of university which controlled examinations, curricula and standards. Each college was headed by a principal who reported directly to the State director of agriculture or veterinary. Although the principal had theoretical responsibility for operating his college, he usually lacked sufficient authority to make the required decisions. The State director of agriculture made some decisions, but even he did not have full authority to act without the approval of the State secretary of agriculture. Financial support for the colleges was channelled through the State department of agriculture.

Agricultural (Crops) Education and Animal Husbandry (Livestock) Education were separated, with Animal Husbandry incorporated into the veterinary colleges. In some States, these agricultural and veterinary colleges were in different locations and had little contact with each other.

Research and extension programmes were the function of the State departments of agriculture and animal husbandry. Research techniques were often poor, and the research tended towards theoretical problems rather than towards applied research, specifically orientated towards solving of the country's serious production problems. There was a particular lack of significant research on the problems of livestock. The agri-

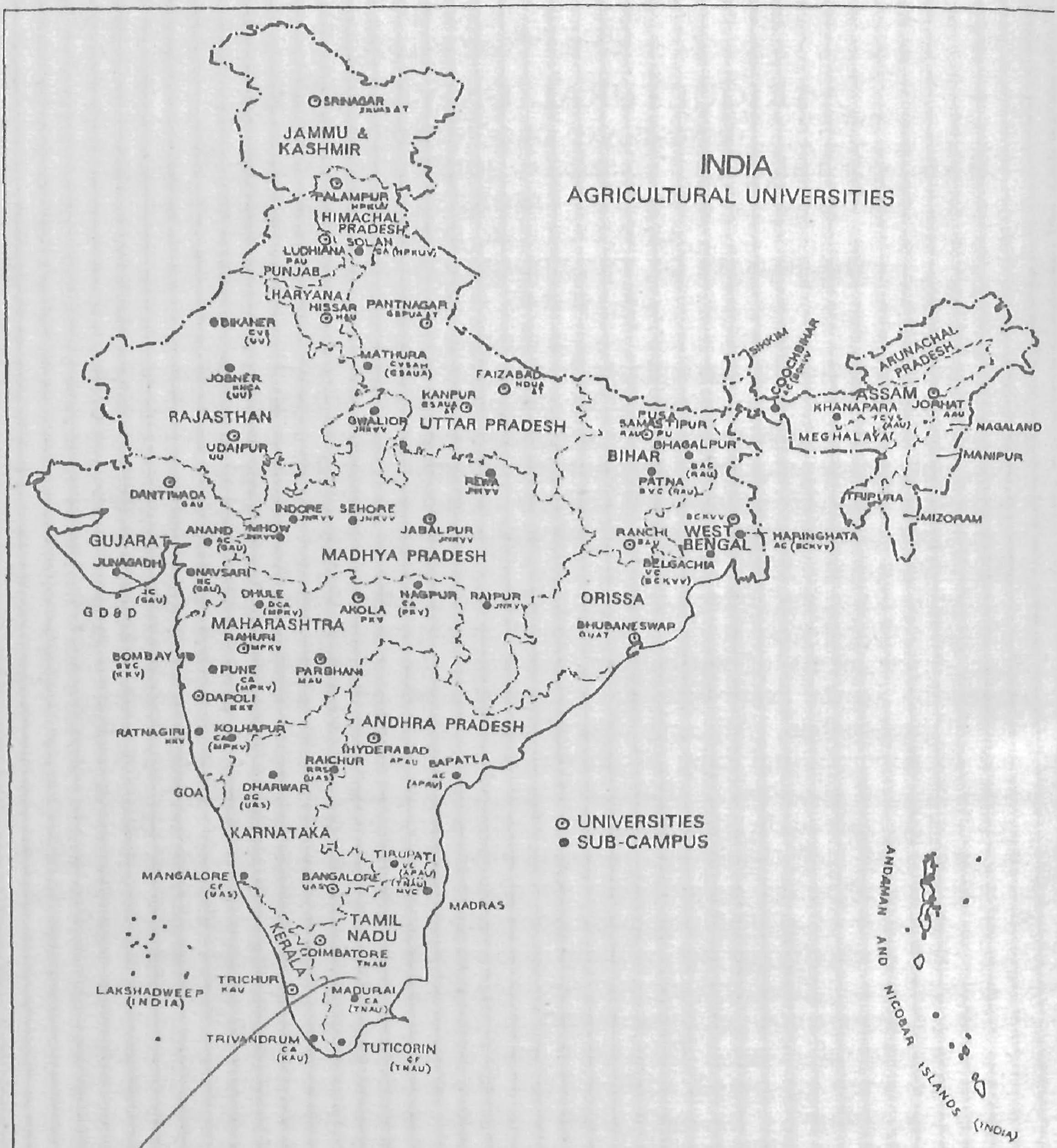
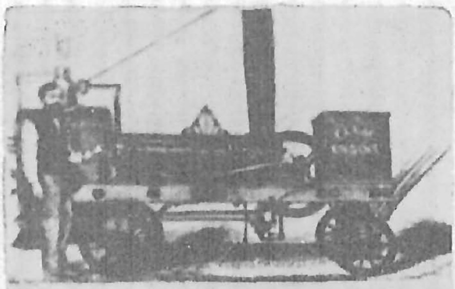
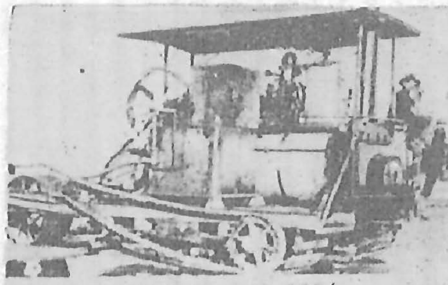


FIG. 47. There are 21 agricultural universities in India. Now every State has an agricultural university and some have more than one.

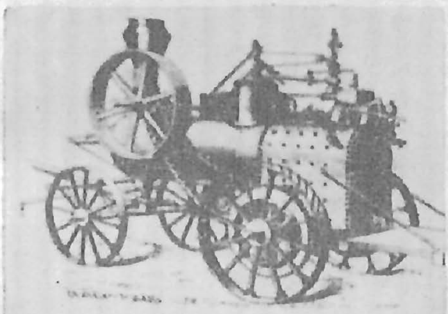
cultural extension work of the State departments of agriculture included service and regulatory activities, in addition to Extension Education, with the result that the latter was neglected. Extension workers placed emphasis



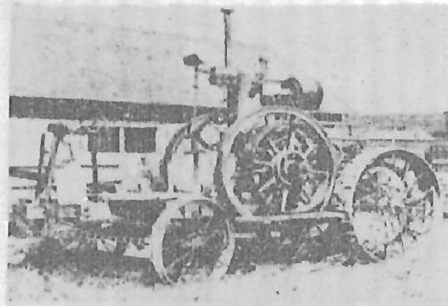
Archambault, "The Forty-Niner," 1849.



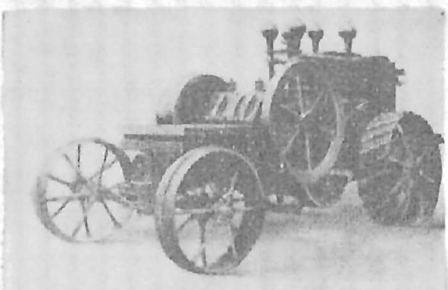
Holt (steam), 1904.



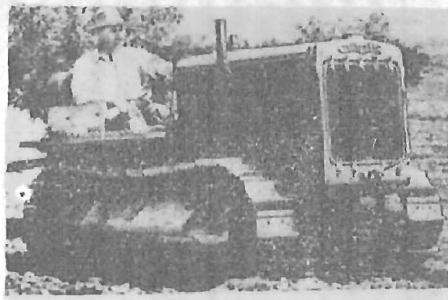
Atlas Engine, 1881.



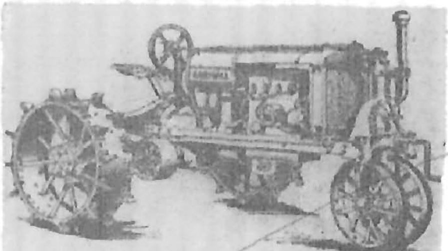
Froelich, 1892.



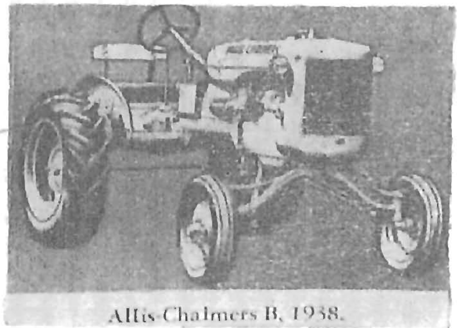
Hart-Parr No. 1, 1902.



Caterpillar 15, 1929.



McCormick-Deering Farmall, 1924.



Allis-Chalmers B, 1938.

FIG. 48. The tractor is an American invention. The first tractors were steam tractors. The first gasoline tractor was built in 1892 by John Froelich, an Iowa farmer and blacksmith. In 1931, tractors were equipped with diesel engines. Low-pressure pneumatic types appeared about 1932. The Fergusson System was introduced into the USA from the UK in 1939. (Courtesy :USDA)

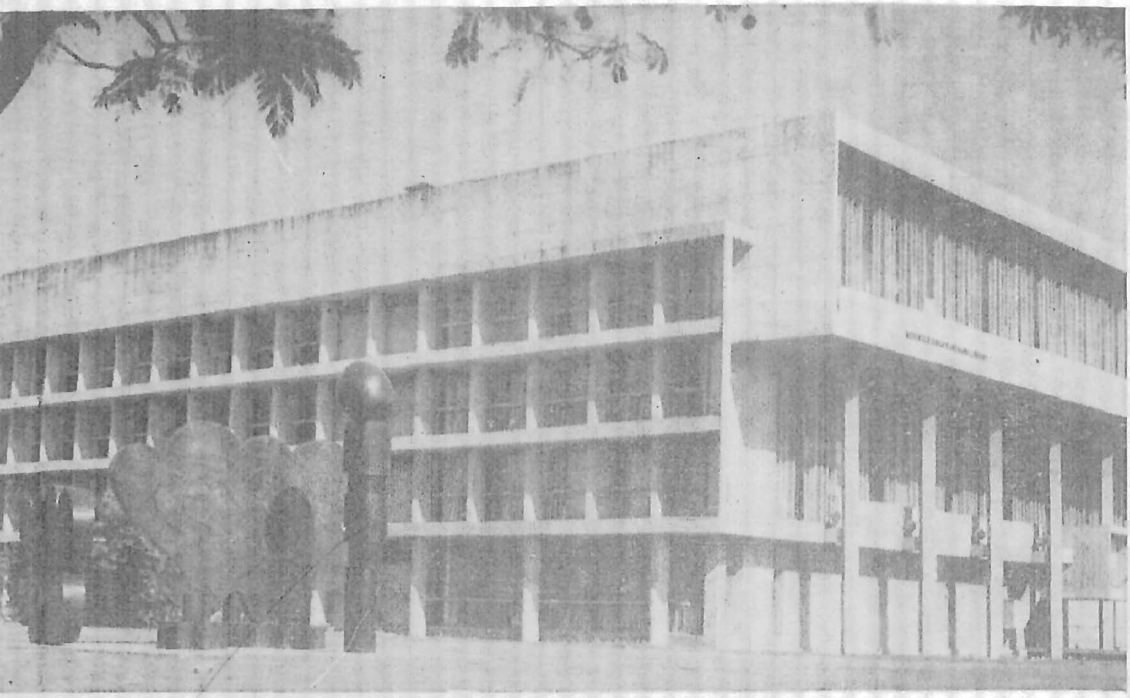


FIG. 49. A view of the library of the Punjab Agricultural University, Ludhiana. It is the most modern library in India, with 300,000 books. All the rooms are decorated with paintings. In front is a sculpture, showing plant and animal life.

FIG. 50. The Gymnasium of the Punjab Agricultural University, Ludhiana, has facilities for all indoor games.

FIG. 51. The Labh Singh Laboratories, in which the Plant Breeding Department of the Punjab Agricultural University is located. It has been named after Labh Singh, the famous cotton breeder.

FIG. 52. The Administrative Building of the Haryana Agricultural University, built at a cost of Rs 2.08 million. It provides accommodation for the offices of the Vice-Chancellor, the Registrar, the Comptroller, the Chief Engineer and the Director of Research.

FIG. 53. The building of the College of Agriculture of the Haryana Agricultural University. Built at a cost of Rs 3.476 million, it consists of three blocks, each of three storeys. It has well-equipped laboratories, a museum and an auditorium.

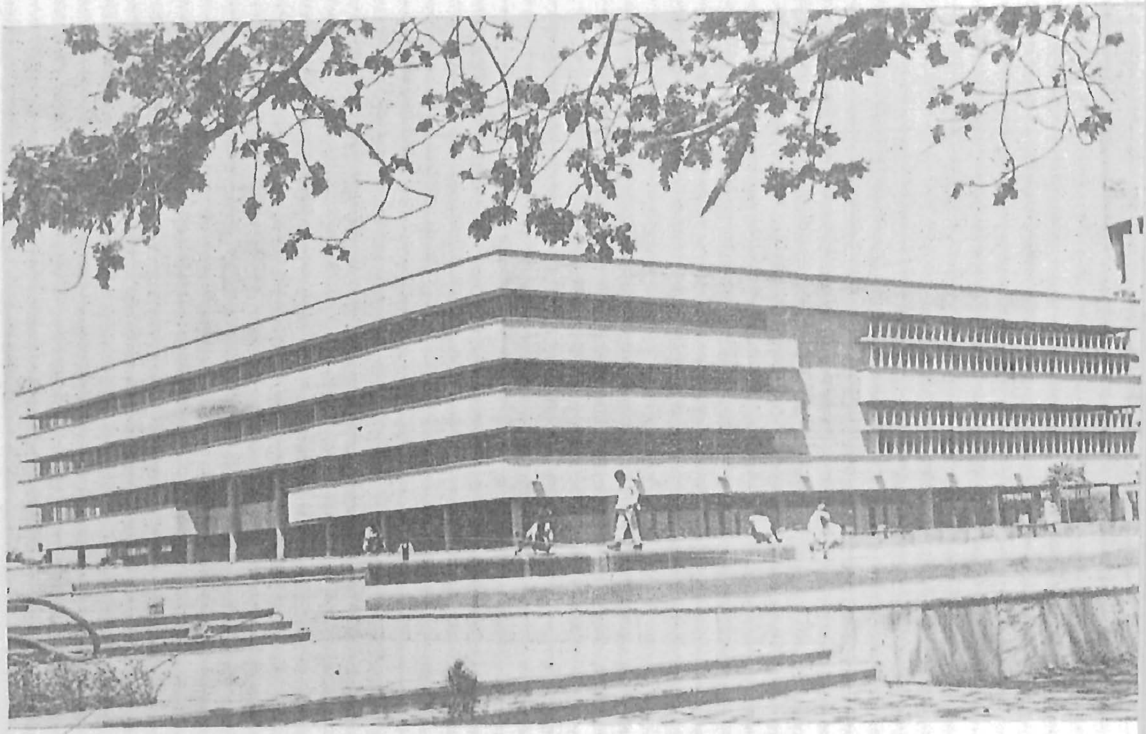


FIG. 54. The Nehru Library, Haryana Agricultural University. Built at a cost of Rs 4.441 million, it is designed to accommodate 300,000 books. It has a seating capacity for 650 readers. It has well-equipped documentation and reprographic sections.

FIG. 55. The Giri Centre. It is a complex of buildings comprising a stadium and a multipurpose hall, which serves as a gymnasium. It is also used for indoor games, e.g. basket-ball, volley-ball, badminton, table tennis, boxing and wrestling. The tower provides a view of the campus.

FIG. 56. The Administrative Building of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

FIG. 57. Laboratories of Himachal Pradesh Agricultural University, Palampur, Kangra district. In the background is snow-covered Dhauladhar Range.

FIG. 58. Dr O. P. Gautam (b. 1924), an eminent agronomist and educator, now Director-General of the ICAR. His contribution to the development of agricultural education in the agricultural universities is outstanding.

on supplying the basic materials and services to the cultivators, without the corresponding attention to instructions about the ways to make the most effective use of these materials and services.

The objective of the students was to pass the annual examinations, and all teaching and learning were orientated towards that end. Students memorized the lecture notes, with little use of outside reference books, without questioning the material in the lecture notes. The system discouraged teacher or student initiative and intellectual curiosity.

University Education Commission, 1949

In 1948-49, the University Education Commission, under the chairmanship of Dr S. Radhakrishnan, recommended that a system of rural universities be established to supply skilled persons that would be needed by the country and to meet the requirements of an educated citizenship. The Commission observed, "A new beginning is desirable, with freedom to create a distinctive tradition as to purposes, spirit and methods".

According to the Commission a rural university should include a ring of small resident undergraduate colleges, with specialized and university facilities at the centre. While the need for a common core of liberal education in the basic sciences and social sciences was recognized, it was stressed that the curriculum should fit in with the needs of individual students and should provide for specialization and for taking courses from more than one college. Each rural university should be autonomous and free to work out its own programme in its own way in terms of syllabuses, curricula, evidence of completion of work, and examinations. Through its concept of rural universities, the University Education Commission introduced the Land-Grant College philosophy of the USA into India.

Visit of A. N. Jha and H. S. Sandhu to the USA, 1950

The earliest advocate of the agricultural university idea was Pandit Govind Ballabh Pant, formerly the Chief Minister of Uttar Pradesh and later the Home Minister of the Government of India. He gave great support to Major Harpal Singh Sandhu in the reclamation of the Tarai. In 1950, Sandhu and A. N. Jha, Chief Secretary and Development Commissioner of Uttar Pradesh, visited the United States and were impressed by the land-grant universities and the contribution they had made to agriculture in that country. On return from there, they reported to Pantji that if such a university were established in the reclaimed area of Rudrapur in the Tarai, it would give an impetus to agriculture in that area. Pantji accepted their advice. This event ultimately led to the fruition of the scheme for agricultural universities in the country.

THE FIRST JOINT INDO-AMERICAN TEAM, 1955

The First Joint Indo-American Team was set up on the advice of Dr Frank W. Parker, who was the TCM Adviser to the Ministry of Food and Agriculture, Government of India. The Team comprised five Indians and three Americans. The American members included Dr A. H. Moseman, U.S. Department of Agriculture; Dean R.E. Buchanan, Iowa State University; and Dean E.E. Leasure, Kansas State University. The Indian members included K.R. Damle, Vice-President of the Indian Council of Agricultural Research; Dr B.N. Uppal, Agricultural Commissioner; L. Sahai, Director of the Indian Veterinary Research Institute; H. K. Nandi, Director of Agriculture, Government of West Bengal; and J.V.A. Nehemiah, Secretary, Indian Council of Agricultural Research. The Indian members of the First Joint Team visited the United States from January to March 1955, whereas the American members came to India in July 1955.

The Team endorsed the recommendation of the University Education Commission that, wherever possible, each State should develop a rural university. Particular places that the Team felt were fit to be considered for establishing a rural university included Uttar Pradesh *(Tarai)*, West Bengal (Haringhatta), Bihar (Patna), Orissa (Bhubaneshwar), Travancore-Cochin, and Bombay State (Anand). Second, the Team suggested that postgraduate colleges be established by the Government of India at the Indian Agricultural Research Institute and the Indian Veterinary Research Institute, among other places.

THE SECOND JOINT INDO-AMERICAN TEAM, 1960

The Second Joint Indo-American Team, set up on 12 September 1959, was headed by me, as the Vice-President of the Indian Council of Agricultural Research. It had three representatives of the American Land-Grant Universities, viz. Dean Arthur D. Weber, Dean A. E. Darlow, and Dean Arthur L. Deering, and Dr Martin G. Weiss, representing the U.S. Department of Agriculture. The Indian members of the Team were Dr B. N. Uppal, Dr L. Sahai, Sardar Bahadur Lal Singh, P.D. Nair, Dr M.D. Patel, Dr K. C. Naik (Secretary), Dr J. S. Patel, and Ibne Ali.

The Team submitted its report on 11 July 1960, and recorded that there was widespread demand from many States for the establishment of agricultural universities. The Team recommended that assistance in establishing an agricultural university should only be granted when there was adherence to basic principles, such as: (1) autonomous status, (2) location of agricultural, veterinary, animal husbandry, home science, technological and science colleges on the same campus, (3) the integration of teaching by offering courses in any of these institutions to provide a composite course, and (4) the integration of education, research and extension.

HANNAH'S BLUEPRINT ON AGRICULTURAL UNIVERSITIES, 1956

The work of this Team was greatly facilitated by a blueprint on agricultural universities. It was prepared by Dean H. W. Hannah in 1956. When Hannah met Pandit Govind Ballabh Pant, he asked the former what his subject of specialization was? When Hannah replied that it was law, Pant was disappointed. Yet the contribution made by Dean Hannah to this scheme while he was living at the Tarai Farm is fundamental. On the basis of his blueprint, the Uttar Pradesh Government submitted a proposal to the Government of India in September 1956 to establish an agricultural university at Rudrapur in the Tarai, now called Pantnagar. The Government of India approached the problem in a cautious manner and agreed to the setting up of the agricultural university in the Tarai only as an experimental measure in the Second Five-Year Plan. However, there were demands from many more States for such universities, and in 1961 the Government of India accepted the need for a few more such universities during the Third Plan and suggested that the existing colleges or institutions which had strong departments for teaching and research should serve as the nuclei for such universities.

CUMMINGS'S COMMITTEE REPORT, 1960-1962

In 1960, the Government of India appointed a committee headed by Dr Cummings to advise the State Governments on the legislation for the establishment of agricultural universities.

Ralph W. Cummings was born on a farm near Reidsville, North Carolina, on 13 December 1911 and for his B.Sc. degree studied at the North Carolina State College. After graduating from the College in 1933, he joined the Ohio State University and obtained his Ph.D. in 1938, majoring in Soil Science He started his career in 1936 as Technical Assistant (Pomology) at the University of Cornell. In 1942, he was made Professor of Agronomy and Head of the Department at the North Carolina State College and he held this office till 1947. He came to India in 1957 as Field Director of the Indian Agricultural Programme of the Rockefeller Foundation and continued as such till 1966.

While in India, Dr Cummings served for one year and a half as the Dean of the Postgraduate School, Indian Agricultural Research Institute, New Delhi. He has been a member of the Standing Committee on Agricultural Education of the Indian Council of Agricultural Research. As Field Director, he was in charge of the Foundation's programme of assistance in the development of the Indian programme of Cereal Crop Improvement, involving wheat, hybrid maize, sorghum etc. The Cereal Research Laboratory of the Indian Agricultural Research Institute was named after him.

The main idea behind the report of the Cummings' Committee was that the new agricultural universities should have the essential features that characterize the system and that they have a uniform base to carry on the functions with which they were charged. The report of the Committee, published in 1962, spelled out the distinctive features of the agricultural universities as compared with the existing universities and provided guidelines for develcping them. On the recommendations made by this Committee, the Indian Council of Agricultural Research developed a model act which could be adopted with such changes as were necessary by the newly developing agricultural universities. This was an important milestone in the development of these universities, for which Dr Cummings and his colleagues deserve much credit.

Agricultural Universities, 1960-1965

From 1960 to 1965, during the Fourth Five-Year Plan, seven agricultural universities came into existence in Uttar Pradesh, Orissa, Rajasthan, the Punjab, Andhra Pradesh, Madhya Pradesh and Mysore (Karnataka). The development patterns as also the functions and responsibilities delegated to these universities, however, varied and in some cases did not strictly conform to the central concept behind this institution-building process as laid down in the Model Act for Agricultural Universities.

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttar Pradesh)

The Govind Ballabh Pant University of Agriculture and Technology established in 1960 is the first agricultural university set up in India. It received support from Shri Ajit Prasad Jain (b. 1902, d. 1976), Minister of Food and Agriculture, who later on became the Chairman of its Board of Management. The University is named after Pandit Govind Ballabh Pant (b. 1887, d. 1961), who belonged to Kumaon. He started his legal practice at Kashipur in the Naini Tal Tarai, and hence he knew the problems of the area intimately. In 1937, he became the first Chief Minister of Uttar Pradesh and later assumed the office of the Home Minister, Government of India. The founder Vice-Chancellor was K.P.A. Stevenson (1959-1964), an IAS officer. The most distinguished Vice-Chancellor of this University was D. P. Singh (1966-1975), who built up the University with dedication. It is a mono-campus institution, with jurisdiction over nineteen districts of Uttar Pradesh. It offers educational programmes in the fields of Agriculture, Agricultural Engineering Technology, Veterinary Science and Home Science. The University has recently acquired a farm at Daurala and another at Rani Chauri in the hills to develop regional research and training facilities. The sanctioned strength of the staff in 1975-76 was 369, and the number of students on the rolls was about 2,000.

This University has an impressive record of achievements to its credit in the fields of education, research and extension education. It has all through laid emphasis on quality and relevance of education and research, and has maintained its all-India character by accepting freely the best students and faculty from any part of the country. As a result, it has a competent faculty which has made excellent contribution to the development of the agricultural university system in India. For example, the university introduced the pioneering programmes of practical training for agricultural and veterinary graduates. It is serving as a model to other agricultural universities. It has also initiated a number of programmes for promoting self-employment among agricultural and agricultural engineering graduates, even though the results of such efforts have not been encouraging. It has achieved reputation for the development of quality seeds which are popular throughout the country. The research programmes are strong, and have the advantage of being backed up with the data available from a large experimental farm.

When the Agricultural University was started, 14,255 acres (5,769 ha) of land was transferred to it by the State Government, so that the farm could provide the finances to the University, and also enable the students to earn while they learn.

By its research and its extension to the farmers, this University has transformed the Tarai. Tractors, threshers and tube-wells are a common sight. On account of a plentiful supply of ground-water, this area is exceptionally favourable for intensive agriculture. The Tarai of Naini Tal in Uttar Pradesh is one of the Green Revolution areas of India.

University of Udaipur, Udaipur (Rajasthan)

In early 1962, the Government of Rajasthan invited Dr Ralph W. Cummings to help draft a bill for the establishment of an agricultural university in the State. As a result, the Rajasthan Agricultural University was established, and the Rajasthan College of Agriculture, Udaipur, the S.K.N. College of Agriculture, Jobner, and the Rajasthan College of Veterinary and Animal Science, Bikaner, were transferred to it. The University was inaugurated on 12 July 1962.

The first Vice-Chancellor of this university was G.B.K. Hooja (1962-1963), an IAS officer. He was followed by Dr G.S. Mahajani, an educationist. Dr Mahajani was a renowned mathematician, but had no knowledge and experience of agriculture. He served as Vice-Chancellor of this University from 1963 to 1972. Dr P.S. Lamba, an agricultural scientist, was its Vice-Chancellor from 1973 to 1977. The present Vice-Chancellor is Dr Ranbir Singh.

Initially, the University had only two faculties, viz. that of Agriculture with two campuses at Udaipur and Jobner, and of Veterinary and Animal Science at Bikaner. In 1963, the Act was amended to facilitate the accession of other colleges within the municipal limits of Udaipur and to make the University a multi-faculty institution. This was an unfortunate decision.

Whereas the instructional campuses of the University are confined only to Bikaner, Jobner and Udaipur, 10 research stations and 10 extension education centres are spread all over the State to serve the different agro-climatic zones.

All research stations were transferred to the University from the Department of Agriculture on 1 April 1976. Facilities in the form of farms, funds and manpower were also increased. During 1978-79, the financial outlay was Rs 18 million, with a strength of 1,240 (450 scientific and 790 supporting staff) in the research component alone.

Orissa University of Agriculture and Technology, Bhubaneswar

The Orissa University of Agriculture and Technology was established in August 1962, and it is the third oldest agricultural university in India. It is a mono-campus institution, offering educational programmes in three faculties—Agriculture, Agricultural Engineering and Veterinary Science. There is a College of Basic Sciences and Humanities. It offers the intermediate-level programmes only.

The first Vice-Chancellor was M. C. Pradhan (1962-1965). He was followed by Dr K. Ramaiah (1965-1968), a well-known rice breeder. The present Vice-Chancellor is Dr K. Kanungo.

Punjab Agricultural University, Ludhiana (Punjab)

Consequent upon the partition of India on 15 August 1947, the famous Lyallpur Agricultural College fell to the share of Pakistan. The refugee farmers of Ludhiana, who mostly came from the Lyallpur Canal Colony, knew the benefits of an agricultural college. They vacated a school building to house the new agricultural college, the Government Agricultural College, Ludhiana. About 600 acres (243 ha) in an evacuee village was allotted to the College in 1950. By 1955, a modern building was raised for the College. In 1962, owing to the interest taken by the Chief Minister, Sardar Partap Singh Kairon, who was keenly interested in agricultural development, Ludhiana was selected for the establishment of an agricultural university. Sardar Kairon (b. 1901, d. 1964) was a farmer's son. His father Nihal Singh founded a high school in the Village of Kairon in the Amritsar District, where Partap Singh received his early education. Later on, he proceeded to the USA and took his Master's degree from the Michigan University. He joined the Indian National Congress in 1930. In 1938, he courted arrest, leading a *kisan* agitation against enhancement in the irrigation cess. Since 1947, he had been a minister in the Punjab Government. He became the Chief Minister in 1956 and served in that capacity up to 1964.

Sardar Darbara Singh, who was then the Minister of Agriculture, Punjab Government, giving his impressions about P. N. Thapar, the founder Vice-Chancellor, stated: 'When Mr P. N. Thapar discussed with me the new concept of this Agricultural University, I was amazed that a person who himself was not a farmer had such a deep understanding of the needs of the tillers of the soil and had positive approaches in his mind for solving their problems. Although the idea of such a university was new for India, I was so much impressed by his clear vision, constructive planning and the newly conceived administrative set-up, that I readily agreed to the establishment of this University and to provide all the facilities and the staff that he wanted to obtain from the Department of Agriculture, Punjab.'[1]

The University was formally inaugurated by Pandit Jawaharlal Nehru on 8 July 1963. Owing to the dedicated efforts of P. N. Thapar, and the enthusiastic support of the Chief Minister Kairon, the University made rapid progress.

The Punjab Agricultural University provides graduate and postgraduate instruction in Agriculture, Veterinary and Animal Science, Agricultural Engineering, Home Science, and Basic Sciences and the Humanities. The University makes provision for instruction in applied fields, for research and for the spread of the findings of research and other technical information through a programme of Extension Education. It is thus responsible for the three functions of teaching, research and extension education in agriculture and allied fields for Punjab.

The University Campus at Ludhiana covers 1,427 acres (577.5 ha), including a research farm, covering about 1,264 acres (511.5 ha). Besides, ten regional research stations and substations cover 1,188 acres (480.7 ha). Two seed farms are also established over 1,175 acres(475.5 ha).

The University has earned the distinction of being the Asia's largest farmer-training centre. Every year, over 250 training courses are organized, involving over 8,000 farmers, dairymen, poultry-keepers, young farmers, farm women and extension workers. Specialized training courses in Farm Machinery, Poultry, Dairy-farming, Piggery, Fruit and Vegetable Cultivation and Preservation are popular with the farmers.

P.N. Thapar, ICS (Retd), the first Vice-Chancellor, was one of the seasoned administrators of the country. During his tenure, the University became a premier institution for agricultural education and research in Asia.

I took over as Vice-Chancellor in 1968 and continued till 1976. During this period, the College of Veterinary Science was started at Ludhiana. A number of new buildings, e.g. the College of Basic Sciences and Humanities, Kairon Kisan Ghar, the Central Library, the Museum

[1]Convocation address by Sardar Darbara Singh, delivered at the Punjab Agricultural University, Ludhiana, on 15 May 1981

of Water and Power Resources of Northern India, the Museum of Rural Life of Punjab, Students' Home and the Communication Centre were built. New crop varieties were discovered. They made the Green Revolution in the State a reality. I made the University the farmers' university in the true sense.

Role in Green Revolution

The role of the Punjab Agricultural University in the Green Revolution is thus described by P.C. Aggarwal, a perceptive observer.

"Twice a year the university organizes *Kisan Melas* on the Campus where farmers from all over Punjab and other States come in large numbers. The university virtually turns itself out on these occasions and allows the visiting farmers to see what is being done there. All the new varieties of plants are put on display together with full details about their merits and their method of cultivation. At the same time, improved machines and animals are exhibited. Scientists explain their research findings and discuss them with the visiting farmers.

"Formal question-and-answer sessions are organized at which the farmers can discuss specific problems with the scientists.

"During the nine years of its existence, the university's scientists have evolved a number of improved seeds, found ways to control plant and animal diseases, designed new machines, and developed more efficient techniques of production. Economists and other social scientists of the university have done a great deal of research on diffusion of innovations, communication patterns, marketing of crops, farm mechanization, and employment. Most of their research has been on current problems and it has led to significant improvements in all aspects of agriculture in the districts of the State.

"Two important points need to be underlined about the contributions of the university. One is that, for the first time in the recent history of India, scientists have gained respectability in the eyes of the farmers. The latter have realized the value of scientific research. Farmers seem to understand that in order to use modern technology effectively they have to depend on the scientist. On many occasions farmers have spontaneously organized meetings to honour scientists. One can easily imagine the effect of such social recognition on the morale of an otherwise meagrely paid college professor. Several Panchayat Samitis and Zila Parishads have voluntarily contributed money in support of the University's activities.

"A second notable point is the development of a close relationship between the University and the farmers. The University extends itself to the farmer through its distinctive teaching methods which require students to visit farms and homes, and set up demonstration plots in the villages. Visits to the villages by the faculty members for research and discussions are also frequent. The farmers are drawn to the university through *Kisan Melas,* farm competitions, field days, demonstration centres, pure seed depots, discussion forums, specialized training courses for young farmers, and special fruit-preservation and animal-husbandry courses for women. They also run their own services for soil and water testing, plant protection, artificial insemination, planning and planting orchards, veterinary treatment, custom hatching of pedigreed eggs, guidance on dairy production and pig-keeping, agricultural information and broadcasting and lately an advisory service for designing and building farm houses, cattle and poultry sheds, grain stores and tube-wells.

"By 1960-61, a strong base for development had been established so that when the IADP, the Agricultural University, and the HYV seed came in quick succession, agriculture was transformed."[2]

JAWAHARLAL NEHRU KRISHI VISHWA VIDYALAYA, JABALPUR (MADHYA PRADESH)

The Jawaharlal Nehru Krishi Vishwa Vidyalaya was established on 1 October 1964 by an Act of the Madhya Pradesh Legislature passed in 1963. The headquarters of the university is located 7 km north of Jabalpur.

In December 1964, the Government of Madhya Pradesh transferred six colleges of agriculture and two colleges of veterinary science and animal husbandry, and nineteen research farms and stations to the University. The colleges of agriculture are located at Jabalpur, Rewa, Raipur, Sehore, Indore and Gwalior; and the colleges of veterinary science and animal husbandry are at Jabalpur and Mhow.

The first Vice-Chancellor was Dr J. S. Patel (1964-1968), who had retired as Agricultural Commissioner to the Government of India. He was followed by Dr L. S. Negi (1968-1972). After Dr Negi left, a period of instability followed, and there have been seven Vice-chancellors. The present Vice-Chancellor is Dr Sukhdev Singh.

There are four faculties—Agriculture, Veterinary Science and Animal Husbandry, Agricultural Engineering, and Basic Sciences and Humanities.

Research facilities are available for the Master's degree in all the colleges, where postgraduate classes are held, and also at the regional research stations. The main areas of research are the improvement of crops, the soil-fertility status and animal nutrition, the production of improved vegetable varieties, pest control, animal diseases, the crossbreeding of dairy cattle, poultry and pigs, the development of vaccines against animal diseases, the study of agronomic and physiological barriers, the improvement of farm machinery, the adoption of soil-conservation measures, the taking up of water management, etc.

[2]Aggarwal, Partap C. *The Green Revolution and Rural Labour: A Study in Ludhiana,* pp. 117-120

Extension strives to keep the personnel of the State Departments of Agriculture and Veterinary abreast of the latest research information on agriculture, veterinary and home science, and to bring research and teaching personnel into direct contact with the farmers' problems.

ANDHRA PRADESH AGRICULTURAL UNIVERSITY, HYDERABAD (ANDHRA PRADESH)

The Andhra Pradesh Agricultural University was established in June 1964, and was formally inaugurated on 20 March 1965 by Shri Lal Bahadur Shastri, Prime Minister of India. It caters for the needs of the entire State, which is predominantly agricultural, with a gross cultivated area of over 13 million hectares. The State Government transferred the research responsibility to the University in 1966, along with the staff, 6,000 acres (2,428 ha) and laboratories.

The University has three faculties: Agriculture, Veterinary Science and Home Science. The establishment of the faculties of Basic Sciences and Humanities, Agricultural Engineering and Dairy Science is under consideration. The University has six constituent colleges—three in Agriculture, two in Veterinary Science and one in Home Science. The three agricultural colleges are located at Rajendranagar, Bapatla and Tirupati; the two colleges of Veterinary Science are located at Rajendranagar and Tirupati, the College of Home Science is located at Hyderabad.

The first Vice-Chancellor was O. Pulla Reddi, a distinguished ICS officer whose last assignment in service was the Defence Secretary to the Government of India. He served the university from 1964 to 1972 and laid a sound foundation. He was followed by M.R. Pai (1972-1974). The next Vice-Chancellor was Dr C. Krishna Rao (1974-1978). The present Vice-Chancellor is J. Raghotham Reddi, a progressive farmer.

UNIVERSITY OF AGRICULTURAL SCIENCES, BANGALORE (KARNATAKA)

The University of Agricultural Sciences, Bangalore, was established under the Mysore Legislative Act 22 of 1963. With the transfer of Colleges of Agriculture at Hebbal and Dharwar and the Veterinary College, Hebbal, along with 34 research stations, it started functioning from 1 October 1965. The Marine Products Processing Centre, Mangalore, was transferred to it later. Most of the research organizations of the State Government have been transferred to the University, along with 3,000 acres (1,215 ha) of the experimental stations.

The contributions of the two successive vice-chancellors, Dr K. C. Naik and Dr H. R. Arakeri, to the establishment and development of the University are outstanding. Dr Naik served as the first Vice-Chancellor for three successive terms between 1964 and 1973. He was responsible for framing the statutes of the University. He took up several innovative measures in teaching, research, extension and administration and provided the University with a sound base.

The University has witnessed unprecedented growth since Dr Arakeri took over as its Vice-Chancellor in 1973. Several new programmes, such as B.Sc. (Hort.), B.H.Sc. and B.Sc. (Agricultural Marketing and Cooperation), besides postgraduate instruction in Seed Technology and undergraduate teaching in Forestry and Sericulture were initiated. The University established fruitful collaborative arrangement with the ICAR and other institutions in the area of teaching, research and extension.

RELATIONSHIP OF *INDIAN AGRICULTURAL* UNIVERSITIES *WITH* THE U.S. LAND-GRANT UNIVERSITIES

The TCM, later the AID programme, which started in India in 1956, was on a regional basis for agricultural education. The trend towards the establishment of one agricultural university in each State took shape in 1960 and all the AID support has been on a State basis since 1963. There were eight agricultural universities which were assisted by the Agency for International Development (AID) through six U.S. Land-Grant Institutions. This university-to-university relationship was a bridge of scientific and cultural understanding between two great democracies.

These relationships were: Govind Ballabh Pant University of Agriculture and Technology and the University of Illinois; Punjab Agricultural University and the Ohio State University; Andhra Pradesh Agricultural University and Kansas State University; University of Udaipur and the Ohio State University; Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, and the University of Illinois; Orissa University of Agriculture and Technology and the University of Missouri; University of Agricultural Sciences, Bangalore, and the University of Tennessee; and Maharashtra Agricultural University and the Pennsylvania State University.

Through the USAID and these US universities, assistance was given for training the faculties of the Indian agricultural universities. In 1968, there were 4,500 participants who had returned after availing themselves of the AID training programmes, and over one-fourth were related to Agriculture, Veterinary Medicine, Engineering and Home Science.

Specialists from the US universities served along with their Indian counterparts in teaching, research and extension education in the agricultural universities. Other AID assistance included limited amounts of equipment for teaching and research. All of these inputs—participants, specialists and equipment—have aided the Indian agricultural universities to become real centres of new ideas and practices for the country's agriculture.

REPORT OF THE EDUCATION COMMISSION, 1964-1966

The impact which the Scheme of Agricultural Universities made on policy-makers is evident from the report of the Education Commission (1964-66), headed by Dr D. S. Kothari, the then Chairman of the University Grants Commission. The Commission recommended the establishment of at least one agricultural university in each State. They further recommended that all aspects of research on agriculture should be the concern of the agricultural universities. The implementation of these recommendations further enlarged the area under the control of these universities. It led to the integration of teaching, research and extension education where it did not exist. That an agricultural university provides a better environment for research than a State department of agriculture was realized in a number of States, and vested interests which believed in holding on to what they possessed ultimately yielded to the pressure of progressive groups.

CHAPTER 16

AGRICULTURAL UNIVERSITIES

1969–1978

CONTRIBUTION OF AGRICULTURAL UNIVERSITIES TO AGRICULTURAL PRODUCTION

ROLE OF THE ICAR IN AGRICULTURAL EDUCATION

THE agricultural universities that had been established during the period 1960-65 made an impact on agricultural production during 1966-68, the early years of the Green Revolution. The over-cautious State governments were also convinced that this innovation in research, teaching and extension was definitely an improvement and, hence, they approached the Government of India for setting up such universities in their territorial areas. From 1969 to 1978, fourteen agricultural universities were inaugurated. Out of them, four are in Maharashtra, and others are in Assam, Haryana, Tamil Nadu, Bihar, Kerala, Gujarat, West Bengal, Uttar Pradesh and Himachal Pradesh.

FOUR AGRICULTURAL UNIVERSITIES OF MAHARASHTRA

Four agricultural universities of Maharashtra are located at Rahuri, Akola, Parbhani and Dapoli.

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI: The Mahatma Phule Agricultural University started functioning from 20 October 1969. This University is named after Mahatma Phule (b. 1827, d. 1890), a social reformer, who started the first school for girls at Poona in 1848. In 1890, he attended the convention of the Indian National Congress and championed the cause of farmers and labourers. Annasahib P. Shinde, a farmer and dairyman, who was Minister of State for Agriculture, played a leading role in fixing the location of the University at Rahuri in the Ahmadnagar District. This is the leading sugar-producing district in Maharashtra, with 17 sugar factories (out of which 12 are in the co-operative sector), and accounts for 35 per cent of Maharashtra's sugar production. Besides, a large area of waste-land was available for the Campus of the University to be built on.

The University with its central Campus at Rahuri has jurisdiction over nine districts of western Maharashtra. The area is distinctly divided into a high-rainfall zone, adjoining the Western Ghats, an assured-rainfall zone, and a drought-prone area.

The first Vice-Chancellor was H.G. Patil, whose term ended in 1971. He was succeeded by Dr M.S. Pawar (1971-1977). Dr A. B. Joshi took over from Dr Pawar in 1977.

PUNJABRAO KRISHI VIDYAPEETH, AKOLA: The Punjabrao Agricultural University (Krishi Vidyapeeth) Act was enacted by the Maharashtra Government in 1968. This University started functioning from 20 October 1969. It has jurisdiction over the Nagpur Revenue Division, comprising eight districts of Maharashtra. It is named after the late Dr Punjabrao Deshmukh who was Minister of Agriculture, Government of India, and the founder of the Bharat Krishak Samaj. He was a great leader of the farmers.

The first Vice-Chancellor was L. N. Bongirwar (1969-1972). He was followed by N. Gopalakrishna (1972-1978). The present Vice-Chancellor, Dr A.N. Chaugule, is a well-known agronomist.

The University has the following colleges under it: the College of Agriculture, Akola; the College of Agriculture, Nagpur; the Nagpur Veterinary College, Nagpur; the College of Agricultural Engineering, Akola; the Postgraduate Institute, Akola; the Anand Niketan College of Agriculture, Warora; and the Shri Shivaji College of Agriculture, Amravati.

MARATHWADA AGRICULTURAL UNIVERSITY, PARBHANI: The Marathwada Agricultural University was established on 18 May 1972 at the Central Campus, Parbhani, Marathwada, to meet the agricultural needs of Marathwada. The total geographical area of this region is 64,525 km^2. Marathwada is a rolling plain. There are two major hill ranges—the Satmala in the north and the Balaghat in the south. The Godavari, the Purna, the Dudhana, the Painganga and the Manjara are the rivers flowing through this region.

Marathwada is covered with black cotton soil derived from the Deccan-trap volcanic rock, which varies greatly in texture and depth.

In the Marathwada Agricultural University, there are four faculties: (1) Agricultural, (2) Veterinary Science, (3) Agricultural Technology, and (4) Home Science. The lower education covers two gramsevak training centres and five agricultural schools. There are in all twelve agricultural research stations. The main centres for research for cotton, sorghum, pearlmillet (*bajra*) and pulses for the entire Maharashtra are located in this University.

L. S. Sundara Rajan was the first Vice-Chancellor (1972-1974). The present Vice-Chancellor is Dr V. S. Khuspe.

KONKAN KRISHI VIDYAPEETH, DAPOLI: The Konkan Krishi Vidyapeeth was established at Dapoli by the Government of Maharashtra on 18 May 1972 as per the Maharashtra Act XVIII of 1972 (Konkan Agricultural University Act, 1972). The objective of establishing this university was to tackle the agricultural problem of the Konkan region with a view to helping the rural people to increase agricultural production, including livestock and fisheries. The region comprises the Thana, Kulaba, Ratnagiri and Greater Bombay districts.

Dr M. S. Pawar was the first Vice-Chancellor (1972-1974). He was followed by S.V. Chavan (1974-1977). The present Vice-Chancellor is Dr P. N. Salvi.

Assam Agricultural University, Jorhat (Assam)

The Assam Agricultural University was established on 1 April 1969 under the Assam Agricultural University Act, 1968. The University started functioning with the Assam Agricultural College and the Assam Veterinary College as its constituents. The jurisdiction of the university extends to the entire Assam. It also caters for the needs of the neighbouring States and the Union Territories of the north-east region.

The first Vice-Chancellor of the University was Dr S. R. Barooah, who took over charge on 19 March 1969. He relinquished office on 11 October 1971. The late Dr R. N. Hazarika, the then Dean of the Faculty of Veterinary Science, took over as the in-charge Vice-Chancellor and continued as such till the assumption of office by Dr L. S. Negi as Vice-Chancellor on 1 June 1972. After completing his five-year term on 1 June 1977, Dr Negi was succeeded by the late P. S. Majumdar, joining on 11 June 1977.

Haryana Agricultural University, Hissar (Haryana)

The Haryana Agricultural University came into existence on 2 February 1970 when the Punjab Agricultural University was bifurcated through an ordinance of the President of India, later replaced by the Haryana and Punjab Agricultural Universities Act of 1970. The HAU inherited 2,244.63 acres (908 ha), on which, besides the farm and experimental plots, it had the colleges of Veterinary Medicine, Animal Science, Agriculture, and Basic Sciences and Humanities. Besides these colleges, there was a Teachers' Home, five hostels and 358 residential houses.

The University during the eight years of its existence has developed into one of the best-planned campuses in India with modern architecture. It is the most impressive campus of all agricultural universities in the country. Planning has been done in such a way that even for years to come there is ample space for extending facilities for research, education and healthy community life.

The first Vice-Chancellor was Anthony Leocadia Fletcher, ICS (Retd). He had no experience of agriculture and, to make up for this deficiency, he purchased a farm. Later on, on finding it unprofitable, he sold it off. Nevertheless, he acquired the first-hand experience of agricultural problems. Fletcher gave top priority to the development of the Campus. He received great support from Chowdhri Bansi Lal, Chief Minister of Haryana, who provided him with funds liberally. One after another, beautiful buildings rose on the Campus. The Campus now has a shopping-centre, a post-office and banking facilities, a hospital and a school, children's parks and a club for the children of the Campus, a community centre, a faculty house, a faculty club and a farmers' hostel, flats for teachers and residential houses for different categories of employees. Other buildings which were completed in this phase are the Gandhi Bhawan—the nucleus of extension activities—the College of Home Science and the College of Basic Sciences and Humanities, the Giri Centre Complex and the Nehru Library.

The building activity was extended to outstations also. The Krishi Vigyan Kendras have their own buildings at district headquarters.

Much of the construction was completed by Fletcher and the rest by N.N. Kashyap, ICS (Retired), who was the Vice-Chancellor from 6 February 1974 to 30 September 1977.

In October 1977, Dr P. S. Lamba became the Vice-Chancellor. He gave a fillip to research, teaching and extension activities. Posts lying vacant for years were filled up. The working of the various departments was streamlined and research activities were stepped up. Owing to his rural background, Dr P.S. Lamba is well acquainted with the problems of the farmers in the State. Hence he has taken keen interest in the problem-oriented research in disciplines of Agriculture, Veterinary and Animal Sciences and Home Science.

TAMIL NADU AGRICULTURAL UNIVERSITY, COIMBATORE (TAMIL NADU)

The Tamil Nadu Agricultural University was established in 1971 by an Act of the State Government and was entrusted with agricultural research, education and extension education needs of the State. The colleges at Coimbatore and Madurai, along with the facilities and research centres in the Coimbatore and Madurai districts were handed over to the Tamil Nadu Agricultural University as its constituents.

Dr G. Rangaswami became its first Vice-Chancellor. He organized the academic programmes and framed the regulations and statutes. He also developed a master plan for the development of the University. All the teaching, research and extension-education works, which were looked after by separate persons, were restructured in terms of departments and separate faculties. The Faculty of Basic Sciences and Humanities was started in 1972, and the College of Agricultural Engineering was established in 1976. The present Vice-Chancellor is T.A. Venkataraman, who joined on 30 August 1978.

Now there are 17 research stations, 9 research centres and 48 departments in the Tamil Nadu Agricultural University, spread over four faculties. Recently, 10 agricultural stations, 7 research centres and 4 animal research stations were also transferred to the University by the State Government.

RAJENDRA AGRICULTURAL UNIVERSITY, PATNA (BIHAR)

The Rajendra Agricultural University started functioning from 1 February 1971 at the Bihar Veterinary College Campus, Patna, when the three agricultural colleges at Sabour, Kanke and Dholi, two veterinary colleges at Patna and Ranchi, four regional agricultural research institutes located at Patna, Dholi, Sabour and Kanke, and the Sugarcane Research Institute, Pusa, besides a number of research schemes, sponsored by the Indian Council of Agricultural Research, were transferred to the University by the State Government, along with the staff, budget and other facilities. The Cattle Farm at Pusa and the Animal Production Research Station, Birauli, were subsequent additions. In view of the unique possibility of agricultural development in the fertile plains of northern Bihar, the State Government decided to locate the headquarters of the University at the Dholi-Pusa Campus. In addition, Kanke (Ranchi) was designated as the main campus for Animal Husbandry and Veterinary Science with a view to developing animal production in the plateau of Chhotanagpur.

S. K. Chakravarty (1970-1973) was the first Vice-Chancellor. Dr D. P. Singh, who had retired from Pantnagar, was the Vice-Chancellor from 1977 to 1981.

From 1972 to 1978, six agricultural universities were started in Kerala, Gujarat, West Bengal, Uttar Pradesh and Himachal Pradesh.

KERALA AGRICULTURAL UNIVERSITY, MANNUTHY (KERALA)

The Kerala Agricultural University came into existence under the Kerala Agricultural University Act, 1971. The university started functioning in February 1972 when the College of Agriculture, Vellayani, and the College of Veterinary and Animal Sciences, Mannuthy, along with 21 agricultural and animal sciences research stations were transferred to it.

The main Campus of the University is at Vellanikkara in the Madakkathara Panchayat, 9 km east of the Trichur Town. Till the shifting of the University office to Vellanikkara in March 1978, the headquarters was temporarily located at the Campus of the College of Veterinary and Animal Sciences, Mannuthy. The area of the main Campus is 848 hectares. The second Campus of the University, the College of Agriculture, Vellayani, covers 243 hectares.

N. Chandrabhanu, an IAS officer, was appointed the first Vice-Chancellor in 1971 and continued for two years. Dr C. M. Jacob, who retired from the Punjab Agricultural University as Dean, College of Agricultural Engineering, Ludhiana, was the Vice-Chancellor from 1973 to 1975. The present Vice-Chancellor is N. Kaleswaran.

GUJARAT AGRICULTURAL UNIVERSITY, DANTIWADA, DISTRICT BANASKANTHA (GUJARAT)

The Gujarat Agricultural University Act was passed by the State Legislature in 1969, and the University was established in 1972. V. R. Mehta was appointed Vice-Chancellor of the University on 1 February 1972 and continued till January 1978. Ishwarbhai J. Patel is the present Vice-Chancellor.

The Institute of Agriculture, Anand, was transferred to the University on 1 June 1972. Thus the three agricultural colleges at Anand, Junagarh and Navsari, the College of Dairy Science and the Gujarat College of Veterinary-Science and Animal Husbandry at Anand, four gramsevak training centres, thirteen agricultural schools, the Home Science School, the Bakery Training School, the Poultry Training Centre and the Bidi-Tobacco Training Centre at Anand and also the Livestock Inspector Training Centre at Baroda came under the administrative control of the University.

With the transfer of these institutions, the University acquired the character of a multi-campus institution, with special problems of co-ordination. The University Act provides for the establishment of campuses, and Junagarh was designated the first campus of the University.

Later on, Anand and Navsari were also declared as campuses of the University. Thus the three principal centres, where educational, research and extension-education activities were practised in Gujarat, became the campuses of the University. A distinctive feature of the Gujarat Agricultural University Act is the provision of appointment by the Government of the Director for each campus for a period of three years. The appointee is to be a public worker.

The main campus of the University will be set up at Dantiwada in the Banaskantha District of Gujarat State.

BIDHAN CHANDRA KRISHI VISHWA VIDYALAYA, HARINGHATTA (WEST BENGAL)

The Bidhan Chandra Krishi Vishwa Vidyalaya was instituted by an ordinance of the Government of West Bengal (Ordinance X of 1974, later on replaced by Act XLIX of 1974) and has been functioning since September 1974. Professor S. D. Chattopadhayay was the first Vice-Chancellor (1974-1978). The present Vice-Chancellor is Dr M. M. Chakravarti.

CHANDRA SHEKHAR AZAD UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, KANPUR (UTTAR PRADESH)

The Chandra Shekhar Azad University of Agriculture and Technology (established in March 1975) has two campuses—Kanpur (main campus, Agriculture) and Mathura (Veterinary Science). Its jurisdiction covers 21 districts of central and south-west Uttar Pradesh. It offers educational programmes in the faculties of Agriculture and Veterinary Science. The College of Agriculture, Kanpur, is one of the oldest institutions in the country (established in 1906). Professor K. N. Kaul was the Vice-Chancellor of this University from March 1975 to 1978.

NARENDRA DEV UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, FAIZABAD (UTTAR PRADESH)

The foundation-stone of the Narendra Dev University of Agriculture and Technology was laid by Prime Minister Mrs Indira Gandhi at Masodha. Later, the site of the University was shifted to Kumarganj on the recommendation of the Committee of Scientists constituted by the Government of Uttar Pradesh. The main campus of the University will be at Kumarganj. The University has jurisdiction over 15 districts in three divisions, viz. Faizabad, Varanasi and Gorakhpur. About 1,200 hectares of land has been transferred by the State Government to the University at Kumarganj.

The State Government transferred five research stations to the University on 1 July 1976.

A. D. Pande, IAS, the first Vice-Chancellor of this University, took over on 10 October 1975. Under his guidance, the guidelines of the master plan of the University Campus was prepared. The academic plan of the first phase of the University, particularly the College of Agriculture, was also completed.

Dr A. S. Yadav, the second Vice-Chancellor, took over on 25 October 1977. The long-pending decision regarding the site for the University was cleared and the construction work was started.

HIMACHAL PRADESH KRISHI VISHWA VIDYALAYA, PALAMPUR (HIMACHAL PRADESH)

Before the establishment of the Himachal Pradesh Krishi Vishwa Vidyalaya, the responsibilities of agricultural education, research and extension were carried out by the Agricultural Complex of the Himachal Pradesh University.

The Himachal Pradesh University, in its Faculty of Agriculture, inherited (i) the College of Agriculture, Palampur, from the Punjab Agricultural University, Ludhiana, in July 1970, and (ii) the College of Agriculture, Solan, from the State Department of Agriculture, Himachal Pradesh, in July 1971. A forest research division of Himachal Pradesh Forest Department was also transferred to the Himachal Pradesh University in 1971. Having been established by the Punjab Agricultural University, the College of Agriculture, Palampur, was already operating on the model of an agricultural university, whereas the College of Agriculture, Solan, being affiliated to the Panjab University, Chandigarh, was following the conventional system of education. The Himachal Pradesh University, therefore, inherited two institutions working differently. But both of them soon adopted the common pattern of an Agricultural University. Dr H. R. Kalia is the founder Vice-Chancellor of this University.

Contribution of Agricultural Universities to Agricultural Production

The concept of integration of teaching, research and extension has already proved its worth through remarkable progress made in the field of agricultural education, research and extension by the new agricultural universities. There is a perceptible improvement in the quality of education. There are more competent teachers, better-equipped libraries, laboratories and farms. The internal-examination system is geared to the continual preparation on the part of both the students and the teachers.

These institutions are largely responsible for the development of the high-yielding varieties of wheat, maize, pearlmillet *(bajra)* and sorghum *(jowar)*. Unprecedented high crop yields were recorded. Agronomic and plant-protection pactices to exploit the maximum yield potentials were developed and effectively extended to the farmers. These institutions today are serving as the fountain-heads of new knowledge, gained through purposeful, problem-solving research, and have become the main centres of dissemination of useful knowledge to the farming community. Some of the best training for farmers is offered by the agricultural universities. There are numerous functional specialists who have gained confidence through experience in successfully applying scientific knowledge to the solution of practical problems.

The working conditions and incentives that they offer to the faculty and the students are providing opportunities for productive work, and are fostering team spirit and a healthy change in the outlook of all—the teachers and the researchers, and the government administration. They are winning the confidence of the farmers. They have assumed leadership in science, education and extension. Their direct contribution to programmes such as the pedigree seed production, fertilizer use and the National Crop Demonstrations, is highly impressive. In this connection, the inter-institutional collaboration within the country needs special mention. Agricultural universities are participating most effectively in the execution of the various co-ordinated programmes of agricultural research, initiated by the Indian Council of Agricultural Research. Collaboration with the US universities was aimed principally at the advanced training of the university personnel at institutions of repute in the United States of America and the securing of subject-matter specialists on long- or short-term basis for raising the standards of teaching and research at these institutions.

Besides improvement in quality, the new system of education has reduced the 'wastage' in higher education. This not only saves cost but provides training opportunities for more students.

Role of the ICAR in Agricultural Education

According to its original aims and objectives, the ICAR was intended to undertake, aid, promote and co-ordinate agricultural education in the country. In practice, however, the Council played a very limited role before 1966, because it had neither the financial resources nor the statutory authority to discharge this responsibility. Although the concept of agricultural universities had been accepted and eight of them had come into existence by 1966, the financial support for their development remained highly inadequate, viz. less than 2.5 million rupees per university during the Third Five-Year Plan.

The ICAR was reorganized in 1966, giving it the role in relation to agricultural education as of the UGC in the case of general education. A full-fledged Division of Agricultural Education was established in the Council to provide necessary leadership and support to accelerate the pace of development of agricultural universities. Dr O.P. Gautam, an eminent agronomist and educationist, joined as the first Deputy Director-General (Education). He built a friendly and constructive relationship with the agricultural universities and the State governments. A number of fellowship and scholarship schemes for staff development and student welfare were started.

During the last decade, the ICAR has played a great role in reorganizing and consolidating agricultural education in the country. It helped to replace the traditional system by introducing the course-credit system, laying down modern courses and curricula for various courses and linking together education and field problems.

The number of agricultural universities, which was eight in 1966, has now gone up to twenty-one. The financial assistance to agricultural universities which was only Rs 12 million during the Third Plan was increased to Rs 417 million during the four years of the Fifth Plan. A liberal pattern of assistance (100 per cent) was adopted for assisting the universities. In order to ensure the minimum uniformity in the structure, organization and governance of these universities, the ICAR developed a Model Act in 1966. It is assisting the universities in the implementation of a number of schemes for improving the quality and standard of education and research, e.g. the establishment of centres of excellence, programmes of higher education in new areas, the creation of the chairs of professors of eminence, faculty improvement, means-cum-merit scholarships, and fellowships.

CHAPTER 17

PACKAGE PROGRAMME

INTENSIVE AGRICULTURAL DISTRICT PROGRAMME AND INTENSIVE AGRICULTURAL AREA PROGRAMME 1959–1964

On account of a succession of droughts, the production of foodgrains in India dipped alarmingly. In 1958-59, the total production of all foodgrains was only 66 million tonnes, which was much less than that in 1957-58. As a result, the country had to import large quantities of wheat under the PL-480 arrangement with the USA. It was apprehended that by 1966 there would be a 28-million-tonne shortfall in the supplies of foodgrains, unless a concerted effort was made to overcome the food crisis.

Keeping in view the serious food situation, the Government of India sponsored an Agricultural Production Team, in collaboration with the Ford Foundation, in 1959 to study the food situation in India. The Team had 13 American scientists as its members. The Chairman of the Team was Sherman E. Johnson, an expert in Farm Management. The other members of the Team were: Dr Marvin Anderson, Associate Director of Extension, Iowa State College; Dr George M. Beal, Professor of Sociology, Iowa State College; Dr E.M. Cralley, Professor and Head, Department of Plant Pathology, University of Arkansas; Dr Gerald Huffman, Assistant Administrator, Federal Extension Service, U.S. Department of Agriculture; Dr Omer J. Kelley, Chief, Western Soil and Water Management Research Branch, U.S. Department of Agriculture; Dr Charles E. Kellogg, Assistant Administrator for Soil Survey, Soil Conservation Service, U.S. Department of Agriculture; Professor Alvin A. Johnson, Professor of Plant Breeding, Cornell University; Mr Harold A. Miles, Deputy Governor, Farm Credit Administration, and Director of the Short-Term Credit Service of Farm Credit Administration; Dr Arthur D. Weber, Dean of Agriculture, Kansas State University; Dr Norman Wengert, Professor of Agricultural Organization and Administration, University of Maryland, and two others. The Indian associates of the team were Dr J.S. Patel, Agricultural Adviser, Ministry of Community Development, Government of India; Dr K. Ramiah, Rice Specialist; Dr S.R. Sen, Joint Secretary, Planning Commission; Dr Arjan Singh, Director of Agriculture, Punjab; J.V.A. Nehemiah, Extension Commissioner, Ministry of Food and Agriculture, Government of India, and seven others.

Selection of Areas for Intensive Agriculture

The Team recommended that in each State areas having irrigation or assured rainfall and the greatest yield potential should be selected for intensive cultivation. The Team observed: 'Efforts should be concentrated on the most promising areas for wheat and rice production, i.e. those which have had the most rapid rate of increase in the recent past, and which have also the highest potential for rapid large increases in the years immediately ahead. For rice, there are 25 important growing districts; for wheat, there are selected districts in the Punjab, Uttar Pradesh, Madhya Pradesh and Bihar. These areas will, the Team believes, increase India's food production more rapidly than others, if given the allocation of fertilizers in combination with other improved practices, such as plant-protection measures, improved seeds, and water for irrigation. Attention to other areas should not be reduced. But, in the national interest, the Team believes that increased effort should be immediately directed to the most responsive areas.'

PACKAGE OF PRACTICES

The Team commented, 'The evidence is clear that startling increases in food production are possible if the known improvements are adopted in effective combinations. A few improved practices can be effective if adopted singly, but the full benefit from most improvements can be obtained *only* if they are adopted in combinations suitable for specific soil and climatic conditions. Sufficient fertilizers, improved seed, pesticides, proper soil and water management practices—all of these, while important in themselves, can be *fully effective only if adopted in combination with one another.* For this reason, improvement programmes should be designed to concentrate on the adoption of those combinations of practices that are most likely to increase food production quickly.'

Other recommendations of the Team related to the stabilization of farm prices, the role of co-operative for credit supplies and marketing.

The package idea was based on the American experience. The key to increased production and productivity of the second agricultural revolution in the USA was not the adopting of some one tool or technique. Rather, it was adopting what has been called a "package" of practices or of technology. This package usually included mechanization, greater use of fertilizer, widespread use of cover crops and other conservation practices, irrigation whenever necessary, use of improved varieties, the adoption of hybrid corn (maize), a better-balanced feeding of livestock, more effective control of insects and diseases, and the use of chemicals for such purposes as weed-killers and defoliants.

The package idea is actually a systems-approach to the problem of increasing agricultural productivity. In this instance, the adoption of all the practices needed for a particular farm enterprise results in an increase greater than might be expected by adding the results usually obtained from each of the practices. This concept was first developed around 1949 by a group of U.S. Department of Agriculture scientists working in North Carolina on corn (maize) production.[1]

Intensive Agricultural District Programme (IADP)

The Intensive Agricultural District Programme (IADP) was started on a 'pilot' basis in 1961 in seven selected districts. Subsequently, it was extended to nine more districts. The first seven districts selected were Thanjavur (Madras), West Godavari (Andhra Pradesh), Shahabad (Bihar), Raipur (Madhya Pradesh), Aligarh (Uttar Pradesh), Ludhiana (Punjab) and Pali (Rajasthan). The second group of districts to which the Programme was extended comprised Mandya (Mysore), Surat (Gujarat), Sambalpur (Orissa), Palghat and Alleppey (Kerala), Burdwan (West Bengal), Bhandara (Maharashtra), Cachar (Assam) and six selected Blocks in the Jammu and Anantnag districts of Jammu and Kashmir.

In all these districts, attempts were made to place all the resources, such as production supplies, credit and technical staff at the service of the farmer. The facilities provided in these areas included:

1. adequate and timely supply of production requisites, such as fertilizers, improved seeds, pesticides and implements;
2. adequate and timely supply of credit through co-operative societies;
3. arrangements for marketing and other services to enable the farmers to obtain a reasonable price for their marketable surplus;
4. adequate storage facilities for stocking production supplies and farm produce;
5. intensive educational efforts, particularly through scientific demonstrations and on-the-job training courses through trained extension workers;
6. strengthening of transport arrangements to ensure the mobility of supplies and staff;
7. village-planning for increased production, including the livestock-improvement programmes;
8. strengthening of village organizations, such as the co-operatives and the *panchayats*; and
9. establishing workshops for making and repairing agricultural implements and the starting of seed and soil-testing laboratories.

Arrangements were also made for evaluating the programme from year to year.

Package of Practices

The IADP was conceived essentially as an impact programme. The

[1]Rasmussen, W.D. A Postscript: Twenty-five years of change in farm productivity, *Agricultural History*

"package of improved practices" evolved for each crop was intended to speed up the production process by presenting a suitable combination of known improvements, based on the results of research which could immediately be applied to individual fields. The "package" includes the use of improved seed, fertilizers and manures, pesticides, improved implements, and proper soil and water management.

Such a "package of practices" was evolved for all the important crops and, in many cases, for different agro-climatic zones in each package district. Specific recommendations were made regarding the variety to be sown, the seed-rate to be used, the time of sowing to be adopted, etc. In many package areas, the seed of the recommended improved variety treated with Agrosan GN was supplied in sealed bags. Recommendations were made regarding the quantity of fertilizers, the doses and the time when these should be applied by a farmer.

This strategy was an important development in Indian agriculture in the sense that for the first time the available findings of agricultural research were selected and summarized for adoption in the field. Thus a link was forged between research and extension. The directors of agriculture in the States were asked to review the "package of practices" for the crops annually, so that gaps in knowledge were brought to the notice of researchers and the package of recommendations was improved upon from time to time.

Farm-planning

The programme was largely farmer-centred and every service intended to help the farmer was co-ordinated in such a manner as to direct the working of several agencies, official and non-official, towards the common aim of stepping up production.

The extension agency prepared a farm-production plan for every participating farmer. For this purpose, the *gramsewak* made concrete recommendations regarding the varieties which the farmer was to grow, the quantities of fertilizer, farmyard manure and compost he had to use, the pesticides he would need for plant protection and the improved agricultural implements that he should have. On this basis, the *gramsewak* prepares an inventory of a farmer's requirements of agricultural supplies and works out his credit needs which the co-operatives had to provide.

The preparation of farm plans ensured a personal contact between the extension workers and the farmers. In the Community Development Scheme, one of the major defects was that there was no live contact between these two. Under this Scheme of Intensive Agriculture, this defect was corrected. Besides, the farm plan was an educational tool for imparting the knowledge of improved agricultural practices and skills concerning their adoption.

Farm-planning under the 'Package Programme' was useful, on the whole, in making a substantial number of farmers aware of the potentialities of improved practices in raising production.

Improved Seed

With a view to strengthening the seed programme in the package districts, a specific programme for production and distribution of quality seeds was implemented in these areas. Special staff and equipment have been provided. The distribution of improved seeds in these districts, both in terms of the quantities used and the area covered, showed a steady improvement year after year. During 1964-65, as much as 16,300 tonnes of improved seeds of major food crops were distributed in these districts as compared with 9,200 tonnes in 1961-62.

Chemical Fertilizers

The requirements of nitrogenous fertilizers in the package districts were met in full every year through increased allocations from the Centre. The progress made in the direction of fertilizer use, which is by far the most important ingredient of the "package of practices", was very encouraging. This was mainly because of the promotional measures taken under the Programme.

Most of the districts started with a fairly low level of consumption of fertilizers. The total consumption of nitrogenous fertilizers (in terms of ammonium sulphate), which was 135,000 tonnes in 1961-62 touched the level of 272,000 tonnes by the end of 1964-65, an increase of 101.1 per cent. Similarly, the consumption of phosphatic fertilizers increased markedly. It increased from 61,585 tonnes in 1961-62 (in terms of superphosphate) to 117,000 tonnes during 1964-65, an increase of 91.2 per cent. Apart from quantitative increases, there was improvement in the rate of application of fertilizers in many of the districts.

An analysis of the crop-wise pattern of fertilizer consumption in the package districts has shown that the bulk of the supply has been used by farmers on food crops, including cereals, vegetables and fruits, and only about 10 per cent has been applied to non-food crops, such as cotton, jute and oilseeds. Among food crops, rice consumed the largest quantity, i.e. about 60 to 70 per cent of the available fertilizers.

Plant-Protection Measures

Plant-protection measures were taken on an intensified scale in all the package districts. Farmers in these districts were educated in preventing the outbreaks of pests and diseases, by adopting both cultural and chemical methods in time. Such measures as the use of disease-free seeds, systematic roguing of crops in the fields to enable the selection of the best seed material, adoption of cultural and agronomic practices for minimizing or preventing the incidence of diseases and pests, adoption of suitable crop rotations, and cleaning and treating of grain-storage godowns were advocated as adjuncts to timely plant-protection measures.

Generally, the following steps were taken in this sphere:

(i) stocking of plant-protection equipment and materials in adequate quantities in depots for timely use;
(ii) prophylactic treatment of seeds and crops on an extensive scale to ward off attacks of pests and diseases;
(iii) control of rats, weeds and the stored-grain pests on a district-wise basis; and
(iv) checking the spread of pests by treating the nurseries and promptly eliminating newly introduced pests.

As much as 1.065 million hectares was treated against pests and diseases, including rodents, during 1964-65 as compared with 316,000 hectares in 1961-62. Great emphasis was laid on the treatment of seed against seed-borne diseases before its distribution to the farmers. Large-scale demonstrations on the control measures against pests and diseases were conducted on an area-wide basis.

Prophylactic treatment of crops, especially rice, cotton, groundnut, tobacco, vegetables and fruits, was carried out on a large scale. The use of power equipment, such as power sprayers-cum-dusters, became increasingly popular in the districts of intensive programme.

Improved Agricultural Implements

A workshop for preparing and repairing agricultural implements was established in each package district, and efforts were made to give a fillip to the production, popularization and demonstration of improved agricultural implements suited to a region. The training of farmers and village artisans in the use of implements and their proper maintenance was another activity undertaken by these workshops. Different types of implements, such as ploughs and harrows for seed-bed preparation, land-shaping and levelling devices, seed- and fertilizer-placement devices, interculture implements, plant-protection equipment and harvesting and threshing equipment, were also tested.

Some of the workshops developed new tillage and interculture implements. After field trials, a large number of prototypes were distributed to the farmers.

Soil-testing

In each package district, either a new soil-testing laboratory was set up or one of the existing ones was strengthened to meet the needs of the district. Soil samples collected from the cultivators' fields were tested in these laboratories and recommendations were made regarding the application of fertilizers in proper doses. The results of soil analysis were used to make more effective the "package of practices" recommended for adoption by the farmers.

Credit and Marketing

The credit under the Package Programme was production-based. The procedure for giving loans was simplified to meet the requirements of the Programme. Attempts were made to relate the disbursement and recovery of the loans to the cropping season.

Systematic efforts were made to strengthen the co-operative institutions, as these are the main channels for supplying the credit and production requisites to the farmers. There was a substantial expansion in the volume of credit. The total credit, mainly the short-term credit, made available to the farmers was 195.8 million rupees in 1963-64 against 169.3 million rupees a year earlier.

Field Demonstrations

The extension-education activities were primarily centred on field demonstrations, mainly of the composite type, constituting the most effective tool for motivating the farmers to adopt improved agricultural practices. A large number of such demonstrations were laid out on the farmers' fields in every crop season in the package districts. In 1964-65, about 21,000 demonstrations were laid out. The results of these demonstrations were encouraging, and appreciable increases in the yield were recorded from the demonstration plots over the yield from the control plots. The increases in the average yields of rice and wheat during 1963-64 ranged from 40 to 70 per cent. The economics of cultivation also showed that for every rupee spent by a farmer on the adoption of the "package of practices", he got in return an additional Rs 2 to 3.

Results

The adoption of improved farm practices resulted in a steady improvement in agricultural productivity in these districts. In some of the districts, the yields of major cereals showed a significant improvement during the short period of operation of the Programme. In Ludhiana, the yield of wheat increased by as much as 48.5 per cent—from 15.62 quintals per hectare in 1960-61 to 23.22 quintals per hectare in 1964-65. In the West Godavari, Shahabad and Raipur districts, the yield of rice increased by 20 to 33 per cent.[2]

[2]Randhawa, M.S. *Intensive Agricultural Programme*, New Delhi, 1965

INTENSIVE AGRICULTURAL AREAS PROGRAMME (IAAP)

Promising results were obtained in the IADP areas. At the same time, India was threatened by another cycle of drought in 1964. At that time, I was in the Planning Commission, working as the Adviser, Natural Resources. With the co-operation of groups of specialists, I carried out a number of studies on natural resources of India, including crops. In March 1964, I happened to meet T.T. Krishnamachari, Finance Minister, Government of India. He asked me about the nature of my work in the Planning Commission. When I told him about the studies, Krishnamachari acidly commented: 'Such studies should be carried out by old people, you are still young and energetic, a challenging job awaits you'. Then he told me about the intention of the Government of India to launch an Intensive Agricultural Areas Programme in 114 blocks out of over 1,080 blocks. I showed my interest in that proposal and, accordingly, the Government of India appointed me the Director-General of the Scheme.

The experiences gained in the working of the Package Programme were drawn upon in the formulation of the Intensive Agricultural Areas Programme, with emphasis on the increasing of production of major food crops, such as rice, wheat, millets and pulses. This Programme followed the 'package' approach—the use in agriculture on interrelated factors (physical, social and institutional)—in strategic combinations which are likely to produce an impact on agricultural production. It was again based on the fact that our planning in agriculture before the 'Package Programme' concept was adopted was defective and less productive because of the dispersal of resources on too many schemes over too wide an area. The programme came into operation in March 1964, when the field work was taken up. It was emphasized upon the State governments that whereas the selection of districts would be done on the basis of the predominant crop and special attention would be given to that crop, the entire crop economy of the area would have to be kept in view for development. The approach should be not in terms of a single crop only, but rather in terms of an intensive agricultural development of the selected areas.

STAFF AND ADMINISTRATIVE ARRANGEMENTS

The normal staff in the districts selected for the Intensive Agricultural Areas Programme was strengthened at the district and block levels for providing effective technical guidance and assistance to the farmers in the adoption of improved methods of farming, and for ensuring a close supervision over the utilization of the resources.

The general pattern adopted in these areas was to provide five additional *gramsewaks* (ultimately 8, when the trained staff became available), one additional agricultural extension officer and one extension officer (co-operation) at the block level, a project officer (of the status of a deputy director of agriculture) in charge of the Programme, supported by at least two subject-matter specialists (in agronomy and plant protection) at the district level.

To ensure a successful implementation of the Intensive Programme, steps were taken to strengthen and streamline the administrative machinery at different levels in each State. These included:

(i) effective co-ordination between the various agencies (official and non-official) concerned with agricultural production at different levels through co-ordination committees;

(ii) delegation of adequate powers, both financial and administrative, to key officials, such as the district collector and the project officer, to ensure a speedy action;

(iii) keeping the transfers of the field staff to the minimum to secure continuity in the planning and implementation of the programme;

(iv) rationalization of the recruitment rules to avoid delays in filling up vacancies; and

(v) creation of a single line of command and administration of the agricultural programmes by vesting the control of the block extension staff, viz. the AEOs and the *gramsewaks*, in the project officers and the district agricultural officers.

Chemical Fertilizers

Concerted efforts were made to promote the consumption of fertilizers in the intensive agricultural areas. The total fertilizer requirements of these areas were assessed and additional allotments were made by the Government of India.

The use of fertilizers is one single factor capable of making a substantial contribution to production in the intensive areas. In view of the general shortage of fertilizers in the country, emphasis was laid on the fertilizers being used in areas which had shown a more economic response to their application. The proper timing of application and placement of fertilizers on individual farms was also being stressed. The existing distribution arrangements were also streamlined to ensure that the distribution agencies, government or private, were fully geared to the task.

Local Manurial Resources

In view of the shortages in the supply of fertilizers, emphasis was laid on compost-making, green-manuring and utilizing urban wastes in the intensive areas.

Bulk plantation of green-manure seeds on waste lands, in forest areas, and on government seed-farms, and on field bunds was suggested to State governments for implementation. The Government of India sanctioned Rs 18.8 million to the States for taking up different schemes on urban composting and on utilization of sewage and sullage.

Storage Godowns

One of the main factors responsible for the low rate of the offtake of fertilizers was the non-availability of stocks during the manuring season at many places, especially in areas in the interior. A high priority was, therefore, given to the construction of storage godowns at various levels. The States were asked to give preference to the construction of large godowns at rail-head/*mandi*-level where the stocks were received first. In the construction of rural godowns, preference was given to areas which were inadequately served. Under the Special Development Programme, Rs 29.9 million was sanctioned by the Government of India to State Governments for the construction of 665 rail-head/*mandi*-level godowns and 2,050 village godowns.

Plant Protection

With a higher intensity of cropping and greater use of fertilizers, the incidence of pests and diseases was likely to increase. Plant-protection activities had, therefore, to be stepped up considerably. The most pressing need was the provision of an adequate number of power sprayers and dusters, and pesticides and insecticides for undertaking large-scale operations. The demand for power equipment rapidly increased in the intensive areas. Arrangements were made to import 18,000 power sprayers-cum-dusters under the Dutch credit and other such credit arrangements with foreign countries.

Extension Education-cum-Information

An important task in a developmental programme of this type is to create awareness among the farmers of the benefits that accrue from the adoption of improved agricultural practices. This was done by building up a sound programme of agricultural information and extension education. M.G. Kamath, Head of the Information Division in the Extension Directorate, was deputed to Australia to study the role of radio in disseminating farmers' programmes. On his return, he submitted a valuable report, on the basis of which radio programmes of the All-India Radio were geared to serve the farmers. The method-and-result demonstrations were one of the most effective media for popularizing the 'package of practices'. Such demonstrations influenced the thinking and action of a substantial number of farmers. Emphasis was, therefore, laid on the laying out of a large number of demonstrations and the utilization of other media of information, such as the use of leaflets, posters, charts, radio, films, and newspapers.

The State governments were asked to appoint information staff in such districts to organize programmes for educating and informing the farmer.

ASSESSMENT OF THE IADP PROGRAMME, 1966

The Government of India constituted an expert committee, headed by Dr S.R. Sen, to review the IADP Programme from 1960 to 1965. The Committee commented as below on the performance of the programme:

'Surveys undertaken at the instance of the Committee show that a majority of the farmers in the districts as a whole are already participating in the programme; total production as well as yield per hectare of foodgrains have gone up and the demand for inputs such as fertilizers has exceeded the supply.

'Participation in individual farm plans is one indication of farmer participation in the IAD Programme. In the fifteen districts 206,000 farm plans were prepared in 1961-62; this had risen to 1,134,000 in 1964-65.

'Although the programme began with only about a fifth of the blocks in each district and has only in its last years covered the bulk of the area of each district, its impact is reflected in both higher total average production and yield rates during the programme period. The increase in production is largely due to the increase in yield per hectare.

'There has been a sharp increase in the demand of the farmers for purchased inputs, such as chemical fertilizers and improved seeds. The total distribution of nitrogenous fertilizers (in the form of ammonium sulphate) increased from 89,000 tonnes in 1961-62 to 196,000 tonnes in 1964-65 in the first seven districts. In the second eight districts, it went up from 67,000 tonnes in 1962-63 to 108,000 tonnes by 1964-65. The rate of increase in fertilizer consumption in the first seven districts is roughly 2½ to 3 times that in the non-IADP districts.

'In the field of credit, there has been considerable increase in membership, paid-up capital, etc., of the co-operatives. But surveys show that more than three-fourths of borrowings are still made from the traditional money-lenders.

'On the whole, the experience of the programme so far has shown that the basic concept of the IADP is essentially sound, but that success would depend upon the extent to which the main components of the programme, viz. (i) the sound technical guidance from the extension personnel, which is adequate in strength as well as in competence, to motivate farmers to change from the traditional thinking and farming practices to new technology; (ii) the production requisites; (iii) credit; (iv) remunerative prices; and (v) administrative machinery geared to accept as well as to accelerate change, are brought together in the effective "package".

'The IADP has also proved that the small farmer can be no less progressive than the big farmer. There are several areas within certain IADP districts where the increase in production would compare favourably with the record of areas of similar size in most other countries.'

The Committee concluded its report with the remarks: 'The quick adoption that a substantial number of Indian farmers have made in the IADP as well as in certain other areas, of new fertilizers, pesticides, seeds implements and farming practices, is indeed one of the most encouraging features of the Indian agricultural scene. In fact, what is holding up progress in the IADP areas today is not so much the lack of demand from the farmers but the lack of supply of essential inputs. One lesson of the IADP experiment is that it is not so much Indian agriculture which has failed the economy but it is Indian industry which has failed to supply the wherewithal which Indian agriculture has been demanding. It has also proved that any programme for modernizing agriculture cannot be carried out in isolation. There has to be a corresponding progress in the field of industries supplying the needs of agriculture and processing the produce of it.'[3]

[3]*Report of the Expert Committee on Assessment of Intensive Agriculture District Programme*, New Delhi, 1966, pp. 432, 433

CHAPTER 18

CREDIT SERVICES FOR THE FARMERS

THE STRENGTHENING OF CO-OPERATIVE BANKS
THE SETTING UP OF THE AGRICULTURAL REFINANCE DEVELOPMENT CORPORATION, COMMERCIAL BANKS AND RURAL CREDIT

THE experience of a number of countries indicates that farm-planning and supervised credit service are essential for agricultural progress. Since Independence, the Government of India initiated several measures for providing the farmers with loans for productive purposes. The most important of these loans were short-term crop loans, which enabled the farmers to use improved seed and chemical fertilizers. Modern agriculture with the use of inputs such as chemical fertilizers and machinery is costly, and a very few farmers have the resources to purchase them. This situation underlines the necessity of farm-credit services.

THE RURAL-CREDIT SURVEY COMMITTEE, 1951-52

In 1951-52, the Rural-Credit Survey Committee at the instance of the Reserve Bank of India carried out a comprehensive investigation into agricultural credit. The investigations revealed that the share of the co-operatives in total agricultural credit was only 3.1 per cent and that of the Government 3.3 per cent; the rest was provided by the money-lenders. The Committee emphasized that it was necessary to have a co-operative bank at the village level. It, therefore, recommended an integrated scheme of rural credit, the main objective of which was State partnership, including financial partnership in programmes for organizing rural credit, co-operative marketing, processing and other similar services; the development of storage and warehousing and State involvement in commercial banking. In furtherance of this objective, the Committee recommended:

(i) the establishment of large primary credit societies;
(ii) the provision of loans on the crop-outlay basis, the development of co-operative marketing, and processing and other economic activities in close co-ordination with rural credit;
(iii) the establishment of the National Co-operative Development Warehousing Board, the All-India Warehousing Corporation and the State Warehousing Corporations;
(iv) the reconstitution of the Imperial Bank of India and certain other State-associated banks into the State Bank of India; and
(v) the creation of special funds at the National, State and institutional levels for meeting specific credit needs.

These recommendations were accepted by the Government and the programmes for the development of co-operative credit and marketing, were included in the Second Plan. Most of the recommendations bearing on institutional arrangements were implemented expeditiously. The State Bank of India began functioning from July 1955 and the National Co-operative Development and Warehousing Board was established in 1965. Two special funds, viz. the National Agricultural Credit (Long-Term Operations) Fund and the National Agricultural Credit (Stabilization) Fund were set up in the Reserve Bank of India in 1956. The National Agricultural Credit (Long-Term Operations) was intended to provide loans to State Governments for subscribing to the share capital of co-operative credit institutions, while the Stabilization Fund could be banked upon for converting part of the short-term loans into medium-term loans in the event of large-scale default, following the widespread failure of crops. With the main objective of mobilizing rural savings for financing long-term loans through land-development banks, Reserve Bank of India introduced a scheme of rural debentures in 1958.

In view of the wide range of activities contemplated for co-operatives, large societies for serving groups of villages were encouraged. The shift in policy came in for severe criticism and public opinion veered round in support of the basic concept "one village, one society". The National Development Council in its policy resolution of 1958 expressed the view that for the development of co-operation as a people's movement, it was essential to organize service co-operatives with broader functions on the basis of the village community as the primary unit and that the responsibility and initiative for social and economic development at the village level should be placed on the village co-operative and the village *panchayat*. Following this resolution, the setting up of large societies was abandoned.

Loans for Agricultural Production

During the Second Plan, a beginning was made to advance loans to cultivators on the basis of production programmes and anticipated crop outturn instead of land security. Recoveries were to be effected through marketing co-operatives. Credit and non-credit societies were to be linked together, so that the agriculturist could be provided with credit for seed, manures, implements and essential consumer goods, and also helped in the marketing of his produce. A tie-up between the credit societies and the marketing societies was considered particularly important, as it facilitated the smooth and immediate recovery of the dues. The policy relating to agricultural co-operatives was generally towards strengthening these organizations through State partnership at various levels.

The All-India Rural Debt and Investment Survey conducted in 1962 by the Reserve Bank of India showed that the proportion of the co-operative credit in the total borrowings of farmers had increased from 3.1 per cent in 1951-52 to 15.5 per cent in 1961-62. The Third Plan envisaged a greater involvement of co-operative agencies in providing credit for agriculture. Efforts were directed towards strengthening and revitalizing the co-operative structure at the grassroots level by increasing the membership and share capital of the existing societies, mobilizing deposits and organizing new societies, wherever needed. The main objectives set for the credit co-operatives in the Third Plan were the extension of the co-operative movement to cover about three-fifths of the agricultural population by 1965-66, and the provision of short-term and medium-term credit to the extent of Rs 5,300 million and long-term credit of Rs 1,500 million as against Rs 2,030 million and Rs 380 million, respectively, made available in 1960-61. The programme for the revitalization of the co-operatives through the amalgamation of weak units and the winding up of dormant units which began during the Second Plan was pursued with vigour. Special promotional measures were taken in Assam, Bihar, West Bengal, Orissa and Rajasthan where the movement was weak. In 1964-65 a special programme was launched in the IADP districts, which linked credit with production plans and simplified the loaning procedures.

Agricultural Refinance and Development Corporation, 1963

In July 1963 the Agricultural Refinance and Development Corporation (ARDC) was set up with an authorized capital of Rs 250 million for providing long-term loans to the central land-mortgage banks and other approved credit institutions to finance specific agricultural development schemes. A special scheme of development debentures was included subsequently for extending financial assistance to special projects. The ARDC was to subscribe 90 per cent of these special debentures, leaving the balance to be contributed either by the public or by the State Government.

Up to the end of 1968-69, the Corporation sanctioned 225 schemes, involving an outlay of Rs 1,790 million. The number of such schemes increased to 1,457 by 31 July 1974, involving a financial outlay of Rs 8,069 million. The majority of these schemes and a very substantial part of the Corporation's commitment continued to be for loans for sinking tube-wells. The share of different States in the expansion of refinance facilities from the Corporation was extremely uneven. Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu and Uttar Pradesh shared nearly 70 per cent of the schemes sanctioned and about 63 per cent of the financial assistance agreed to by the Corporation.

All-India Rural Credit Review Committee, 1966

The spread of the new strategy of crop production based on inputs required greater credit facilities for a larger number of people. However, the bulk of the farming population could not secure adequate credit from the co-operatives because of procedural rigidities and difficulties. In July 1966, the All-India Rural Credit Review Committee was appointed under the chairmanship of B. Venkatappiah to look into the problem. The recommendations made by the Committee related to (a) the setting up of Small Farmers' Development Agencies in different States, (b) the establishment of Rural Electrification Corporation, and (c) the expansion of activities of the ARDC. These recommendations were accepted by the Government. In the final report submitted in July 1969, the Committee also made a large number of suggestions relating to the problem areas where the co-operatives were weak, the promotion of the units at the primary level and the special problems of credit facilities for small farmers. It also made proposals with respect to commercial banks, the role of the Government and the Reserve Bank of India, and the different aspects of investment credit.

COMMERCIAL BANKS AND RURAL CREDIT, 1968

In April 1968, a consortium of commercial banks set up the Agricultural Finance Corporation with the object of helping commercial banks to participate in the development of agriculture. Two important functions assigned to the Corporation were: (a) financing important priority projects which contributed to agricultural development, and (b) promoting commercial banks' advance to worthwhile agricultural projects and rendering them consultancy service.

The Fourth Plan envisaged that though the co-operatives would continue to be the principal agency for agricultural credit, and would have to be strengthened for the purpose, the approach would be to ensure that agricultural production was not inhibited by the weakness of the co-operatives. The policy aimed at institutionalizing agricultural credit to the maximum extent possible and reducing the direct loaning by the Government to the minimum. The Plan proposed improvements in the working of the ARDC *vis a vis* the borrowing institutions and a definite orientation in the policies and procedures followed by the credit co-operatives and land-development banks towards small cultivators.

On 19 July 1969, fourteen leading commercial banks were nationalized. After this development, they began taking greater interest in agricultural lending. These banks introduced an experimental scheme of concessional finance at 4 per cent interest for the weaker sections, including agriculturists. A Credit Guarantee Corporation was set up in April 1971 to operate a voluntary scheme of guaranteeing losses up to 75 per cent, subject to certain upper limits to the loans advanced by the commercial banks to priority sectors. They were also drawn into agricultural development work at the district level through the "Lead Bank" scheme.

Next to the co-operatives, the Fourth Plan stressed the role of commercial banks in providing agricultural credit. As a result, the total agricultural advances of Rs 1,880 million of the scheduled commercial banks in June 1969 went up to Rs 6,180 million in June 1974. There was a sharp increase in the number of agricultural loan accounts which went up to 1.806 million by December 1973. However, the growth of advances by commercial banks to agriculture was quite uneven in different States. Maharashtra, Tamil Nadu, West Bengal, Karnataka, Uttar Pradesh and Andhra Pradesh accounted for nearly 65 per cent of the total outstandings in December 1973. Generally, the States that are weak from the point of veiw of co-operative credit also failed to attract adequate loans from the commercial banks.

Co-operative Credit Societies : Progress from 1950 to 1969

In 1950-51, there were 105,000 agricultural co-operative credit societies, with a membership of 4.41 million and a working capital of Rs 372.5 million. In 1968-69, the number of societies increased to 168,000, their membership to 29.17 million and the working capital to Rs 8,122.2 million. The loans advanced by these societies to individuals rose from Rs 229 million in 1950-51 to Rs 5,039.7 million in 1968-69. These societies played a major role in providing short- and medium-term credit. During 1950-51, these societies covered only 9 per cent of the agricultural population, but the coverage increased to 42 per cent in 1968-69. The long-term credit needs of the farmers were taken care of by the co-operative land-development banks. The number of banks increased from 5 in 1950-51 to 19 in 1968-69.

The quantum of fresh long-term loans advanced by such banks rose from Rs 13.8 million in 1950-51 to Rs 1,481.6 million in 1968-69. Whereas the loans outstanding in 1950-51 amounted to Rs 65.9 million, in 1968-69 they rose to Rs 4,021.5 million. Over 90 per cent of the loans advanced by these banks were for productive purposes; a substantial number of them were for tube-wells.

During the Fourth Plan, a high priority was accorded to the reorganization of agricultural credit societies into viable units. It was also decided to undertake suitable programmes directed towards the rehabilitation and reorganization of the large number of district central co-operative banks in the rural areas to stimulate the flow of adequate co-operative credit Rajasthan, Orissa, Madhya Pradesh, Kerala, Punjab and Haryana converted most of the societies into viable units by the end of the Plan period. With the reorganization of the credit societies, their number declined to 157,000 in 1971-72 but the membership increased to 32.10 million and the working capital to Rs 12,761.7 million. The co-operative credit was expected to grow to Rs 7,500 million in 1973-74, as against which the loans advanced amounted to Rs 7,350 million. For the country as a whole the targets of short- and medium-term co-operative credit were more or less achieved, but the progress was strikingly uneven in different States. According to the available data for 1971-72, Gujarat, Madhya Pradesh, Maharashtra, Punjab and Tamil Nadu accounted for over 61 per cent of the total volume of co-operative short- and medium-term credit. In Assam, Orissa, Rajasthan and West Bengal, there were heavy overdues.

Co-operative Land-Mortgage Banks

Long-term loans advanced by the co-operative land-mortgage banks also recorded a further increase. During 1969-70 to 1973-74, the loans advanced by these banks amounted to Rs 8,320 million as against the Fourth Plan target of Rs 7,000 million. However, the position regarding these loans also showed wide inter-State variations. Andhra Pradesh, Gujarat, Maharashtra, Punjab, Tamil Nadu and Uttar Pradesh accounted for 72 per cent of the total ordinary loans sanctioned by the banks during 1971-72. In Punjab and Haryana, the overdues were negligible, but in Assam, Gujarat, Himachal Pradesh and Orissa, the overdues were over 50 per cent of the demand.

Reserve Bank Aid to Co-operative Banks

The Reserve Bank of India catered for the farmer's credit needs indirectly through its financing of the central co-operative banks and primary co-operative societies. As against about Rs 30 million of credit funds provided for agriculture during 1950-51, as much as Rs 6,187 million was made available during 1973-74 for financing the credit needs of agriculture.

An analysis of agricultural lending by the public-sector banks, as on 30 March 1973, showed that nearly 60 per cent of the amount advanced was against medium- and long-term loans. Secondly, the farmers having holdings above 2.02 ha got 74 per cent of the total credit from this source. In terms of short-term advances, i.e. crop loans, 69 per cent of the accounts pertained to holdings up to 2.02 ha, with a share of 45 per cent in the amount. Big holdings received 55 per cent of the amount. The average outstanding amount of short-term advance came to Rs 900 per account of holdings up to 2.02 ha, as against Rs 3,500 per account in the case of others. In respect of medium- and long-term loans, holdings up to 2.02 ha constituted 36 per cent of the total accounts, with only a share of 17 per cent in the total amount.[1]

It is the provision of liberal credit which enabled the farmers to sink tube-wells and to purchase tractors and farm machinery. The crop-loaning system enabled the small and marginal farmers to purchase improved seed and chemical fertilizers. Thus they also were enabled to benefit from modern technology, and substantially contributed to the success of India's Green Revolution.

[1] *Report of the National Commission on Agriculture*, Part I, pp. 290-93

CHAPTER 19

INCENTIVE PRICE TO THE FARMERS

PIVOT OF THE GREEN REVOLUTION

SETTING UP OF THE AGRICULTURAL PRICES COMMISSION AND THE FOOD CORPORATION OF INDIA

AGRICULTURE remained stagnant in India in the colonial period as the producers never got remunerative prices for their crops. The policies of the Government were consumer-oriented and the urban-dominated officialdom never bothered about the farmers. Besides, a vicious system of commerce prevailed which led to the exploitation of the peasants. At the time of harvest, when there was glut in the market, the merchants had the peasants at their mercy. When they brought their produce to the market, the merchants would refuse to buy and dictated their own price. Thus after buying the foodgrains at a cheap price, they would hoard them for some months and sell them at a much higher price during the lean months. Apart from following this strategy, they indulged in malpractices, e.g. adulteration, short-weighing and occasionally fraudulent accounting. It was obvious that so long as this system of commerce continued, good farming would be checked by bad business. Whereas this system could be tolerated when agriculture was of a subsistence type, it had no place in the economic life of the country, when modern agriculture, with the use of costly inputs, viz. chemical fertilizers, improved seed and machinery, was introduced into the country after Independence.

In 1959, Dr Frank W. Parker wrote a note entitled 'Essentials of an Agricultural Production Programme', for Ajit Prasad Jain, Minister, Food and Agriculture of the Government of India. In this note, he emphasized that to conquer food scarcity, agriculture must become a commercial enterprise and incentive prices must be given to the growers.

'The Government of India and all concerned should recognize that agriculture must become a commercial enterprise in a money rather than a subsistence and barter system', wrote Parker. He continued, 'Presently, in a large measure, it is not. Successful development, however, requires that it must be a commercial enterprise and that government fully understand the significance of the change. If this is recognized, policies and programs developed for agricultural production will be similar, in many respects, to the policies and programmes developed for industry and other commercial segments of the economy. It may be noted that in the development process in all countries agriculture becomes a commercial enterprise and it is only in those countries where it is so treated that it has successfully met the requirements for the economic

FIG. 59. Shri C. Subramaniam, Minister, Food and Agriculture, Government of India (1964 to 1967), gave strong support to the cultivation of high-yielding varieties. He induced the Government of India to accept the policy of giving incentive prices to farmers for wheat and rice.

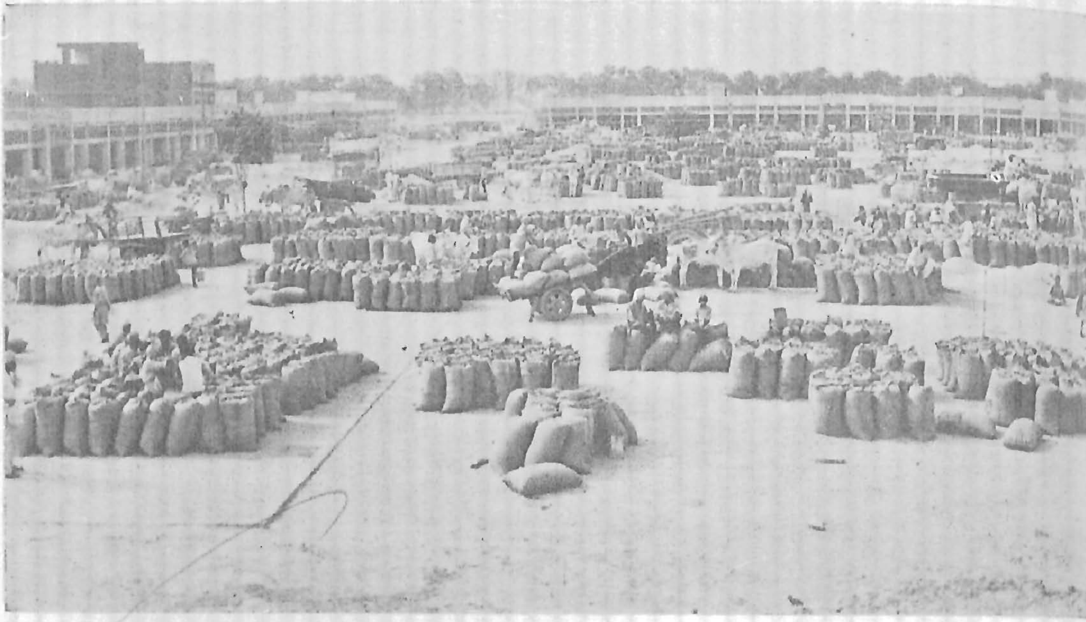


FIG. 60. A view of the grain-market at Samrala, District Ludhiana. In May, when wheat arrives, the entire yard gets covered with jute bags, containing wheat. (PAU)

FIG. 61. Concrete silos for the storage of wheat at the Ambala Cantonment Railway Station. Many such silos were built in railway yards for the storage of wheat. (PAU)

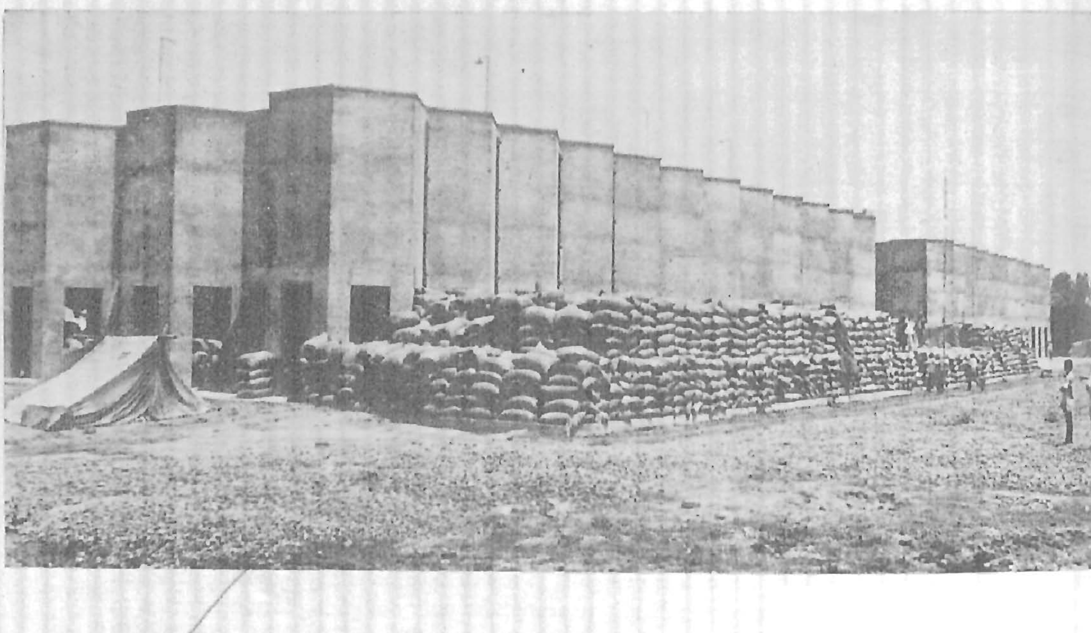


FIG. 62. An enormous increase in the production of wheat in the Punjab has led to new methods of storage. In this silo at Khanna in the Ludhiana District, 20,000 tonnes of wheat is stored. (PAU)

FIG. 63. The introduction of high-yielding semi-dwarf varieties of rice has led to a rice revolution in Punjab. Paddy-shellers have proliferated all over the countryside. This rice-sheller at Doraha in the Ludhiana District has also arrangement for drying moist paddy. (PAU)

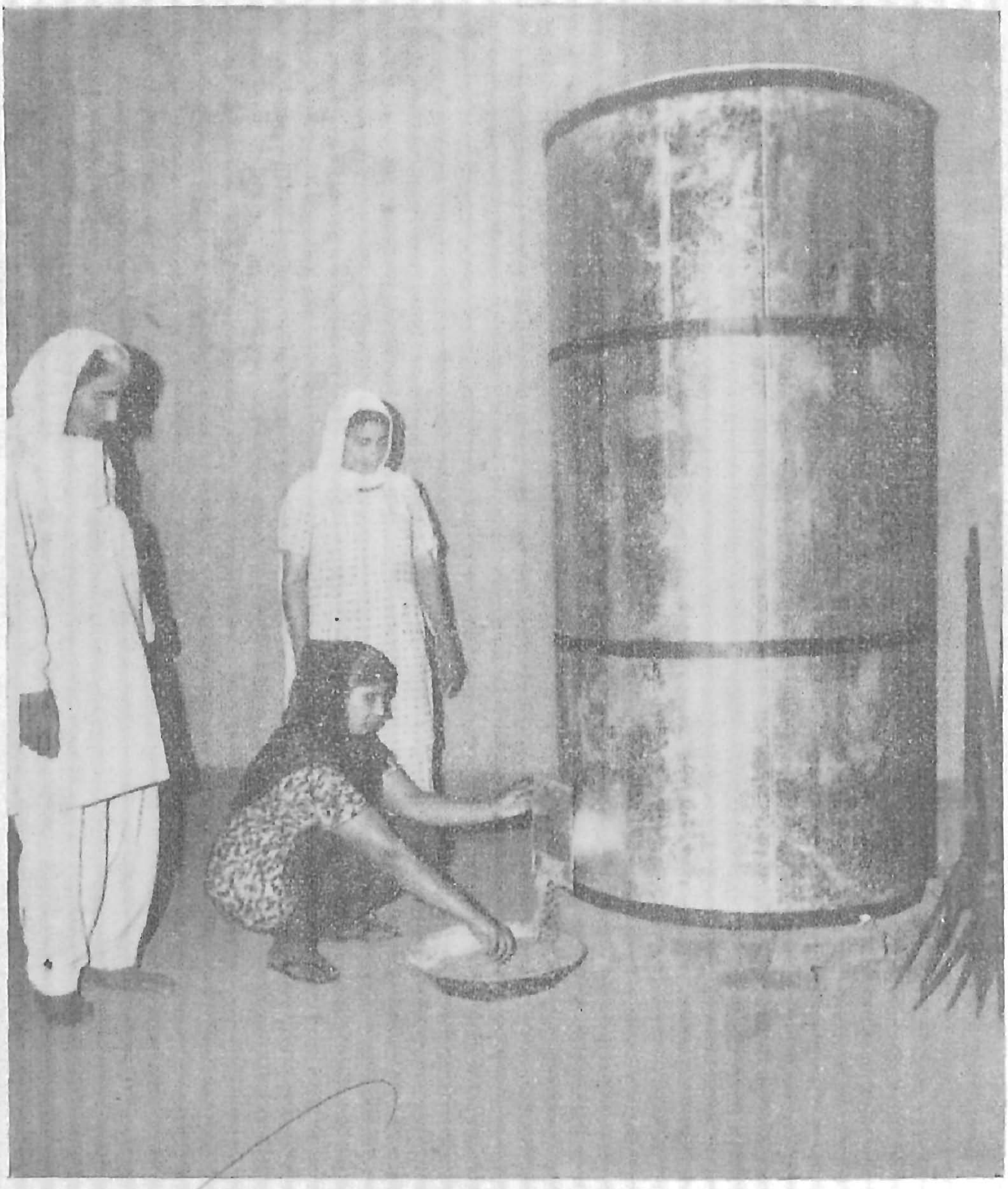


FIG. 64. Aluminium bins for the storage of wheat have become popular in the homes of the farmers in the rural areas of India. (PAU)

and industrial development of the country.

'*Recommendation.* Government should consider agricultural production a business or commercial enterprise that is operated for a profit and develop policies and programmes to make the enterprise more profitable.

'*Prices.* One of the greatest economic incentives for production is a satisfactory and dependable level of prices for farm crops. The Indian cultivator has not enjoyed such incentives in the past. There have been large fluctuations in the prices of major crops from year to year and from season to season. These variations have been much greater than variations in prices of labour, industrial products, and other things that the cultivator must buy. Unless this situation is corrected by governmental action there will not be a favourable climate for the adoption of the technological changes required for increased agricultural production.

'A support price, at the local market, can remove much of the uncertainty the cultivator now has by protecting him from very low prices that are commonly associated with harvest time and large crops. It should be high enough to encourage investment in good seed, fertilizers and other things required for technological change. The support price, on the other hand, must not be enough to work a hardship on the labour and other urban consumers. The more efficient and increased production promoted by price supports should give a profit to the cultivator and protect consumers from recurring shortages and high prices. The consumer may be further protected by ceiling prices.

"*Recommendation.* Establish minimum or support prices for all major crops at least one year before harvest.'[1]

Price Support

While others merely tinkered with the problem, C. Subramaniam, who became India's Minister of Food and Agriculture in June 1964, took a bold and resolute stand and got the policy of incentive price for the growers accepted by the Government of India. Apart from this, he got constituted an Agricultural Prices Commission. To make purchases of foodgrains by the Government, he also founded the Food Corporation of India. How this was accomplished is thus narrated by him.

'This situation of a low procurement price for foodgrains, which incidentally also influenced the price level of all other agricultural commodities, had continued for a long time.

'I found on analysis that the farmer was not getting an economic or incentive price and this was one of the main constraints which impeded any further private investments in agriculture. The limited increases in output

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[1]Parker, F. W. *Essentials of an Agricultural Production Programme in India*, February 1959

that were taking place were due to an increasing area under cultivation and to the effect of the new government irrigation projects that enabled a switch from dry to irrigated farming.

'I thought that if a new spurt was to be given to agriculture, price policy would have to undergo a radical change, so this was the first paper I prepared for the cabinet, pointing out that so far we had been paying an uneconomic price to the farmer and that an immediate increase was called for. There was a heated debate in the Cabinet about this, with particular opposition from Finance Minister T.T. Krishnamachari. He argued the other side: how could we afford to increase food prices, particularly for industrial labour and for the urban population? It would lead to much discontent and therefore he was totally opposed to any increase in the procurement price. He thought in terms of giving other incentives to the farmer. My argument was that any other incentives he might provide would not be adequate to give a new dimension to agriculture in the absence of an economic and incentive price to the farmer.

'When a difference of opinion arises in the cabinet it is ultimately the Prime Minister who makes the final decision. I told the Prime Minister Lal Bahadur Shastri frankly that it was the first paper I had brought to the cabinet and more would follow, but this was the basic problem and if he did not agree with me he could immediately relieve me of the portfolio and could choose another minister who would fall in line with the existing price policy and make his attempts to achieve progress in agriculture within this policy context. Ultimately my view prevailed and immediately a small committee was appointed with L. K. Jha (who was then the Prime Minister's secretary) as chairman. He was a very distinguished civil servant with an economic background and extensive experience in economic management.'[2]

Agricultural Prices Commission, 1965

The committee immediately recommended an increase of 15 per cent in the procurement prices, and in October 1964 an announcement was made that, for the next crop season, a 15 per cent increase would be given. At the same time the committee pointed out that this was an *ad-hoc* decision; it had not made a deep study of cultivation costs and of what would be an economic price, let alone an incentive price for the farmer. Therefore, it was suggested that an intensive study should be made of the price structure of the agricultural sector and it was in that context I persuaded the Government to appoint an Agricultural Prices Commission in January 1965, with a leading agricultural economist as the head of the Commission. It started with wheat and rice, later on examined coarse grains and then other

[2]Subramaniam, C. 1979, *The New Strategy in Indian Agriculture—the First Decade and After*, New Delhi, pp. 6, 7

commodities, such as sugarcane, cotton and oilseeds.

The prices of foodgrains are annually reviewed by the Government of India, and the support price is suitably increased keeping the rise in the price of inputs in view.

Warehousing Corporation

To deal with the storage problem, the Warehousing Corporation was constituted and was given the responsibility for building stores and warehouses at strategic points in the country.

Food Corporation of India

The Food Corporation of India was set up under an Act of Parliament in 1965 with the primary duty "to undertake the purchase, storage, movement, transport and distribution and the sale of foodgrains and other foodstuffs." The Corporation was expected to function as a major instrument of State policy in securing the following objectives:

(i) to ensure a reasonable support price which will induce the farmer to adopt improved methods of cultivation for increasing production;
(ii) to ensure that consumer prices do not rise unduly;
(iii) to avoid excessive price fluctuations and reduce the disparity of prices between States; and
(iv) to build up sizeable buffer stocks of wheat and rice from imports and internal procurement.[3]

Operation and Growth

To fulfil the objectives assigned to it, the Corporation has been undertaking the purchase, storage, movement, distribution and sale of foodgrains and other foodstuffs at the national level—a gigantic task which, over the years, became possible through a network of operating points throughout the length and breadth of the country. The activities of the Corporation were initially limited to the southern region—Andhra Pradesh, Madras, Mysore and Kerala—in most of which procurement and purchases on Central or State Government account had already been undertaken by the Government agencies under appropriate legal authority and where restrictions on prices and on the movement of grain were also in force.

In 1966, the Corporation extended its operations to Orissa, Punjab, Rajasthan, Gujarat and Pondicherry. Broadly, foodgrains subject to price control were purchased by the Food Corporation of India at the rates notified by the State Governments. Other foodgrains not subject to such control were bought at market rates under a ceiling determined in consultation

[3] *Annual Report of the Food Corporation of India, 1964-65*, p. 10

with the State Governments concerned. The disposal of grain purchased in each State was decided by the State Government. Even where an appropriation was made to the Central Pool, the State-wise allocations were made by the Central Government.

Under Section 6 (2) of the FCI Act, the Corporation has to function in the interests of both the producer and the consumer. The Corporation, therefore, readily responded to the requests of the State governments in undertaking price-support operations in the interest of the producer. In order to make available to the consumer the foodgrains handled by it at a reasonable price, it kept its operational/incidental charges at the minimum level.

By the end of 1967, the Food Corporation of India was functioning in 15 States, including the Union Territories of Delhi and Pondicherry. The Government of India had also transferred to it the procurement, storage and distribution functions, so far performed by its Department of Food in several States.

Modern Rice-mills and Mechanical Dryers

In 1967-68, the Food Corporation of India devoted attention to the introduction of modernization in some of its processes of handling foodgrains in the country. The old mills were inefficient and their outturn was sub-standard. A major step in this direction was to set up 20 modern rice-mills in various parts of the country. Thirty mechanical dryers were installed in the Thanjavur District of Tamil Nadu to provide impetus to the cultivation of high-yielding varieties of rice in the area and save the harvested wet crop from damage and deterioration.

Buffer Stocks

By 1969, the Corporation had already started playing a dominant role in purchase, storage and distribution of foodgrains in the country. Further it had registered a remarkable progress in building up and holding a buffer stock which had already exceeded the target of 5 million tonnes prescribed for the end of the Fourth Five-year Plan.

By the end of 1972-73, the Food Corporation of India had assumed a commanding role in the foodgrains trade. It ensured incentive prices to the farmer for his produce, and easy availability of foodgrains to the consumer at reasonable prices throughout the year. Its buffer stock build-up continued as a national insurance against the effects of a sudden drop in production and also to even out any abnormal seasonal gaps between supply and demand during the lean periods. The effectiveness of the massive procurement and distribution operations was reflected in the comparative stability in the prices of foodgrains in the country throughout the year, even though the price index of other commodities was showing an upward trend.

In 1970-72, the Food Corporation of India played a major role in organizing country-wide support price and procurement operations, both in the *rabi* and *kharif* seasons—with more than 50 per cent increase over those during the previous year in the volume of operations. The Food Corporation of India faced the challenge of the biggest-ever bumper crop of 1975-76 when apart from handling more than 6 million tonnes of imported grain, it had to partly procure and mainly take over more than 13 million tonnes of procured grain in a single yearly operation, in a situation of inadequate storage capacity and availability of pesticides.

PROCUREMENT OF FOODGRAINS

A bulk of the surplus of foodgrains is marketed in a few months of the post-harvest period, but the demand for grain supplies is spread throughout the year. As such, the surpluses have to be mopped up and handled in a limited period for distribution in the lean months so as to ensure regular supply throughout the year, thus minimizing price fluctuations. The volume of procurement of foodgrains at the national level and on central account has generally gone on increasing after the establishment of the Food Corporation of India. The magnitude of this procurement effort is presented in Table 1.

TABLE 1. PROCUREMENT OF FOODGRAINS (IN '000)

	Before FCI 1958-65					By FCI			
Year	Total procurement	2, as % of production	Procurement on Central account	4, as % of production	Year	Total procurement	7, as % of production	Procurement on Central account	9, as % of production
1958	526	0.9	288	0.5	1968	6,805	8.4	3,230	4.0
1959	1,806	2.6	905	1.3	1959	6,381	7.7	3,635	4.4
1960	1,275	1.9	541	0.8	1970	6,714	7.7	4,533	5.2
1961	541	0.8	305	0.4	1971	8,857	9.3	7,366	7.8
1962	479	0.7	296	0.4	1972	7,665	8.3	6,541	7.1
1963	750	1.1	545	0.8	1973	8,428	9.9	6,205	7.3
1964	1,430	2.0	741	1.0	1974-75	8,152	9.1	5,336	5.9
1965	4,030	5.1	1,678	2.1	1975-76	13,261	12.3	9,310	8.6
1966	4,009	6.3	730	1.1	1976-77	9,832	9.8	7,114	7.1
1967	4,462	6.9	1,001	1.5	1977-78	10,341	8.2	8,395	6.7

SOURCE: Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, *1976. Food Statistics*

'It will be seen that the procurement of foodgrains on Central account significantly increased after the establishment of the Corporation. During the period 1958-64, the maximum procurement on Central account was 1.3% of the total net production of foodgrains which was achieved in 1959. In 1964, the percentage went down to 1, going up to 2.1 in 1965. At the peak of the 'Green Revolution' in 1971, it was 7.8%. In 1976 it went up to 11%.

'In Punjab and Haryana, apart from the FCI, foodgrains are also procured by the State Civil Supplies Departments and the Marketing Federation.'

Handling of Imported Foodgrains and Fertilizers

To meet the foodgrains production deficit, vis-a-vis the requirements of the public distribution system, foodgrains imports, till recently—the last imports (more than 6 million tons) being in 1976—were an important element of India's Food Economy. The Food Corporation of India has been the main agency for handling them at all the ports, where it had developed the necessary discharge facilities and made arrangements for the movement of grain to numerous storage and distribution points in the country.

'The resourcefulness of the Corporation was stretched to its utmost in building new godowns, hiring the existing ones from private parties, making the best of the available owned storage, and improvising *ad-hoc* arrangements of CAP (Cover and Plinth) in a big way. It also persuaded private parties/entrepreneurs to build godowns by obtaining for them concessional loans from the banks/Agricultural Refinance Corporation. The Food Corporation of India reached the incredible height of performance in procuring, moving and holding more than 16 million tonnes of grain, including 6 million tonnes under CAP.

Storage

To meet the growing storage requirements, at a pinch and in an emergency, the experts in the FCI devised an effective, efficient and economic system of *temporary* storage, known as CAP (Cover and Plinth). Under CAP storage wheat is kept stacked (150 tonnes in one stack) on a pucca platform, with wooden dunnage underneath, covered with polythene plain sheet and then tied with nylon ropes against storms and rain. The total accommodation, including CAP storage, available with the Corporation at the end of 1975-76 was 11.198 million tonnes—made up of 5.47 million tonnes owned, 3.736 million tonnes hired and 1,992 million tonnes of CAP.

'With the heavy procurement of indigenous grain, continued imports and declining offtake, the foodgrains stocks registered a steep increase during 1975-76. The storage problem assumed serious dimensions. The Corporation had to further gear up its machinery for augmenting its capacity in every conceivable manner. Its own construction programme was speeded up; additional hiring of storage was resorted to from the Central Warehousing Corporation, State Warehousing Corporations, State Government and

TABLE 2. NUMBER OF FAIR PRICE/RATION SHOPS AND POPULATION COVERED BY THEM IN 1977

(Prepared as on 15 October 1977)

Union Territory	Number of fair-price shops	Population covered (million)
State		
Andhra Pradesh	20,238	43.50
Assam	16,635	16.48
Bihar	26,821	60.42
Gujarat	9,335	32.45
Haryana	4,674	11.20
Himachal Pradesh	2,662	3.92
Jammu & Kashmir	1,082	2.20
Karnataka	14,920	29.30
Kerala	11,784	22.80
Madhya Pradesh	15,700	39.36
Maharashtra	28,609	55.56
Manipur	481	1.35
Meghalaya	1,374	1.40
Nagaland	48	0.10
Orissa	12,086	21.95
Punjab	12,070	16.96
Rajasthan	8,967	28.61
Sikkim	13	0.03
Tamil Nadu	9,287	47.00
Tripura	654	1.85
Uttar Pradesh	26,891	94.58
West Bengal	17,800	48.54
Total	242,131	579.56
Union Territory		
Andaman and Nicobar Islands	172	0.19
Arunachal Pradesh	110	0.15
Chandigarh	148	0.41
Dadra and Nagar Haveli	32	0.08
Delhi	2,248	5.41
Goa, Daman and Diu	365	0.97
Lakshadweep	21	0.04
Mizoram	226	0.38
Pondicherry	183	0.53
Total	3,505	8.16
Total (all-India)	245,636	587.72

SOURCE: The Ministry of Food and Agriculture, Directorate of Economics and Statistics private parties. The Food Corporation of India also put up a large number of open plinths—temporary as well as convertible type—for CAP. The Corporation also negotiated with the Defence and Civil Aviation Ministries of the Centre and obtained a number of unused and abandoned airstrips for putting up CAP storage facilities. It stored foodgrains on the verandahs of the existing godowns and covered them with polythene covers. It put up CAP storages within the existing godown premises. The height of the stacks in the godowns was also raised considerably. The total storage capacity with the Food Corporation of India at the end of 1975-76 was 11.198 million tonnes, including CAP, compared with 7.859 million tonnes at the beginning of that year.'[4]

FAIR-PRICE SHOPS

To meet the needs of consumers, 245,636 fair-price shops have been opened in the country where people can buy foodgrains at controlled price.

The adoption of the policy of giving incentive price to the farmers is the pivot of the Green Revolution. The Food Corporation of India and the State Marketing Corporation by spreading a network of purchase points all over the country have provided an opportunity for the farmers to benefit from this policy. The consumers, too, have profited by making purchases of foodgrains from fair-price shops. So long as the incentive-price policy is continued, Green Revolution will roll on and there will be prosperity in the rural area and food for the consumers.

[4]Chopra, R. N. *Evolution of Food Policy in India*, New Delhi, 1981

CHAPTER 20

LAND REFORMS

A SOUND policy of land reforms is one of the important components of the strategy of Green Revolution. It has two aims: to increase agricultural production and social justice. It has been seen that the best production is obtained at the farms which are cultivated by the proprietors themselves and the most inefficient ones are those which are cultivated by the tenants who are not actuated by any incentive for land improvement because of the uncertainty of tenure.

Land is an indispensable input in the process of agricultural production. Factor-employment, level and distribution of income and the State policy interact within the rest of the agricultural environment through influencing the structure of land holdings. The process of agricultural production depends on the system of rights and obligations of the holders of land to its use, and there is a close relationship between the land system and the efficiency in agricultural production.

LAND-OWNERSHIP SYSTEM IN INDIA

Systems of land tenure vary in the States of India. Considering the dimensions of the subcontinent and the diversity of its people and their religious and social systems, this is what could be expected. The caste factor is also important. Certain castes have special aptitude for agriculture, e.g. the Jats, the Ahirs, the Sainis, the Kurmis, the Patels, the Kammas, the Reddis and the Gounders. In the southern States of Tamil Nadu, Kerala, Andhra Pradesh, Karnataka and Maharashtra, *ryotwari* system prevails. However, there is a sharp cleavage between the land-owners, the tenants or the agricultural labourers in these States. The land-owner uses hired labour for ploughing muddy rice fields. He himself is the manager who organizes labour and arranges the supply of chemical fertilizers, seed and other inputs. When the ploughing of fields goes on, he stands on the edge of the field, holding an umbrella. In the northern States of Punjab, Haryana, and the western Uttar Pradesh, the land-owner is not only a manager, but also participates in agricultural operations, e.g. he ploughs the fields, often with tractors, and manages tubewells and other means of irrigation. Thus he is a farmer in the real sense.

In eastern India comprising Oudh and Bihar, which is the most fertile belt of India, and also in the princely States, feudalism prevailed in the pre-Independence period. *Taluqdars* or rajas, as the feudal landlords were called, owned from five to hundred or more villages. How these rajas lived and mismanaged their estates is described in the account which follows. The name Pankhapur is imaginary, but could apply to any *taluqdar's* estate in Oudh and Bihar during the British rule. No doubt there were certain notable exceptions, e.g. the Raja of Bhadri in Uttar Pradesh, who was keenly interested in animal husbandry, and the Rajas of Kala Kankar, who were enlightened and progressive. However, one or two swallows do not make a summer.

THE RAJA OF PANKHAPUR AND HIS ESTATE

The Raja of Pankhapur lived in town of that name, a busy mercantile place of some 11,000 inhabitants. The main street of Pankhapur led up to the palace gate, a lofty and beautiful structure, high enough for an elephant to pass under. The gate gave access to numerous large, untidy courtyards full of horses, elephants and retainers. In the centre was a stately pile of buildings., three storeys high, in which the Raja lived. He had also a garden palace two miles outside the town. He was a man of about forty, but looked much older from the effects of dissipation, for he was an inveterate drunkard and had a large harem. His estate comprising forty villages was very badly managed and he was heavily in debt. To save him, if possible, from ruin, the Government had, at his request, appointed a manager. With a raja who was constantly drunk, and in that state easily lead to make presents and sign grants of land and money to his hangers-on, toadies and other ministers to his base pleasures, always interfering under backstairs influences and upsetting the manager's most carefully studied arrangements; or refusing consent to his plans because they displeased the host of harpies who made court to him, and preyed on him—with the Raja's mother and her nest of intriguers—with his wife, the Rani, and her court of greedy parasites, the poor manager's life was made a burden to him. Still he struggled on manfully. He succeeded in getting the Raja to consent to a scheme by which his personal expenses and those of his wife, mother, son and household, in general, were limited to Rs 100,000 a year. The rest of the profits of the estate were to be spent on paying the debts and discharging the government revenue. But the night after he signed the agreement to this scheme, he signed, while drunk, a deed granting a long lease of a large area for a nominal sum to one of his parasites.

As regards his tenants, neither the Raja nor the manager were interested in their welfare in any manner, beyond collecting the rent. The tenants lived in a most wretched condition and had no incentive for making any improvement in the land under their cultivation. Though the Raja had a personal farm of 200 acres, he seldom paid a visit to it and did not even know what crops were grown. No improvements of any type were made. Under such conditions, no agricultural development could take place.

THE UTTAR PRADESH ZAMINDARI ABOLITION AND LAND REFORMS ACT, 1953

One of the major tasks that the governments, both at the Centre and in the States, in India have been busy with since Independence is the restructuring of the age-old agrarian system of feudal nature into a new order based on the principles of 'land to the tiller' and distributive justice so as to remove institutional impediments in the way of development of an efficient system of agricultural production. Political leaders in Uttar Pradesh were fully conscious of the evil effects of *taluqdari* and absentee landlord system, known as *zamindari*. 'Various agrarian-reform measures were pushed through in the States. The notable agrarian reform among them during the pre-plan period was the Uttar Pradesh Zamindari Abolition and Land Reforms Act of January 1951. By the end of 1953, all States had abolished the *zamindari* system. A number of States also enacted legislation to fix the shares of the produce between the landlord and the tenant to prevent unfair eviction of tenants and to confer ownership rights on them on specified conditions.'[1]

TENANCY REFORMS

The land policy set out in the First Plan recognized that the pattern of land ownership and cultivation was a fundamental issue in planned economic and social development. The adequacy of land policy was to be judged in the measure in which it "reduces disparity in wealth and income, eliminates exploitation, provides security for tenant and worker and finally promises equality of status and opportunity to different sections of the rural populations". The principal programmes of land and tenancy reforms envisaged in the First Plan included the abolition of intermediary rights, limitations on the future acquisition of land and on resumption for personal cultivation, the provision of security of tenure for tenant cultivators and the fixation of reasonable rents. The distribution of available land among landless workers and encouragement to co-operative farming societies was also envisaged.

Intermediary tenures having been abolished practically all over the country, the tenancy-reforms policy now aims at ensuring the security of tenure to the tenants and share-croppers, the fixation of fair rent and conferring ultimately the ownership rights on them. Most of the State governments have enacted legislation to protect the tenants from eviction and rack-renting and to confer ownership rights on them. Tenants cannot now be ejected except in accordance with the provisions of the law. Penalty provision has been made in some States, such as West Bengal, Himachal Pradesh and Bihar in the case of wrongful dispossession or ejectment of tenants in contravention of the law. The maximum rate of rent has been brought to the level of 1/5 or 1/4 of the gross produce in all the States, except

[1] *Report of the National Commission on Agriculture* (1976), Part I, p.144

in a part of Andhra Pradesh, Haryana and Punjab, where peasant-proprietorship prevails. Most of the State laws provide that the non-issuance of receipt to the tenant shall be punishable with fine. About 3 million tenants and share-croppers have acquired the ownership of more than 2.8328 million hectares under the tenancy laws.

Special drives have been launched in Assam, Orissa, Gujarat, Karnataka and West Bengal to record the names of tenants and share-croppers in the record of rights. In Gujarat, special record-of-right teams were deputed to detect concealed tenancies with a view to conferring tenancy rights on the tenants.

Ceiling on the Ownership of Land

The Second Plan reiterated the stress on the abolition of intermediaries and tenancy reforms. The Plan also suggested the fixation of ceilings on land holdings. A number of States enacted legislation for providing security of tenure and placing ceiling on agricultural holdings.

Considerable attention was given to the problem of land ceilings during the Fourth Plan. Although almost all States had passed legislation prescribing ceilings, because of the faulty implementation and legal loopholes the legislation had not led to any major redistribution of land. All that the Government could get by way of surplus for redistribution among the landless was about a million hectares. The Central Land Reforms Committee made a number of suggestions for improvement in ceiling laws of different States in August 1971. These, in turn, were considered by the Government of India and the Chief Ministers' Conference in July 1972. Based on the recommendations of the Committee and other relevant facts, the Conference formulated a set of national guidelines on agricultural land ceilings. The purport of the directives was to bring about a certain measure of uniformity in the ceiling legislation currently being revised in various States and generally to reduce the level of ceilings. The ceiling on irrigated lands for a family of five members would be between 4.05 ha (10 acres) and 7.28 ha (18 acres) if the land was double-cropped, and 10.93 ha (27 acres) if it was single-cropped. For all other categories of land, including orchards, the family ceiling would be 21.85 ha (54 acres). The area irrigated by private sources, such as tubewells and pumping-sets, was to get some weightage, but only within the overall ceilings. Where the number of members in a family exceeded five, additional land might be allowed to each member, subject to an overall maximum of twice the family ceiling. Besides, the categories exempted from the purview of ceilings were drastically reduced.

Under the revised ceiling laws, out of about 1.567 million hectares declared surplus in different States, about 1 million hectares has been taken possession of by the States and about 0.69 million hectares has been distributed to the landless agricultural labourers. The distribution of ceiling-surplus land has benefited nearly 1.178 million landless persons, of whom 0.628 million belong to the Scheduled Castes and the Scheduled Tribes. Earlier, about 0.781 million hectares was distributed under the pre-revised ceiling laws. Andhra Pradesh, Assam, Bihar, Maharashtra and Uttar Pradesh account for three-fourths of the total surplus land distributed in the country.

At the time of the formulation of the National Policy on land ceilings, it was felt that it would not be sufficient merely to distribute surplus land to landless workers and other eligible categories of the rural poor. The allottees of the ceiling-surplus land, which was land of generally poorer quality, had little resources of their own to develop these lands. The Government of India, therefore, launched a scheme during the Fifth Five-Year Plan for giving financial assistance to the allottees of the surplus land. Rs 1,000 per hectare was given as outright grant for both inputs/consumption and land development in one lump sum, half of which was provided by the Central Government and the other half by the State government.

TENANCY REFORMS FOR HOMESTEAD TENANTS

The conferment of ownership rights on homestead tenants belonging to the poor sections of the rural community, such as share-croppers, agricultural labourers and artisans, has been one of the objectives of the Land Reforms policy.

Guidelines were issued to State governments in 1973 to take necessary steps for the conferment of ownership rights on homestead-dwellers. Accordingly, practically all the State governments have conferred security of tenure and ownership rights upon homestead tenants. There is also a scheme under the 'Minimum Needs Programme' for the provision of house-sites to landless in rural areas since 1971, under which 7.8 million house-sites had been given till 1981, to landless workers and artisans in the rural areas.

Besides, the distribution of ceiling-surplus land and the conferment of ownership rights on the homestead dwellers, 0.84984 million hectares of government wasteland was distributed during 1975-78 to the landless, the majority of whom belong to the Scheduled Castes, the Scheduled Tribes and other weaker sections.

The land-reform enactments have brought about a silent revolution in the countryside. The owners of land who formerly lived on rents extracted from their tenants are now themselves engaged in farming. Those who could not manage their land have sold their land to the working farmers, and have invested their capital in other enterprises. Millions of cultivators who were once mere tenants now enjoy the dignity of land-ownership and have participated in the Green Revolution, which the high-yielding seeds have sparked in the countryside.

CHAPTER 21

ESTABLISHMENT OF AGRO-INDUSTRIES CORPORATIONS IN THE STATES

IN the dark days of 1964, when India was suffering from the ravages of a serious drought, many innovations were made to improve food production. The role of agricultural machinery in the transformation of agriculture was fully realized. As the industrial production of tractors, trailers, electric motors and pumping-sets greatly lagged behind the demand from the farmers, the Government of India was of the view that a lead should be provided by the Central and State governments in this matter. A suggestion came from T.T. Krishnamachari, the then Finance Minister, Government of India, that agro-industries corporations should be set up in all the States. The State governments were accordingly advised by the Government of India in 1964 to set up agro-industries corporations in the public sector to deal with the manufacture and utilization of various industrial products.

The special functions of these corporations were to provide the industrial wherewithal for modern progressive agriculture, study the market requirements, link the demand with the supply and to adopt a firm manufacturing programme. It was envisaged that the corporations would undertake the manufacture of some of the implements, and encourage private manufacturers to produce others. The corporations were also expected to provide credit facilities and common services for the industries. They would act as active units for studying the demands for and arranging the supplies of agricultural inputs, to encourage the manufacture and promote sale of agricultural implements and also to educate the farmers to increase production by taking full advantage of the available aids.

The agro-industries corporations were set up in 17 States, viz. the Punjab, Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Jammu and Kashmir, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. The first corporation was established in Maharashtra in December 1965.

The main objectives of the State Agro-Industries Corporations are as below:

(i) the manufacture and distribution of agricultural machinery and implements as well as of the equipment pertaining to processing, dairying, poultry-farming, fishery and other industries connected with agriculture;

(ii) the enabling of persons engaged in agricultural and allied pursuits to own the means of modernizing their operations or alternatively making available the necessary custom service for this purpose;

(iii) the undertaking of, and assisting in, the efficient distribution of inputs for agriculture;

(iv) the promotion and execution of industries having a bearing on production, preservation and supply of food; and

(v) the providing of technical guidance for farmers and persons concerned with agro-industries with a view to enabling them to conduct their enterprise efficiently.

FINANCE

The States were advised to set up these corporations in the public sector with Central participation in the equity share. It was agreed that the Government of India and the State governments concerned would contribute 25 per cent and 50 per cent respectively of the share capital and the balance capital would be raised by inviting private participation. In case private participation was not forthcoming, the Government of India's share would be 50 per cent. At present, these corporations are government companies within the meaning of Section 617 of the Companies Act, 1956, and the Government of India's equity participation ranges from 49 to 50 per cent. The total paid-up capital of the 17 corporations, as on 31 March 1979, was 656.42 million rupees, of which the Government of India's share is 315.67 million rupees. The details are given in Table 1.

Sale of agricultural machinery. In the initial stages, the corporations concentrated on the sale of tractors, power-tillers and pumping-sets to the farmers on cash and hire-purchase terms. To ensure the supply of tractors at reasonable prices to the farmers, imported tractors were also sold through these corporations, which also provided after-sale maintenance service. The corporations of Haryana, Uttar Pradesh and Bihar took up the assembling of the Czechoslovakian Zetor tractors. The corporations sold 50,000 tractors, 5,000 power-tillers, and 50,000 diesel engines, electric motors and pumping-sets to the farmers.

Supply of spare parts. Private dealers were charging exhorbitant prices for the spare parts of tractors. To save the farmers from such exploitation, spare parts worth millions of rupees were sold by the corporations.

Agricultural machinery hiring centres. With a view to providing machinery-hiring and servicing facilities for the farmers, the agro-industries corporations in most of the States set up agricultural-machinery hiring centres, to be run on no-profit-no-loss basis. On account of losses incurred by these centres, they were later on closed down.

An important function of the corporations was to supply agricultural machinery and equipments on hire-purchase terms to the farmers. Some of the corporations, on advice from the Government of India in 1967, implemented this programme. The Bihar Corporation supplied over 5,000

TABLE 1. PAID-UP CAPITALS BY THE CENTRAL GOVERNMENT AND STATE GOVERNMENTS TO THE AGRO-INDUSTRIES CORPORATIONS (IN MILLION RUPEES), AS ON 31 DECEMBER 1979

No.	*Name of the corporation*	*Date of inception*	*Paid-up capital*		*Total*
		Date-Month-Year	*State Govt*	*Govt of India*	
1	Andhra Pradesh	5-03-1968	28.0000	26.9020	54.9020
2	Assam	25-01-1967	11.0000	11.0000	22.0000
3	Bihar	28-04-1966	25.5000	24.5000	50.0000
4	Gujarat	10-05-1970	24.5830	24.8000	49.3830
5	Haryana	30-03-1967	9.4830	9.4830	18.9660
6	Himachal Pradesh	24-09-1970	20.4000	17.1500	37.5500
7	Jammu & Kashmir	31-01-1970	10.2000	9.3760	19.5760
8	Kerala	22-03-1968	20.7868	16.3187	37.1055
9	Karnataka	1-09-1967	30.6000	29.4000	60.0000
10	Madhya Pradesh	21-03-1969	7.5000	7.5000	15.0000
11	Maharashtra	15-12-1965	25.0000	25.0000	50.0000
12	Orissa	17-02-1968	6.9500	6.6772	13.6272
13	Punjab	11-02-1966	13.2000	12.0000	25.2000
14	Rajasthan	1-08-1969	19.5449	18.7775	38.3224
15	Tamil Nadu	5-07-1966	16.5000	16.5000	33.0000
16	Uttar Pradesh	29-03-1967	37.6000	33.2828	70.8828
17	West Bengal	16-08-1968	34.0000	26.9021	60.9021
	Total:		340.8477	315.5693	656.4170

SOURCE: *The Ministry of Food and Agriculture, Government of India*

pumping-sets and 170 tractors on the hire-purchase basis, besides power-threshers and power-tillers. On account of the difficulties involved in the recovery of loans from the farmers, the corporations suffered losses and later on curtailed this programme.

Diversification of activities. Some of the corporations diversified their activities in other fields, such as the processing of fruit and vegetable products, the setting up of cattle- and poultry-feed plants, cold stores, oil-extraction plants, compost plants, maize-milling plants, granulated fertilizer plants, pesticide plants, projects on agricultural aviation, and the processing of fish products.

The apple-growing States, such as Himachal Pradesh and Jammu and Kashmir, set up cold stores to stabilize the market for the benefit of the growers and the consumers. The Himachal Pradesh Agro-Industries Corporation constructed a cold store, with a capacity of 2,000 tonnes at Bombay.

The Jammu and Kashmir Agro-Industries Corporation set up cold stores of 2,000 tonnes each at Delhi and Srinagar. The Assam Agro-Industries Corporation has taken up a project of cultivation, processing and marketing of pineapple at Bahalput in the Goalpara District.

The Gujarat Agro-Industries Corporation has taken up the aerial spraying of cotton. It has also set up a mechanical compost-manufacturing plant at Ahmedabad. The Haryana Corporation has set up a plant for assembling and progressive manufacturing of Kubota power-tillers. The Madhya Pradesh Corporation has set up a workshop at Bhopal for the repair and maintenance of tractors. Trailers, discs, harrows and other implements are also manufactured at this workshop. The Corporation is running 30 air-compressors on hire for drilling work in dug wells.

The Maharashtra Corporation's fertilizer complex comprises one granulated-fertilizer plant and one superphosphate plant. The Corporation has set up at Nagpur a plant for the processing and canning of vegetables and fruits.

The Orissa Corporation has initiated a scheme for land reclamation. It has set up units at Berhampur, Bhubaneshwar and Sambalpur for manufacturing cattle and poultry feed.

The Punjab Corporation is selling tractors, discs, implements, seed-bins, tyres and tubes, and spare parts. It is also selling fertilizers and has set up 11 centres for hiring agricultural machinery. It has started six diesel or petrol pump-stations in the rural areas.

The Rajasthan Corporation sold imported and other tractors, threshers-cum-winnowers, seed-bins, biogas plants, and spare parts of tractors. It manufactured agricultural implements and distributed quality seeds and fertilizers. It has also taken up the aerial spraying of cotton and sugarcane.

The Tamil Nadu Corporation has set up tractor-hiring-cum-service centres and sub-centres in many districts. It has one service workshop at the headquarters where stocks of spare parts from all makes of tractors are available.

The Uttar Pradesh Corporation is selling tractors, seed-cum-fertilizer drills, trailers, power-tillers and biogas plants. It has also undertaken the fabrication and manufacture of spare parts for the HMT Zetor 2511 tractors. It has set up its 300 sale points for selling fertilizers, pesticides and sprayers. It has also set up a custom-hiring and servicing division and processed-food and cattle-feed divisions.

The West Bengal Corporation sold tractors, pumping-sets and power-tillers to the farmers. Over 20 custom-service centres have been established in the districts. It has developed a 5-HP diesel pumping-set, which is being manufactured by approved collaborators. The Corporation has also formulated pesticides.

Performance and Achievements of State Agro-Industries Corporations

On the financial side, the performance of the corporations was not very satisfactory and most of them incurred losses. One of the reasons was that in many cases departmentally operated schemes of machinery-hiring were transferred to the corporations, along with the equipment, which was not serviceable and its cost was taken as loan for capital. The staff was also not geared up for operations on a commercial basis. There was a lack of continuity of senior executive positions owing to frequent changes.

The performance of the corporations was reviewed in December 1978 and measures were taken up for effecting improvements in their working and planning their operation on long-term corporate plans. As a result, there has been a conspicuous change for the better in their financial positions. Some of the corporations have now come out of the red and are showing profit.

On the whole, these corporations rendered useful service to farmers through manufacture, procurement and distribution of agricultural machinery, besides ensuring remunerative returns to farmers by building up cold-storage capacity and by setting up agro-based industries in the rural areas. Some of the corporations made commendable achievement in the export of processed fruit and vegetable products. Above all, by providing healthy competition to private agro-industries, they put a stop to profiteering and thus served the farmers.

Concept of Setting up Central Agro-Industries Corporation

The need was felt for the development of an apex organization to reduce competition among the corporations and to establish a sound marketing system for their products. It was also felt that such an organization would be useful for importing spare parts of machinery in a collective way and for reducing the cost of handling. The functions of the apex organizations were conceived as under:

(i) to co-ordinate the activities taken up by the State agro-industries corporations in the sale of inputs and the development and execution of agro-based industries;

(ii) to act as a clearing-house for the exchange of information, technical know-how and to develop a suitable infrastructure for providing consultancy for the State corporations as well as for other organizations within the country and abroad;

(iii) to implement projects selected by the State corporations on a turnkey basis and develop overseas operations;

(iv) to handle the import of inputs, spare parts and farm equipment and their stocking and distribution; and

(v) to develop collaborative projects for manufacturing items in short supply, such as containers for processed fruits and farm equipment.

It was thought that the Central Corporation might initially have an authorized capital of Rs 10 million, contributed by the Government of India and the State agro-industries corporations. The activities of the above Central Corporation were expected to be self-supporting.

NATIONAL ASSOCIATION OF STATE AGRO-INDUSTRIES CORPORATIONS

In the absence of an apex organization, which has still to come up, the State agro-industries corporations formed in1975 a National Association as an Apex Organization (NAIC) and got it registered under the Societies Registration Act XXI of 1860 (Punjab Amendment Act). The main object of the Association is to advise the member-corporations in the fulfilment of tasks assigned to them and to render service in liaison work with the Central Government offices and manufacturers of farm machinery, implements, fertilizers and pesticides. The Association is taking interest in evolving a common marketing approach for products manufactured by the Corporations.

AGRO-SERVICE CENTRES

The operation of the agricultural-machinery-custom service by the Corporation suffered from high overhead charges. On reconsideration, it was thought appropriate that agricultural-machinery-custom centres might be set up by unemployed engineers and graduates in agriculture. Accordingly, in 1970, the Government of India launched a centrally sponsored scheme for setting up entrepreneurs agro-service centres all over the country. The State agro-industries corporations were entrusted with the task of arranging training programmes for unemployed engineers and agricultural graduates and assisting them to secure loans for capital equipment from the banks. The Government of India agreed to pay subsidy on the interest exceeding 5% on the capital equipment. The State agro-industries corporations were given assistance to set up training-cells for these entrepreneurs. The Government of India also established two regional training centres in the Tractors Training and Testing Centre at Budni (Madhya Pradesh), and at Hissar (Haryana) for these entrepreneurs. By March 1981, 5,534 entrepreneurs had been trained and 3,206 agro-service centres were established. Out of these, 508 centres later on closed down owing to the lack of initiative on the part of entrepreneurs and competition from tractor-owning farmers, who could provide these services cheaper than the graduate entrepreneurs. Nevertheless, 2,698 agro-service centres are functioning. Out of these, 386 are in Rajasthan, 293 in Madhya Pradesh, 292 in Kerala, 272 in West Bengal, 263 in Punjab, 233 in Uttar Pradesh, 179 in Tamil Nadu, 162 in Karnataka, 121 in Gujarat, 110 in Andhra Pradesh and 40 in Orissa.

The agro-industries corporations provided inputs and services for the farmers at a crucial stage, when the private-sector and the public-sector agro-industries were not existing or were inadequately developed. Thus they materially contributed to the success of the Green Revolution.

CHAPTER 22

NATIONAL SEEDS CORPORATION

BEFORE Independence, the multiplication and dissemination of the seeds of improved varieties was the responsibility of the provincial departments of agriculture. They evolved improved varieties of rice, wheat, chickpea, sugarcane, cotton, jute, tobacco, groundnut and mustard. Between 1926-27 and 1938-39, the area under improved varieties increased from 7.2 to 68.2 per cent in the case of sugarcane, from 13.1 to 50.2 per cent in the case of jute, and from 22.7 to 27.5 per cent in the case of cotton. All these are commercial crops and the farmers could invest money for purchasing their seed. In the case of foodgrains, a significant increase was achieved only in the case of wheat, where the area under improved varieties increased from 11.9 to 22.4 per cent.

With the rising population, foodgrains can no longer be regarded as non-commercial. No one can do without food, though one can manage with fewer clothes. With the rise in the price of foodgrains, farmers could purchase chemical fertilizers and improved seed. In fact, the consciousness regarding improved seed in the case of wheat, rice and maize developed with the arrival of high-yielding varieties, and the farmers began to distinguish between seed and foodgrain. They also realized that seed production, according to modern technology, involved rogueing, the application of high doses of chemical fertilizers and, in the case of some crops, rigid plant-protection measures and the prevention of moisture stress during period of seed formation and development.

TEN-HECTARE SEED FARMS

During the First Five-Year Plan, seed farms of the average size of 10 hectares were set up in the State in every block of 100 villages. By the end of the Second Five-Year Plan, about 4,000 such seed farms were set up. Later on, it was found that small seed farms were uneconomic, and the emphasis shifted to the selection of large farms, where the economy of scale ensured a better utilization of agricultural machinery.

NATIONAL SEEDS CORPORATION, 1963

With the arrival of hybrids and exotic varieties, the need for an efficient Central organization for seed production was felt. The Government of India, therefore, set up the National Seeds Corporation (NSC) in 1963, charging it with the task of producing, stocking and supplying foundation seeds, particularly of hybrids and vegetables. The Corporation was greatly expanded in 1965; it played an important role in producing foundation seed. Seed-testing laboratories were also set up at the Indian Agricultural Research Institute, New Delhi, and in the agricultural universities. The Government also passed the Seeds Act, 1966, to ensure that seeds produced in the country were of requisite quality. The genuine labelling of the seed material was made compulsory.

The existing production and distribution arrangements were subjected to a scrutiny by the Seed Review Team in 1968. The Team reviewed the gamut of seed production, commencing from the release of varieties to their multiplication, quality control, procuring, packaging, storage, distribution and transport. Seed-processing involves drying, preconditioning, cleaning size-grading, upgrading and chemical dressing. A number of shortcomings were brought to light. They included the non-availability of quality breeders' stock in adequate quantities; the insufficiency or absence of appropriate storage facilities at seed farms, and inadequacies in the processing of seeds and in the arrangements to distribute them. The recommendations made by the Team aimed at remedying some of these defects.

State Seeds Corporations

In view of the increasing demand for quality seed, State farms were drawn into the programme. A measure of decentralization of responsibility in seed production was introduced in 1967-68, when each State was made responsible for making its own arrangements to produce seed in accordance with the targets fixed.

During the Fourth Plan, in the context of intensive agriculture, the availability of quality seeds on an adequate scale determined the pace and progress of all agricultural programmes. The multiplication and distribution of improved seeds, therefore, received special attention. The programme was streamlined in such a way that the breeder's seed could be produced in adequate quantities with the help of the ICAR and the NSC, and the foundation seeds by the NSC and selected agricultural universities. In the production of certified seeds, however, a number of agencies were brought in, including State seed farms, Central farms, private seed-producers and seed-producers' co-operatives. The biggest seed farm, covering 9,300 hectares, was established at Suratgarh in Rajasthan. All the machinery, viz. tractors and combines, were donated by the USSR. A number of big seed farms were established in other States, and a State Farms Corporation was established at the national level to manage them. Efforts were also made to provide the right type of storage facilities and to set up the requisite number of seed-processing plants. A significant development during the Fourth Plan was the setting up of the Tarai Seed-Development Corporation in 1969-70 as a joint venture of the Govind Ballabh Pant University of Agriculture and Technology, the NSC and the seed-growers of the area, with the aid of the World Bank.[1]

The agricultural universities also suitably improved their seeds at their extensive farms. These seeds are sold to farmers on the occasion of farmers' festivals, and they further multiply them at their own farms.

Now that seeds corporations have been established in most of the States, the universities supply them with the foundation seed, which they multiply and sell to their agents, who have shops in most of the market towns.

[1] *Report of the National Commission on Agriculture* (1976), Part I, p. 144

CHAPTER 23

RURAL LINK ROADS

ROADS are commonly called arteries through which the life-blood of an economy flows; they are the key to the development of an economy, and catalysts in the transformation of an economy from poverty into prosperity. Economic development is the technological transformation of an economy, in respect of not only skill and labour but also space and location, and roads are the essential elements in this transformation. As Wilfred Owen observes, 'Transport is a necessary ingredient of nearly every aspect of economic and social development. It plays a key role in getting land into production, in marketing agricultural commodities, and in making forest, agricultural and mineral wealth accessible. It is a significant factor in the development of industry, in the expansion of trade, in the conduct of health and education programmes, and in the exchange of ideas.'[1]

Once a village and a town are linked together by permanent road, the economy of the village undergoes a remarkable transformation. The farmers market their produce with facility, and are also enabled to purchase fertilizers, plant-protection chemicals and agricultural implements from the market town with ease. These facilities lead to rapid changes in agriculture. Villagers who have had no experience of growing commercial crops, such as potatoes and vegetables, adopt them easily. Roads also promote industry directly as well as indirectly. Villagers who have never used bicycles and scooters, purchase them once they have the facility of a road. Tractors can command larger areas for cultivation along the roads, and custom-ploughing is also promoted. Besides, the sons and the daughters of the farmers are enabled to take advantage of the educational facilities in the town.

The construction of roads to serve the rural population was never taken seriously during the colonial period. Even at a very conservative rate of road construction, what the British accomplished in a century was achieved in the first 15 years after Independence. Until recently, the State governments were concerned with the National and State highways only, and minor roads, so important to the rural masses, were within the jurisdiction of the district boards, which chronically suffered from a paucity of funds.

For the first time, an attempt to undertake a road-construction programme as a National project was made in 1943 when the Nagpur Plan was formulated. One of the objectives of this Plan was to bring every

[1]Wilfred Owen, *Strategy for Mobility*, Washington, 1961, p.1

village in India within 3.2 kilometres of a road in 20 years. The target was subsequently revised in 1958 and it was proposed that during 1961-1981 every village in an agricultural area should be within 2.4 kilometres of a road. Not to speak of achievements, even these targets were too modest to be compared with some of the countries in western Europe. Construction of rural roads did not make any significant headway in the first 15 years of our planning. The pace of road construction during the three Plan periods did not make a perceptible impact on the social and economic life of the rural masses. In the Community Development Programme also, the construction of metalled roads was not adequately emphasized. As a result, the village communities could not join the mainstream of the national development process.

PUNJAB AND HARYANA: LEADERS IN RURAL-LINK-ROAD SCHEME

Punjab and Haryana provided a lead in giving all-weather link roads to their villages. Out of 12,188 villages, 11,824 were linked up by April 1980 with metalled roads in Punjab, constructed at a cost of Rs 900 million. Haryana followed Punjab in taking up the link-road programme with zeal.

How did it happen that Punjab could give a lead in this scheme, which resulted in the transformation of its rural area? In 1968, Sardar Lachhman Singh Gill became the Chief Minister of Punjab. He had a slender majority and knew that he could not last long. I had known him since 1947 and had admiration for his integrity and courage. He came to me for advice and aked if I could tell him about some scheme that could make an impact on the rural people in a short time. I told him that he should lay aside sophisticated schemes and should put all the available resources in a crash programme for constructing rural link roads, which would transform the economy of the villages, which remained primitive, because they were cut off from the markets by a couple of kilometres of dirt roads. I had myself seen the transformation of the economy of the Garden Colony of Khanpur in the Ropar District, where I am residing. This Colony was only a kilometre from the Town of Kharar and had only a *kachcha* link road which became muddy in the rainy season. Thus for three months, no motor-vehicle could reach the Colony. The Colony had the benefit of the Consolidation of Holdings Scheme and the farmers' tube-wells were electrified. But no farmer could live on his land. The garden colonists, helped by the boys of a local high school, provided earthwork, and the Punjab Government metalled the link road in 1964. This facility led to a change in agriculture. Farmers took up vegetable-growing along with fruit-growing. They could market their produce with facility and also bring bulky inputs, such as manure and chemical fertilizers, to their fields. Their children could go to school on bicycles. A number of them purchased tractors. Agriculture was transformed and even the economy of Kharar, a decaying Rip Van

Winkle town, received impetus. Lachhman Singh Gill was thoroughly convinced of the soundness of my advice and launched a crash programme of constructing rural link roads in his constituency of Jagraon-Moga. This Programme won him unprecedented popularity. It became a peoples' programme, for it satisfied a long-felt need of the rural people. The benefits have been tremendous—economic, social and cultural—to all sections of the rural people. Lachhman Singh Gill died a few months later, but his memory is respected in Punjab. After him, Bansi Lal, who came from a farming stock, and belonged to a remote village in the Bhiwani District in Haryana, cut off from civilization, and had experienced hardships of life in such villages, took up this scheme in Haryana with earnestness. By now, out of 6,731 villages in Haryana, more than 6,000 have been provided with permanent link roads. From 1967-68 to 1980-81, about 13,160 km of link roads have been constructed in Haryana at a cost of Rs 1,100 million.

Link Roads and the Green Revolution

There is a close relationship between the programme of rural link roads and the Green Revolution in Punjab and Haryana. By 1968-69, the Green Revolution had acquired a momentum in these States. The production of foodgrains was trebled. The extraordinary development, which accrued in a short period, created the problem of marketing of surplus farm produce. To cope with the situation, the need was felt for new marketing centres to sell the farm produce at the nearest place in the shortest time, and the easiest manner. What was required was more markets. These markets *(mandis)* enjoyed unprecedented prosperity, and the market fee became a major source of revenue. The Punjab Government used these funds for constructing rural link roads. Thus resources for the road programme generated in agriculture by the adoption of new technology were ploughed back into the rural area. That step, in turn, further promoted agricultural production.

Since the rural link roads ultimately join the main roads, there has been great improvement in transport and communication between the rural areas and the urban centres. One healthy effect of the increasing intercourse between the rural and urban areas has been the improvement in the living standards of the rural people.

As a result of the construction of link roads, the mobility of the rural labour between villages as well as between villages and towns has increased and, to that extent, has resulted in the reduction of under-employment and seasonal unemployment.

The link roads have given a fillip to the production of perishable products, such as vegetables, milk and eggs. Besides, the quicker and better marketing facilities have resulted in the reduction of distress sales of agricultural produce.

The development of link roads has facilitated the timely supply of inputs to the agricultural sector. This facility had a favourable effect on agricultural productivity. This is one of the major factors which has contributed to the growth of agriculture. It facilitated the provision of extension services on a larger scale with greater mobility, thus favourably effecting agricultural production. As a result of link roads and of increased service facilities, the mechanization of agriculture was promoted.

The link roads gave a fillip to the transport industry as cycles, motorcycles, three-wheelers, minibuses, goods transport and passenger transport could ply with greater ease and frequency. This has also contributed to the generation of employment in this sector.

The contact of the administration with the rural public has increased, thus breaking the communication barrier between the two, and the breaking of this barrier is a must for development. The construction of rural roads has enabled medicines and supplies of life-saving drugs to reach the sick in the villages speedily. The villagers now enjoy health and family-planning facilities. Veterinary extension work has become easier and veterinary doctors now attend to serious diseases of livestock in the villages.

Rural Link Roads in India

At the end of 1977-78, there were about 500,000 km of rural roads in the country. In addition, there were 400,000 km of earth roads constructed under the Community Development and National Extension Schemes. According to the *Report of the National Transport Policy Committee,* the number of villages provided with all-weather link roads is about 400,000 and 314,000 villages are still without such a facility. In Table 1, information is given regarding the progress of the rural link-road scheme in the major States of India.

Link-Road Programme : an Urgent Necessity in Eastern India

A link-road programme is an urgent necessity in the Indo-Gangetic alluvial plain, where the countryside becomes a sea of mud in the rainy season. In Uttar Pradesh, out of 112,561 villages, only 20,907 are linked with all-weather roads. In Bihar, out of 67,566 villages, only 14,632 are connected with all-weather roads. In West Bengal, out of 38,074 villages, only 16,275 are linked with permanent roads. When villages in these States are linked to the markets with all-weather roads, there will be improvement in agricultural production in these States, which in spite of the fact that they have the most fertile soil have a stagnant rural economy.

TABLE 1. NUMBER OF VILLAGES CONNECTED BY ROADS AS ON 31 MARCH 1978

State/Union territory	*Number of villages*	*Number of villages connected with all-weather roads*
Andhra Pradesh	27,221	10,507
Assam	21,995	8,672
Bihar	67,566	14,632
Gujarat	18,275	6,199
Haryana	6,731	5,450
Himachal Pradesh	16,916	1,881
Jammu & Kashmir	6,503	350
Karnataka	26,826	12,733
Kerala	1,268	345
Madhya Pradesh	70,883	20,707
Maharashtra	35,778	17,954
Punjab	12,188	10,403
Rajasthan	33,305	4,686
Tamil Nadu	15,735	6,271
Uttar Pradesh	112,561	20,907
West Bengal	38,074	16,275
Total	520,353	159,726

SOURCE : *Planning Commission*

CHAPTER 24

RURAL ELECTRIFICATION, TUBE-WELLS AND PUMPING-SETS

A SOURCE OF IRRIGATION AT THE COMMAND OF THE FARMER

RURAL electrification plays a key role in modernizing agriculture. Electricity not only lights up dark rural homes, thus providing the sons and daughters of the farmers with an opportunity to study after the sunset, but it also provides mechanical power for tube-wells, pumping-sets, threshers and fodder-cutters. Its importance is paramount in providing perennial irrigation in areas not served by the canals. The rapid mechanization of agriculture is making a staggering demand for mechanical power. Being cheaper than mineral oil, the demand for electric power is fast increasing.

ADVANTAGES OF TUBE-WELL IRRIGATION

Tube-well irrigation based on the exploitation of ground-water has many advantages over surface irrigation by canals, as it does not involve expenditure on storage of water and its transport. 'It does not involve the loss through submergence of large areas of valuable land under reservoirs or the disturbance of the ecological balance as is caused by big irrigation projects. The use of ground water also avoids the loss of land needed to build canals and distributaries. Again, it does not require any costly and complicated systems of water distribution and drainage as canal systems do. It is so because private tube-wells serve only small areas of land and because the farmer who bears the cost of pumping uses just as much water as is really required for his crop and no more. Again, the owner of the tube-well-irrigated lands carries out the levelling and shaping of his fields with his own efforts whereas such works in canal commands require large outlays and big bureaucracies as they have to be taken up on the basis of large outlet commands. Ground water is also not susceptible to serious losses by evaporation or seepage which characterise irrigation projects. Yet again, ground water development does not call for the subsidies which the operation of most irrigation projects demand.

'From the farmer's point of view ground-water-tube-well irrigation is incomparably superior to surface irrigation because it is entirely under his own control. On the other hand, in canal irrigated areas the arrival of water and its distribution during cropping seasons is at the mercy of huge bureaucracies. This explains why the use of ground water has such a profound psychological effect on the farmer and makes him self-reliant even in matters other than irrigation.[1] It, however, does not mean that canal irrigation is not required. Tube-wells are also necessary in canal-irrigated areas to keep the ground water at a safe level, and thus to save the land from water-logging. Besides, canal water is often not sufficient to irrigate the entire area and is available after long intervals. The best agricultural areas are those in which there is conjunctive use of canal and ground water.

TUBE-WELLS

A tube-well places water at the command of the farmer and he can use it as and when he is in need of it. That is why shallow tube-wells owned by the farmers are more popular than deep tube-wells owned by the Government. A tube-well provides water for irrigating crops, and also for washing clothes and for bathing (Fig. 65). Thus, apart from multiple cropping, rural hygiene has improved in those States where the tube-wells have become popular. Tube-wells have also saved land from water-logging.

Tube-wells are constructed by inserting a pipe below the ground level, passing through geological formations consisting of water-bearing and non-water-bearing strata. Blind pipes are located at the non-water-bearing strata and perforated pipes or well-screens are placed against the aquifer (Fig. 70). In cavity wells, screens are not required, as the well-casing rests over a confined water-bearing formation of sand and gravel. Water enters the well through the bottom only. In deltaic regions, where the aquifer formations are of coarse sand and gravel, the tube-wells are shallow and consist of a well-screen and a short length of casing pipe.

Power-operated drilling-rigs for boring tube-wells were introduced into the country in 1880, but their widespread use started only after World War I (Fig. 66).

The first record of a deep tube-well is from Amritsar, where it was sunk by the Amritsar Municipality in 1912 under the supervision of S. Leggett, Superintendent, Central Workshops, Public Works Department, which gave a supply of $\frac{1}{4}$ cusec. A larger and deeper tube-well was sunk shortly afterwards, which yielded 2 cusecs, a volume of water astonishing at that time.

As regards the suitability of areas for sinking tube-wells, Leggett's opinion was as follows. "Desert lands remote from rivers and underground sources of supply, with rainfall less than 10 inches per annum, cannot be watered by tube-wells because insufficient water reaches the sub-soil by percolation from above. There is no continuous feed to the sub-soil and any water contained therein is soon exhausted. Our present knowledge of the laws governing the flow of underground water is imperfect, but it is safe to assume that where the rainfall is more than 20 inches a certain number

[1]Vohra, B. B. 'A Policy for Land and Water', *Sardar Patel Memorial Lectures*, 1980

of tube wells may be operated with success, provided they are not spaced so closely as to dry out the sub-soil. The monsoon rainfall over most of India exceeds 20 inches, and a store of water collects below ground during the wet season which may be drawn upon during the dry weather."

He concluded, "The great plains of India have been formed by sedimentary deposits of sand and clay in past ages, and the process still continues. No water can of course be drawn from a clay stratum, but the intervening sands are fully charged with water of incalculable amount. No authenticated case of exhaustion has yet been brought to notice."[2]

It has been observed in Punjab that in the majority of tube-wells, the yield begins to fall after some time. The reasons are partly mechanical and partly chemical. Sometimes the strainer is choked by small particles of soil or deflocculated clay. At other times choking is due to the chemical action of the salts in the subsoil water on the strainer.

The velocity of the pump should be kept at the lowest economic limit, for this is helpful in avoiding chemical choking. When the subsoil water contains calcium bicarbonate, with the reduction of pressure of such water, carbon dioxide is liberated and calcium carbonate is precipitated on the strainer. To avoid choking, the slot area should be as large as possible and the strainer should not be made up of such metals as mild steel, cast-iron, zinc, aluminium and copper which are liable to be attacked by the salts of sodium. Brass is not readily attacked by salts normally present in the soils, and cadmium is non-corrodible under ordinary conditions. If a strainer is sufficiently corroded, complete collapse of well will follow and the well will fail.

Choked strainers are cleaned by pumping air into them with compressors and by using acid for dissolving the salts.

Pumping of Water with an Oil-engine, 1914

The first report of pumping water for irrigation from wells by using oil-engines and centrifugal pumps is from the Bulandshahr District of Uttar Pradesh in 1914 by Dr A.E. Parr, Deputy Director of Agriculture. In this pioneering effort, he had the co-operation of Chaudhri Amar Singh, a progressive farmer of Pali.

"Our early experiments showed", states Parr, "that water can be raised much cheaper by an oil engine and centrifugal pump than by bullocks.

"Demonstrations were given and *zamindars* and cultivators soon began to realize the economic advantage of this class of installation and a big demand quickly arose. The experimental stage was only completed about a year ago and since then thirty-five sets have been dealt with. There appears to be no reason why during the next few years hundreds should not be put down. The plant consists of a 4½ or 7 B.H.P. oil engine and a

[2]Leggett, S. 'Tube-wells and Agriculture', *Agric. J. India*, Vol. 23, 1928

3″ or 4″ centrifugal pump. The engines are made by Turners, Ipswich, England, and are imported direct by us. The pumps are made by the Pulsometer Centrifugal Co., and by Tangyes and are bought through Burn & Co., and Jessops, respectively. The engine is put on the top of the well and the pump just above the water level in the well. The drive is either direct from engine to pump or through a piece of shafting. The engine also drives in some cases cotton gins, chaff cutters, etc., when it is not required to work the pump. The installations cost from Rs 1,400 to Rs 1,800 according to their size.

'One year's experience has shown the work to be a success and there now remains nothing but the rapid development of the organization for erecting and keeping the machinery in repair. The progress in the future should be rapid. During the first year we have trained a staff of supervising *mistries* and a large staff of drivers. A school for turning out drivers has now been organized. Ordinary village youths are taken, preferably sons or dependents of men who have put down, or propose to put down, oil engines, and two months training makes them into efficient drivers. Only one type of engine is being put down. This makes it easier to train the driver. The demand at present is greater than we can cope with efficiently and it has really got large enough to interest commercial firms."[3]

MANUFACTURE OF PUMPING SETS AND DIESEL ENGINES BY KIRLOSKARS OF PUNE

Kirloskars of Pune in Maharashtra have played a notable role in providing pumping-sets and oil engines to the farmers. The firm Kirloskar Brothers was started by L.K. Kirloskar and his brother R.K. Kirloskar in 1903, when they started manufacturing a chaff-cutter in a small workshop in Belgaum. As the chaff-cutter proved a success, they next introduced an iron plough for tilling heavy black cotton soil. When it also proved a success, Kirloskars manufactured thousands of such iron ploughs. Next they manufactured a sugarcane crusher run by two pairs of bullocks. During 1935-38, this cane-crusher was converted to run on power by an attachment driven by a 5-HP engine. After World War II, Kirloskars established a factory to provide 5-HP engines. When electricity became widely available in the rural areas, Kirloskars started manufacturing electric pumping-sets which became popular all over the country. Their factory now has a capacity to provide about 10,000 pumps a month.

FILTER POINTS

Filter points are normally sunk in sandy aquifers and are provided with strainers. River basins, with sandy formations and high water-table are

[3]Parr, A. E. 'Pumping installations in the western circle of the United Provinces', *Agric. J. India*, Vol. X, 1915

ideal for sinking filter points. Filter points have been successfully sunk in the Cauvery Delta in Tamil Nadu, and the deltas of the Krishna and the Godavari in Andhra Pradesh.

Floating Pumps

In recent years, a number of floating-pump schemes have been initiated in India. In Orissa, there are a number of barge-mounted, electrically operated pumps each with a discharge capacity of about 80 litres per second. An electric line running along the river bank provides power for the pumps (Fig. 68). The barges are moved up and down the stream to irrigate fields along the bank. In Maharashtra, co-operative lift-irrigation schemes are popular. Water is lifted from the rivers and streams with pumps operated by diesel-engines or electricity. In some schemes, the lift is as high as 55 metres. Large-scale river-pumping schemes have also been undertaken successfully in Uttar Pradesh, West Bengal, Assam and Tamil Nadu."[4]

Rural Electrification during the Five-Year Plans

Rural electrification in a planned manner started with the launching of the First Five-Year Plan in 1951. A special programme of power-expansion facilities to several growing towns and villages to relieve unemployment was taken up in 1953-54, with an outlay of 200 million rupees, out of which the expenditure incurred was 80 million only.

In the Second Five-Year Plan, a separate Head of Rural Electrification was created in the budget of the Ministry of Irrigation and Power, and the earmarked Central assistance was made available to the States for the approved rural electrification schemes. During the Second Five-Year Plan, an investment of Rs 750 million was made on the programme for electrifying 14,456 villages and energizing 143,000 pumping-sets.

The main thrust under the programme up to the end of March 1966 was for the electrification of villages, the energization of pumping-sets being only complementary to the programme. The investment during the Third Five-Year Plan under the programme was Rs 1,530 million, and 23,394 villages were electrified and 314,000 pumping-sets were energized. The cumulative progress up to the end of the Third Five-Year Plan is summarized in the table below.

	Investment during Plan (million rupees)	*Number of electrified villages*	*Number of pumpsets energized*
End of the First Plan	80.0	7,294	56,056
End of the Second Plan	750.0	21,750	198,904
End of the Third Plan	1530 0	45,144	512,756

Source: *Planning Commission*

[4]Dakshinamurti, C. *et al. Water Resources of India and their Utilization in Agriculture*, IARI, New Delhi (1973), p. 267

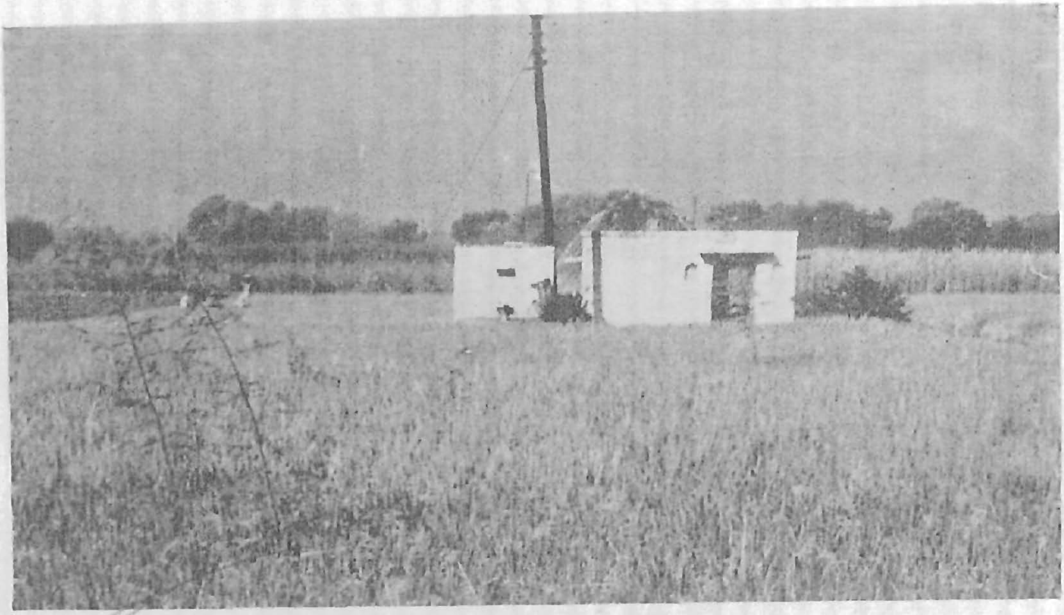


FIG. 65. *Above.* A private tube-well on a farm. A tube-well provides a source of irrigation at the command of the farmer. In canal-irrigated areas, too, tube-wells are necessary, as they lower the water-table and prevent water-logging. Though classified under the head 'minor irrigation' in the official jargon, tube-wells and pump-sets provide nearly half of the total irrigation in India in terms of area, and much more than half in terms of irrigation efficiency and productivity. There are over 7 million tube-wells (pump-sets) in India. *Below.* Tube-wells have also promoted personal hygiene. Their water is also used for washing clothes and for bathing.

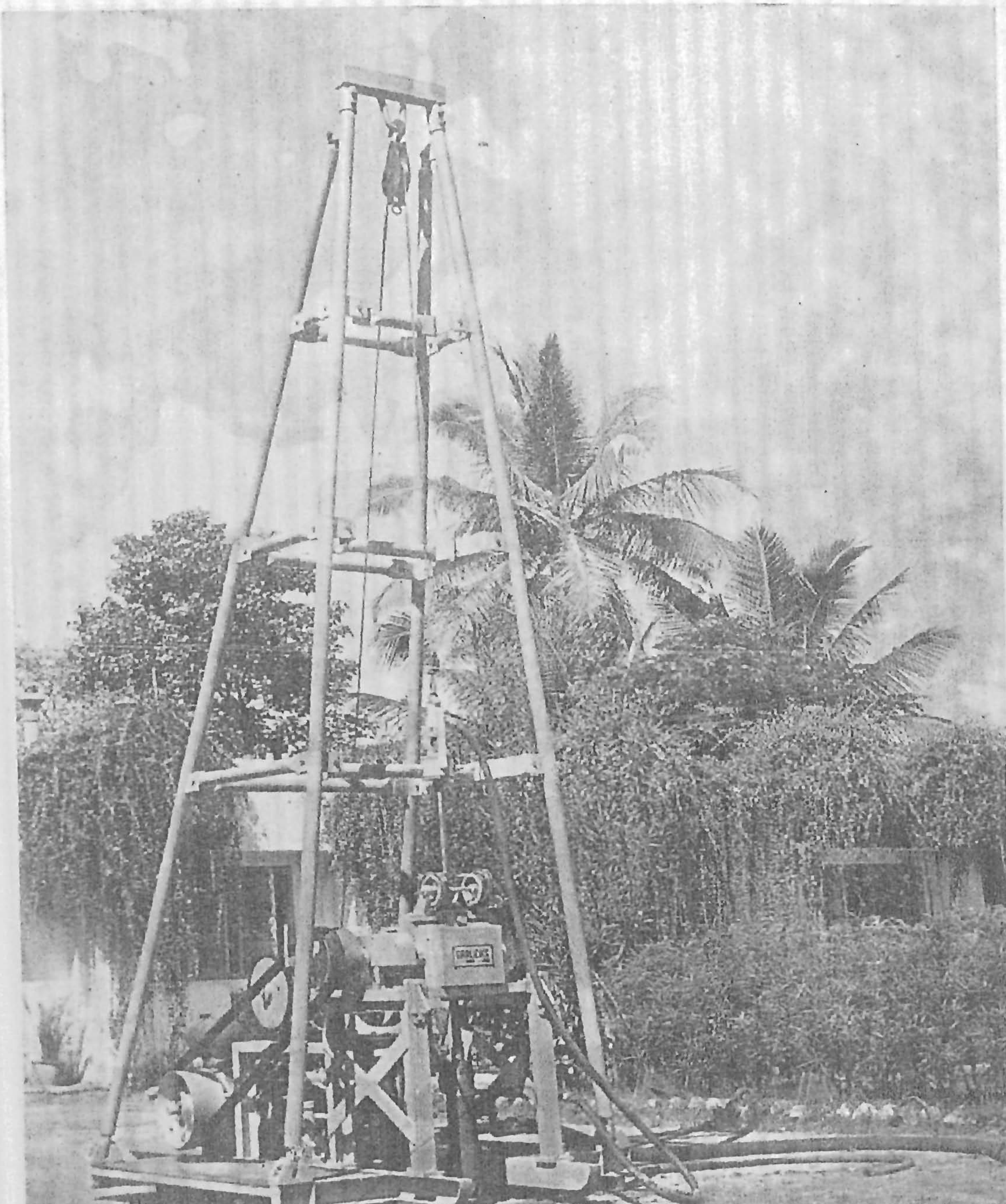


FIG. 66. A rotary rig for boring tube-wells. (IARI)

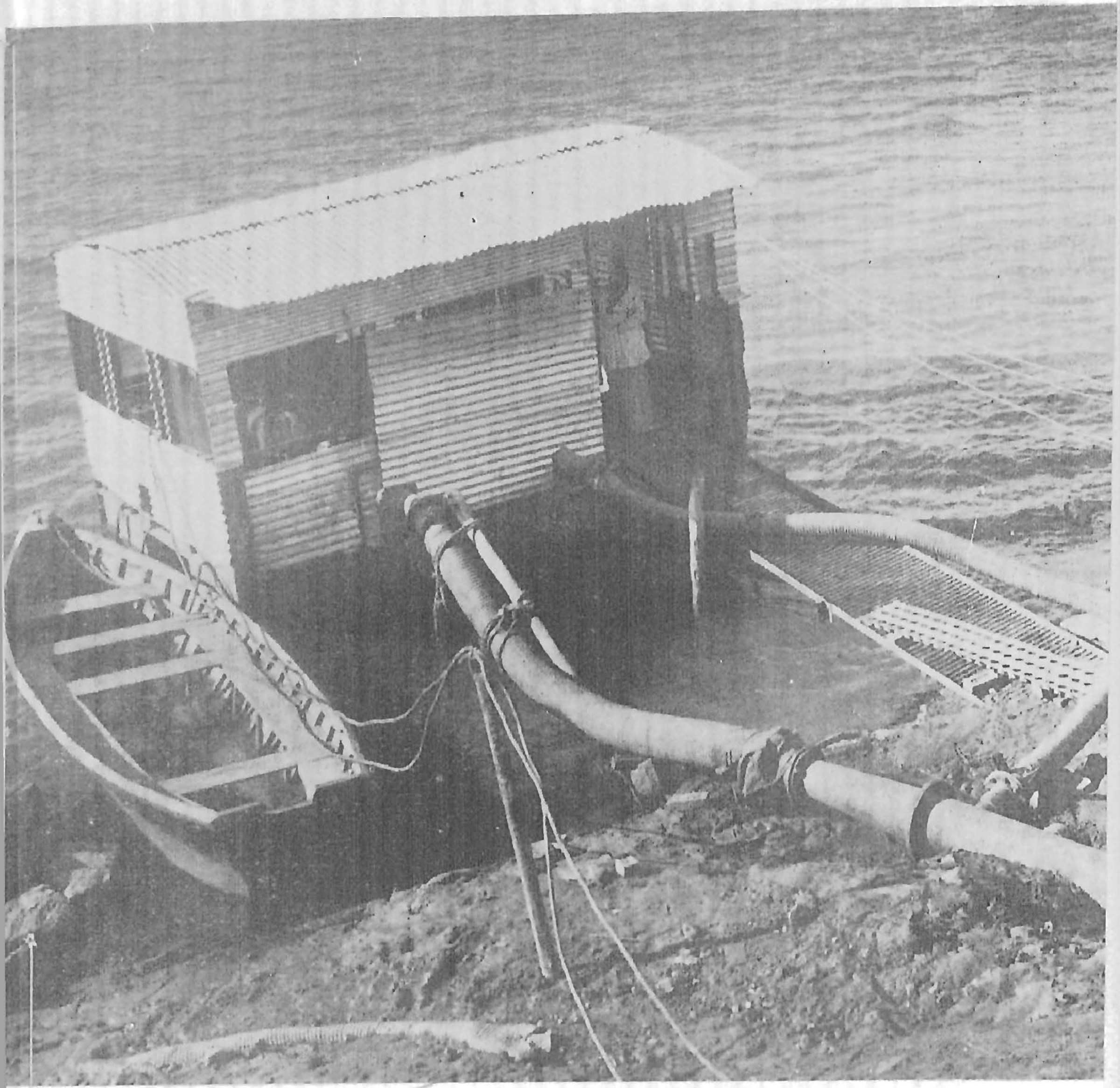


FIG. 67. A pumping-set mounted on a barge for pumping water from a river for irrigating fields in Orissa. (IARI)

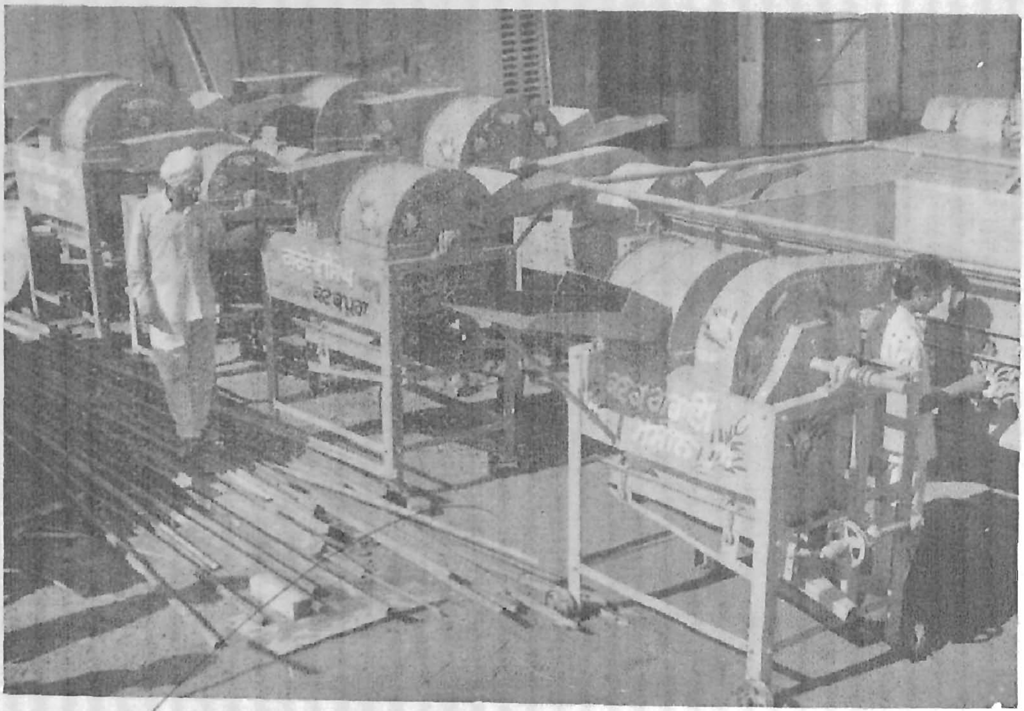


FIG. 68. *Above.* Electricity boards supply electricity to farmers in their fields for threshing wheat with threshers, worked with electric motors. *Below.* These threshers, called drummies, are manufactured by the artisans in the towns of Punjab. They are worked with electric motors of the farmers' tube-wells. With the mounting oil crisis, there would be a greater reliance on electricity for threshing wheat.

EXPLORATORY TUBE-WELL ORGANIZATION (1954), AND CENTRAL GROUND-WATER BOARD (1970)

The Government of India set up the Exploratory Tube-well Organization (ETO) in 1954 to intensify efforts at deep-strata exploration. A substantial part of the Central assistance to States was allocated to tube-wells. In the Second Plan, allocations for such schemes were made under the Community Development Programme, with a view to mobilizing public co-operation and involving the community development organization. With increased emphasis on groundwater development, the activities of the Exploratory Tube-well Organization were greatly intensified. Besides, the Department of Agriculture initiated in 1966-67 a Ground Water Survey and Investigation Programme, to provide assistance to the States in this field. In 1970, the Government of India took measures to streamline the administrative set-up for groundwater development by re-organizing the Exploratory Tube-well Organization into the Central Ground Water Board. From 1 August 1972, the Ground Water Wing of the Geological Survey was also integrated with the Board. The Board thus emerged as the single unified organization at the national level, dealing with all aspects of groundwater exploration, assessment, development and management.

RURAL ELECTRIFICATION, REORIENTATION IN FAVOUR OF TUBE-WELLS

The serious drought in the country in the mid-sixties pointed to the necessity of exploitation of groundwater resources for food production and it led to a shift in the concept of the programme for village electrification to the energization of pumping-sets and shallow tube-wells for irrigation. From 1966 to 1969, more than 500,000 additional pumping-sets were energized and this number exceeded the total number of those energized up to the end of the Third Five-Year Plan. The investment made on the programme during the three years was Rs 2,370 million. The consumption of electricity in the agricultural sector also showed a sharp increase from 4.1 per cent in 1951 to 9.3 per cent by the end of March 1969.

The following promotional measures were also simultaneously recommended to accelerate the programme of energizing pumping-sets: (i) a time limit was set by the State electricity boards to give connections to the farmers; (ii) during the period when the wells were dry or during the rainy season, when there was no demand for irrigation, the guarantee for the minimum consumption may not be insisted upon; (iii) ways and means should be devised for cutting short the delays in obtaining no-objection certificate; (iv) the electricity duty on power consumption for agricultural purposes was abolished; and (v) subsidy was given by the State Government for rates above 12 paise per kWh for agricultural loads.

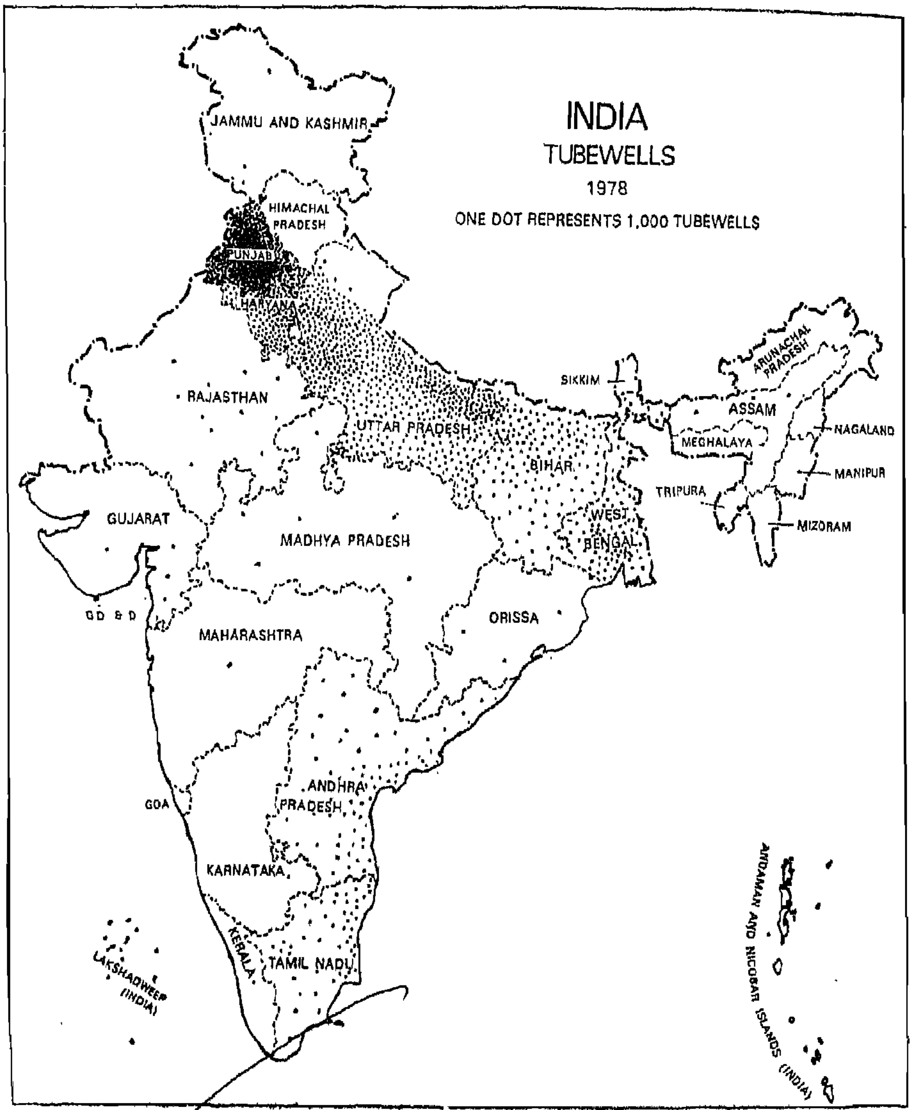


FIG. 69. A map of India, showing the distribution of shallow tube-wells (pump-sets). The largest concentration of tube-wells is in Punjab, Haryana and western Uttar Pradesh, the Green Revolution areas of northern India

Some New Developments after 1969

Notwithstanding the accelerated growth witnessed in the programme during 1966-69, certain aberrations in the implementation of the programme came to notice, namely: (i) State-wise imbalances in the progress of energization of pumping-sets, shallow tube-wells and the electrification of villages; (ii) lack of suitable transmission and rural-distribution system to cope with the growth of rural loads; (iii) lack of co-ordination between the availability of groundwater and the programme of energizing the pumping-sets; (iv) unremunerative nature of the programme of rural electrification; and (v) inadequate Plan finances and the reluctance of some State electricity boards to take up the programme energetically.

Committee of Members of Parliament on Rural Electrification

At an informal meeting of the Consultative Committee of the Members of Parliament of the Ministry of Irrigation and Power in 1968, a Committee on Rural Electrification, with the Union Deputy Minister as Chairman and Convenor, and one M.P. from each State, where the rural electrification progress had been below the all-India level, was constituted to go into the above aspects and suggest measures. This Committee gave its report in 1972. It helped to promote rural electrification.

FUNDS FOR RURAL ELECTRIFICATION

All-India Rural Credit Review Committee, 1968, and Rural Electrification Corporation, 1969

In 1968, the All-India Rural Credit Review Committee was constituted by the Reserve Bank of India to examine in detail the question of accelerating rural electrification in the country in the overall context of the Plan programme for increased agricultural production. This Committee was of the view that rural electrification was necessary adjunct to planned irrigation and should be viewed as complementary to the scheme of constructing wells, and installing pumping-sets, financed by the ARDC. The Committee was of the view that whereas larger resources should be made available to the State electricity boards as long-term loans, the projects financed by the boards should be such as not to weaken the financial position of the electricity boards. The Committee suggested the constitution of a special fund for financing rural electrification with the help of grants from the US-use funds and matching contributions from the Central Government. In pursuance of these recommendations, the Government of India set up the Rural Electrification Corporation in July 1969. It received a grant of Rs 1,050 million from the US-use fund up to the end of 1973-74. Since then, the rural electrification programme is funded through the budgetary support of the Central Government, market borrowings, and internal resources.

FOURTH FIVE-YEAR PLAN, 1969-74

From 1969-74, Rs 66,170 million was invested in rural electrification. As many as 82, 997 villages were electrified and 134,000 pumping-sets (tube-wells) were energized, bringing the cumulative total by the end of the Fourth Plan to 242,600. The consumption of electricity in agricultural operation rose from 9.3 per cent in 1968-69 to 12.6 per cent in 1973-74. The institution of the Rural Electrification Corporation as a financing organization resulted in the extension of the programme in a more organized manner. The production-oriented activities, such as tube-well irrigation and the rural industries, received greater support.

FIFTH PLAN, 1974-78

A target of energizing an additional 150,000 pumping-sets (tube-wells) and the electrification of 110,000 villages during the Plan was envisaged, involving an outlay of Rs 1,980 million. These targets were revised in 1976. The revised targets and achievements during the four years of the Plan, (1974-78), are as follows:

	Outlay (million rupees)	*Number of additional villages*	*Number of additional pumping-sets*
1974-78 (achievement)	7,430	60,169	880,000

ROLE OF INSTITUTIONS OTHER THAN RURAL ELECTRIFICATION CORPORATION

From the Fourth Plan onwards rural electrification schemes attracted more loans from the Agricultural Refinance and Development Corporation, the AFC, commercial banks and the State land-development banks.

COMMERCIAL BANKS AS ON 31 MARCH 1977

State	*Number of Pumping-sets*	*Loan sanctioned (million rupees)*
Maharashtra	160,834	696.475
Uttar Pradesh	310,045	325.553
Gujarat	61,348	172.150
Madhya Pradesh	12,046	74.956
West Bengal	11,257	42.240
Bihar	4,381	16.000
Rajasthan	2,514	12.676
Orissa	1,844	11.550
Karnataka	N.A.	0.992
Punjab	174	0.741
Andhra Pradesh	N.A.	0.182
Haryana	500	2.000
Total:	564,943	1,355.515

SOURCE: *Planning Commission*

STATE LAND DEVELOPMENT BANKS AS ON 30 JUNE 1977

State	*Disbursement*		
	1975-76	1976-77 (*million rupees*)	*As on June* 1977
Haryana	102	47	1.49
Rajasthan	—	0.8	0.8
Orissa	—	1.1	1.1
Madhya Pradesh	—	45.7	45.7
Uttar Pradesh	—	—	—
Gujarat	—	—	—
Maharashtra	—	14.0	14.0
Karnataka	340	9.6	43.6
Tamil Nadu	—	13.0	13.0
Total:	44.2	88.9	133.1

SOURCE: *Planning Commission*

AGRICULTURAL REFINANCE AND DEVELOPMENT CORPORATION (ARDC)

The refinance from the ARDC is available up to 90 per cent of the loans issued by commercial banks to the SEFs, whereas in the case of the State land-development banks the ARDC's contribution to special debentures is up to 90 per cent of each debenture floated. The remaining 10 per cent was contributed by the State government.

The ARDC's refinance assistance for the energization of pumping-sets (tube-wells) was earlier available only when the wells or the pumps or both were covered under the ARDC credit. It now includes the energization of all pumping-sets (tube-wells,) even if installed with a farmer's own or other resources. The scope of refinance was extended to cover the energization of the pumping-sets (tube-wells)under the jurisdiction of the Rural Electrification Corporation. The loanees of the financing institutions for the energization of pumping-sets (tube-wells) installed on lift-irrigation units were also made eligible for refinance assistance from the ARDC. As on 30 June 1977, the ARDC had sanctioned 38 schemes for energizing the pumping-sets (tube-wells) in nine States, with a total commitment of Rs 252.6 million.

AGRICULTURAL FINANCE CORPORATION (AFC)

The Agricultural Finance Corporation has the experience of arranging finance for energizing the pumping-sets (tube-wells) on a consortium basis. As on September 1977, it had arranged for a total consortium finance to the extent of over Rs 800 million to energize 267,000 pumping-sets (tube-wells) in seven States.

JOINT PARTICIPATION PROGRAMME

The pattern of loans from commercial banks, the State land-

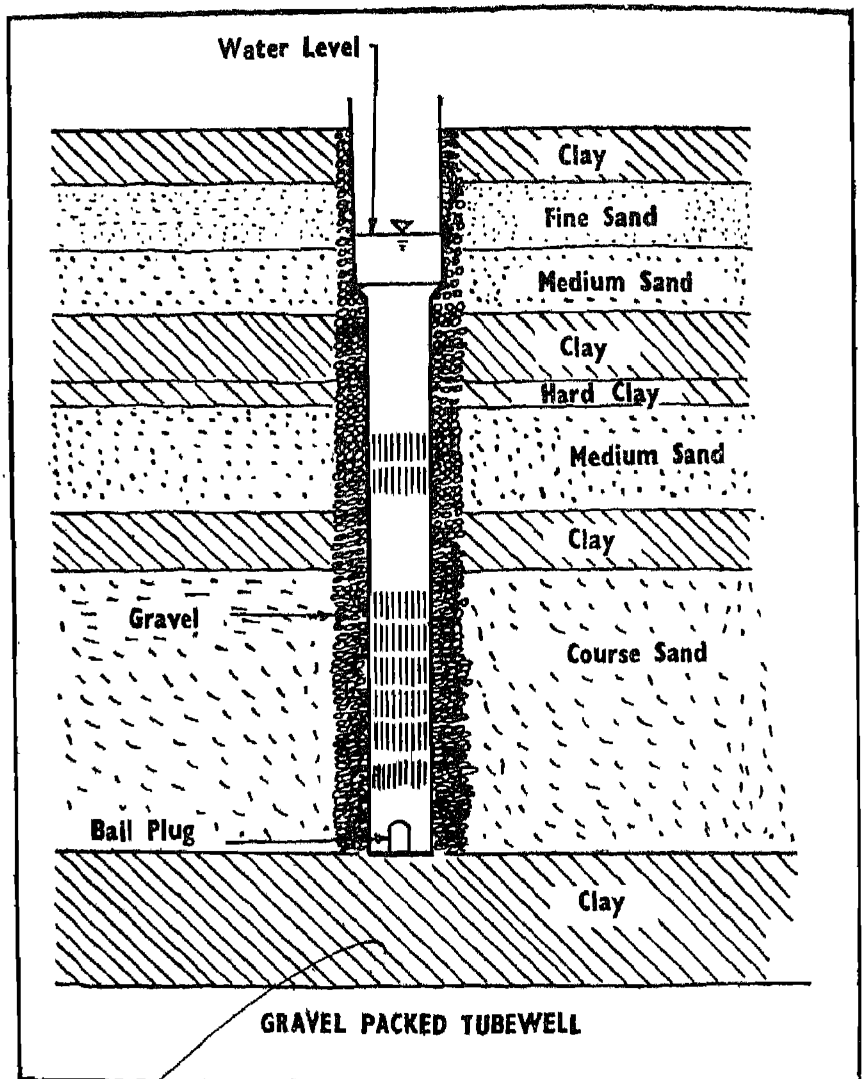


FIG. 70 The cross-section of a gravel-packed tube-well. Blind pipes are loated at the non-water-bearing strata and perforated pipes are placed against the aquifer. (PAU)

development banks and the ARDC/AFC showed that the availability of bank finances had been highly heterogeneous, being skewed in favour of advanced States, such as Maharashtra, Gujarat and Haryana. There had been several deficiencies in the utilization of such institutional finances also. The backward States, despite their urgent need for the electrification of the

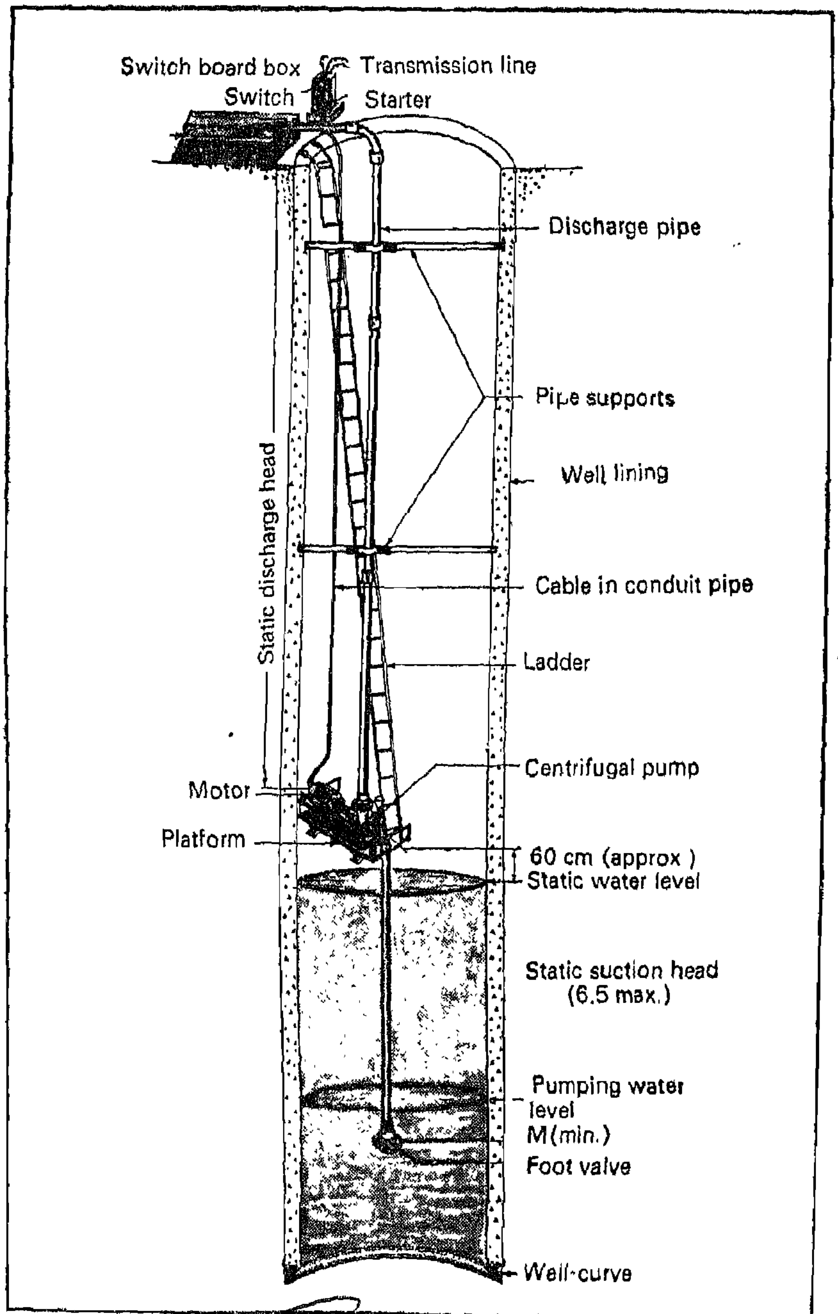


FIG. 71. A schematic sketch, illustrating the details of the installation of a motor-driven centrifugal pump in a deep open well. (IARI)

pumping-sets (tube-wells), had not benefited from them. Thus there had been a less than optimal use of the non-Plan resources and also a possible aggravation of regional imbalances. Also the lending terms and conditions for such finances often had been different for different agencies and also generally not beneficial to the electricity boards for reasons of viability in view of low agricultural tariffs. These issues were gone into by a working group set up by the Reserve Bank of India, and the group submitted its report in June 1978. It recommended the joint participation of financing organizations, e.g. the REC/ARDC/commercial banks, the contribution from the REC, the AFC and the ARDC being 1/3 each. The scheme of joint participation was approved by the Planning Commission and introduced during 1978-79, with a provision of Rs 100 million under the REC, with a matching provision of Rs 200 million from the ARDC and commercial banks. The Annual Plan 1979-80 envisaged an outlay of Rs 250 million for this programme under the REC, with a matching contribution of Rs 500 million from the ARDC and the AFC. Operationally, the thrust of the joint participation schemes would be in Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal, Orissa and Assam, which have vast quantities of untapped groundwater.

World Bank Aid

India has been a major beneficiary of the economic aid extended by the World Bank. A feature of the World Bank assistance was that a substantial part of loans extended through its affiliate, the International Development Association (IDA), was on soft terms and for a long term. Rural electrification was a programme which received such support.[5]

Progress in Rural Electrification by 31 March 1980

By the end of 31 March 1980, 249,810 villages had been electrified out of a total of 575,936. Thus 43.4 per cent of the villages had been electrified and about 64 per cent of the rural people had been provided with electricity. The number of pumping-sets (tube-wells) energized in the country was 3.97 million. The State-wise details are given below.

Of the 22 States in the country, Punjab, Haryana and Kerala, achieved 100 per cent electrification of their village by the end of 31 March 1980, along with the Union territories of Chandigarh, Delhi and Pondicherry. Tamil Nadu was close to achieving this target. Andhra Pradesh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Karnataka and Maharashtra were past the halfway mark. The progress in Bihar, Madhya Pradesh, Orissa, Sikkim, Rajasthan, Uttar Pradesh, West Bengal, Manipur, Meghalaya, Nagaland, Tripura and in the Union territories of Arunachal Pradesh,

[5] *Report of the National Commission on Agriculture* (1976), Part I, p. 193

and Mizoram and Andaman and Nicobar Islands ranges from 9 per cent to 34 per cent. The percentage of electrification is another index of progress in agriculture. It is the states with hundred per cent rural electrification that are most advanced in agriculture.

The rural electrification programme of India particularly in relation to energization of farmers' tube-wells is an impressive achievement. Any person who travels by night in Punjab and Haryana sees the countryside lit up by lakhs of electric bulbs on the tube-wells. Irrigation by tube-wells is an important input, which has made Green Revolution a reality in Punjab, Haryana and western Uttar Pradesh.

CHAPTER 25

CHEMICAL FERTILIZERS-I

EARLY VENTURES AND FACTORY AT SINDRI
F. W. PARKER'S ROLE IN PROMOTING FERTILIZERS
FERTILIZER ASSOCIATION OF INDIA
FERTILIZER CORPORATION OF INDIA
TALCHER, RAMGUNDAM, ROURKELA, NANGAL AND NEYVELI FERTILIZER PLANTS

CHEMICAL fertilizers play a crucial role in agricultural production. The stage of agricultural development of a country is often judged by the amount of chemical fertilizers used per hectare. In India's Green Revolution, chemical fertilizers played a key role. How this happened is told in this chapter.

Discussing the possibility of import and the use of chemical fertilizers in India, Voelcker observed in 1897, "...imported manures, in which an account of English agriculture would fill a most important place, may, so far as India is concerned, be very summarily dismissed. If natural manures such as bones are not yet likely to be used, still less so are artificial manures. Not only have no sources of the raw material been discovered which would pay for working, but the acid (sulphuric acid, or oil of vitriol) required for their manufacture, costs, at present, far too much. Over and above would be the cost of carriage both of raw and manufactured material. Once again, the real difficulty comes in; who is to pay for these? Only crops giving a high return could possibly meet the outlay, and, owing to lowness of prices for produce, the tendency among planters towards economy in artificial manures has of late been marked. The day is still distant, I believe, when artificial manures can be profitably used in India. Some great change, either in the cost of manufacture or in the condition of the agricultural classes, must take place first. A leading firm of chemical manure manufactures told me, before I went out to India, the result of their efforts at introducing artificial manures into Russia and the East. The only manure which they succeeded in getting into use in Russia was the cheapest mineral superphosphate, and then only in the enlightened Baltic Provinces, where the farmers were for the most part Germans.'[1]

In the early stage, chemical fertilizers were used in southern India for commercial crops, such as tea, coffee and sugarcane. The pioneer manufacturers were Parry & Co., Madras, the Mysore Chemical and Fertilizers, and the FACT in Kerala.

[1]Voelcker, J.A. *Report on the Improvement of Indian Agriculture*, p.117

THE E.I.D. PARRY (INDIA) LTD; SUPERPHOSPHATE FACTORY AT RANIPET, MADRAS, 1906

Thomas Parry, who arrived in India in 1788 to seek his fortune, was granted a licence to trade within limits as a free merchant by the East India company, which held the monopoly of trade between India and the United Kingdom. So began Parry & Co., which remained a private partnership until 1928, when it was converted into a private limited company.

The E.I.D. Parry Group are pioneers in the fertilizer field, having established a bone-meal factory at Ranipet in the early twentieth century. They were the first in India to start a superphosphate factory in 1906 at Ranipet, where preparation of various standard fertilizer mixtures, insecticides and fungicides was subsequently undertaken.

MYSORE CHEMICALS AND FERTILIZERS LTD, BELAGOLA, 1941

The production of nitrogenous fertilizers, based on synthetic ammonia, was first taken up in 1941 by the Mysore Chemicals and Fertilizers Ltd, at Belagola, near Mysore. Hydrogen was produced by the electrolysis of water, and nitrogen was isolated from air to produce ammonia.

FERTILIZERS AND CHEMICALS TRAVANCORE LIMITED, UDYOGAMANDAL, KERALA, 1947

The Fertilizers and Chemicals Travancore Limited (FACT) was conceived at a time of great food shortage in the former State of Travancore. Sir C.P. Ramaswamy Aiyer, the Dewan of Travancore, had the vision to recognize that only chemical fertilizers could solve the food problem of the State. The large-scale production of nitrogenous fertilizers started in 1947 when the FACT at Udyogamandal near Cochin set up a plant, using wood as a raw material for the production of ammonia. Ammonia was fixed with gypsum and sulphuric acid to form ammonium sulphate.

CENTRAL FERTILIZER POOL, 1944

The 'Pool' was established by the Government of India in1944 as an official agency "....to ensure the equitable distribution of the available quantities of fertilizers at fair prices to all provinces of the country."

These purposes necessarily implied the 'pooling' of all products of domestic manufacture—at that time single superphosphate, ammonium sulphate and ammonium phosphate—along with the materials imported by the Government. Primary importance was attached to the distribution aspect of fertilizer marketing.

BENGAL FAMINE OF 1943 AND THE FERTILIZER FACTORY AT SINDRI (BIHAR), 1951

Owing to the occupation of Burma by the Japanese in April 1942, the imports of rice from Burma were cut off. The Provincial Government of Bengal adopted the so-called 'Denial Policy', under which they seized the boats of villagers as well as the local stocks of grain, lest they should fall into the hands of the Japanese invaders. Boats were the chief means of transport in East Bengal. Out of a total of 66,563, as many as 46,146 were acquired by the military.[2] In October 1942, a disastrous cyclone and torrential rain, followed by tidal waves, destroyed paddy crop over 3,200 square miles (8,288 km^2) in Midnapur and 24-Parganas. The Provincial Government failed to cope with the situation. The grain-traders were greedy and callous, and made a profit of 1,500 million rupees during the famine. Deaths from famine and diseases totalled 1.5 million.

In 1945, the Government of India decided to act upon the recommendations of the Foodgrains Policy Committee (1943) and the Bengal Famine Enquiry Commission (1945) and set up a factory at Sindri in Bihar for manufacturing 355,000 tonnes of ammonium sulphate per annum. This project was taken up in 1947 and production commenced in 1951. At the dawn of Independence, the fertilizer industry in India was in its infancy and the consumption of fertilizers in Indian agriculture amounted to 35,000 tonnes of N, 4,400 tonnes of P_2P_5 and 1,800 tonnes of K_2O.

Dr Frank W. Parker's Role in Promoting Fertilizer Use, 1953-1959

The drought years of 1950 and 1951 worsened the food situation in India. In 1951, India imported about 3,400,000 tonnes of foodgrains from the USA under a special wheat loan. India's proposals for technical and economic assistance included fertilizer projects and services of an eminent fertilizer expert. Dr F.W. Parker, a fertilizer expert, accompanied by a small group of US technicians, arrived in India in December 1952 to establish the US Technical Mission and to develop the Indo-American Programme.

In the entire history of international co-operation since Independence, no foreign expert has served India with such dedication and sincerity as Frank W. Parker. Parker was born on 23 October 1897 at Hamilton, Illinois, USA. He received his B.S. degree with the "Highest Distinction" from Auburn University in 1918. He obtained his Ph.D. in Soil Science from the University of Wisconsin in 1921. He began his professional career in 1922 as Soil Scientist at the Alabama Agricultural Experiment Station of Auburn University, where he continued till 1928. He served as a Senior Soil and Fertilizer Specialist with the Dupont Co. from 1929 to 1942. During those 13 years, he obtained an all-round experience with research chemists, engineers, the fertilizer industry and agricultural research organizations. From 1942 to 1952, he was in charge of Soil, Fertilizer and Water-Management Research of the US Department of Agriculture, with the

[2] *The Bengal Famine Enquiry Commission Report* (1945), p. 26

FIG. 72. Dr Frank W. Parker, a great friend of India, who had a key role in pyomoting the use of chemical fertilizers in India. (Portrait by G.S. Bansal, Hall of Fame, M.S.R. Library, Punjab Agricultural University, Ludhiana)

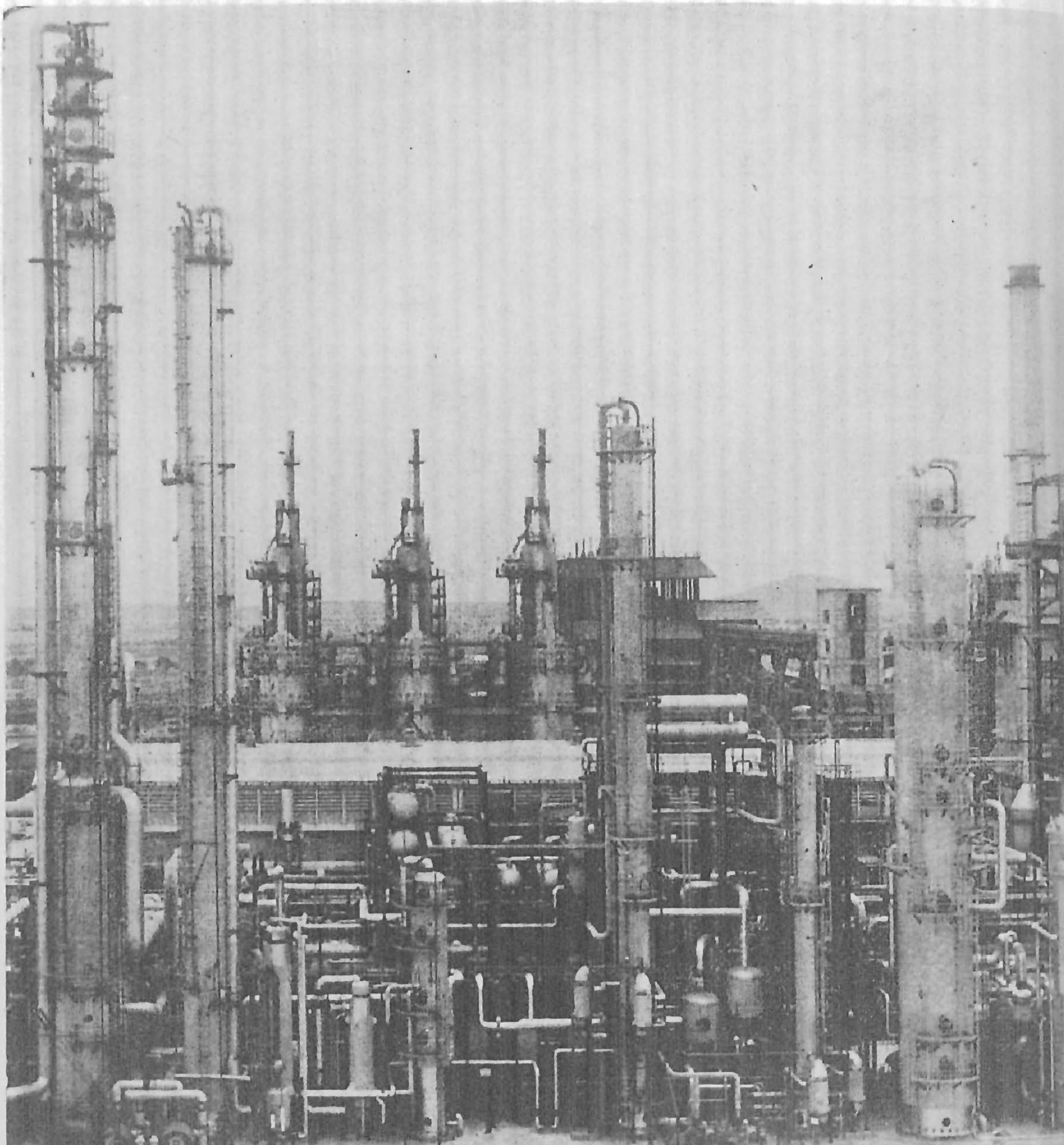


FIG. 73. The Ramgundam fertilizer plant. In the foreground is the ammonia plant rectisol, and in the background is the coal-gasification section. (Fertilizer Association of India).

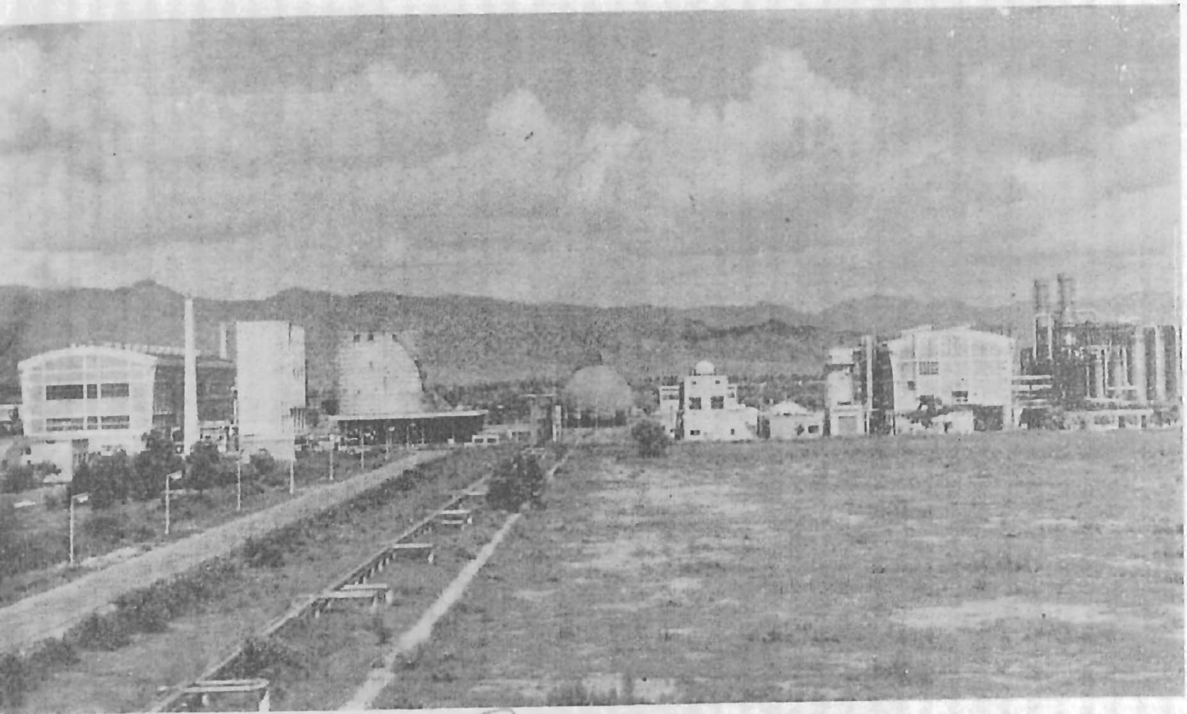
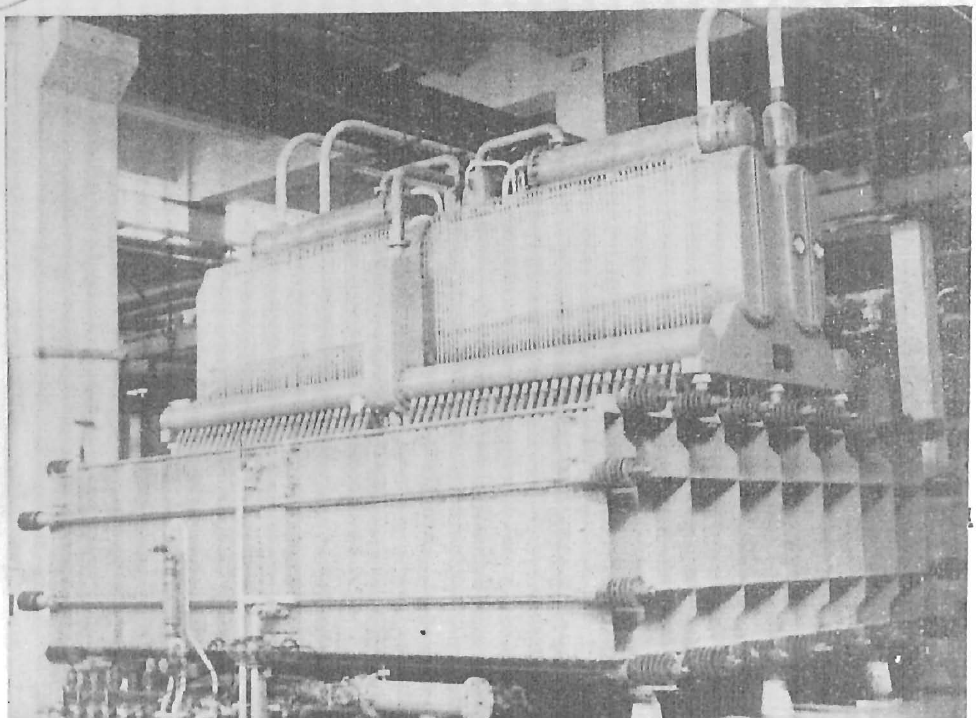


FIG. 74. A general view of the calcium ammonium nitrate plants of the Nangal Fertilizer Factory (*Above*). An inside view of the electrolysis plant (*Below*).



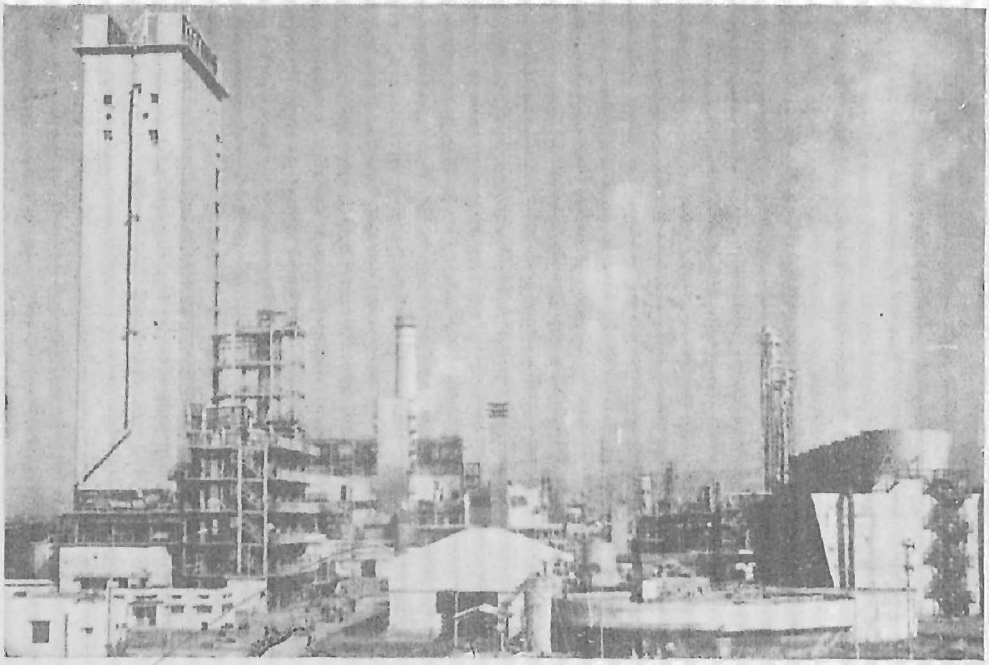


FIG. 75. (*Above*) A general view of the Nangal Fertilizer Factory. The urea plant is to the left. (*Below*) Horton sphere, in which ammonia is stored in the Nangal Fertilizer Factory.

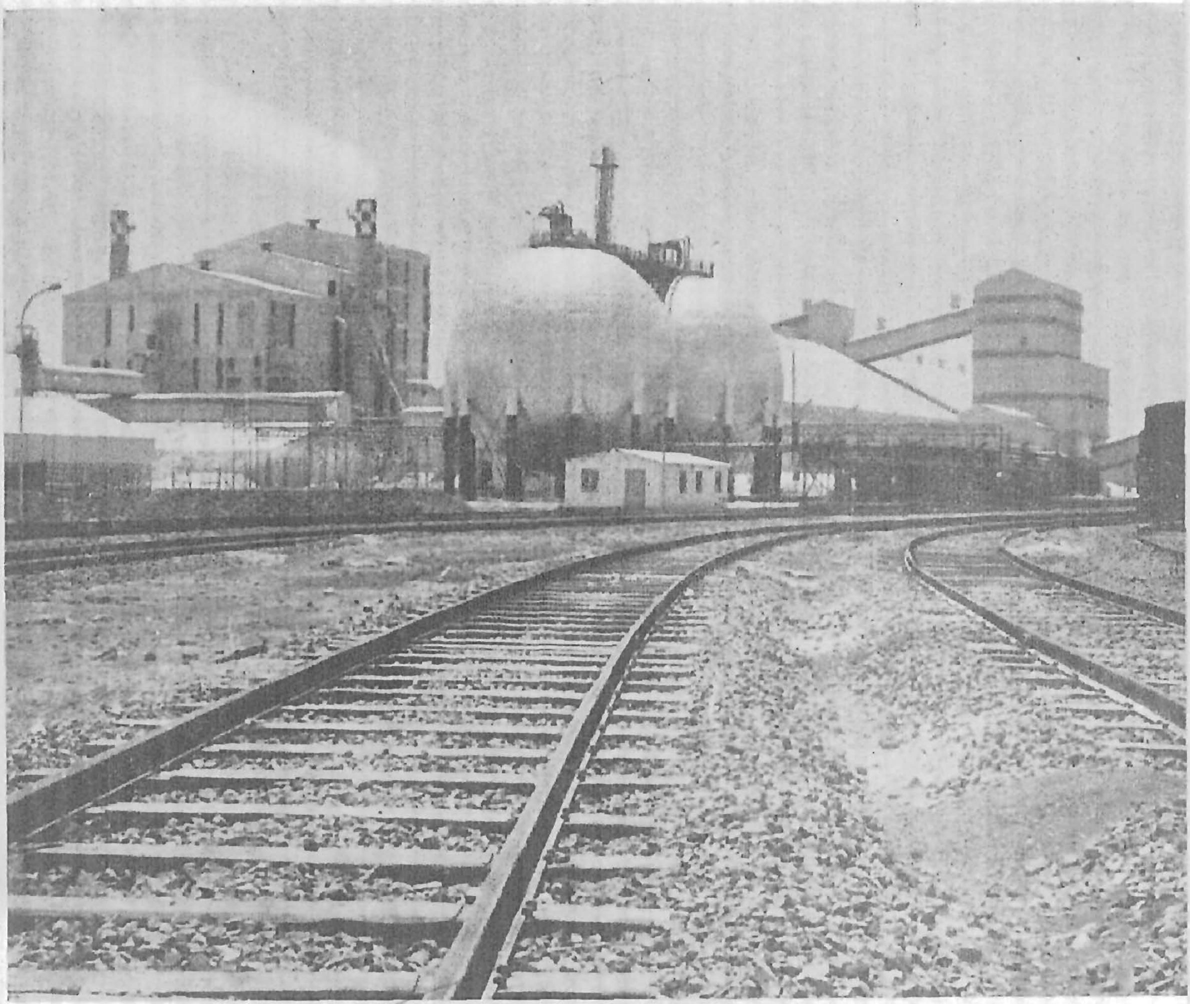


FIG. 76. The Kandla NPK plant of the IFFCO. The engineering expertise for this plant came from Indian sources. (FAI)

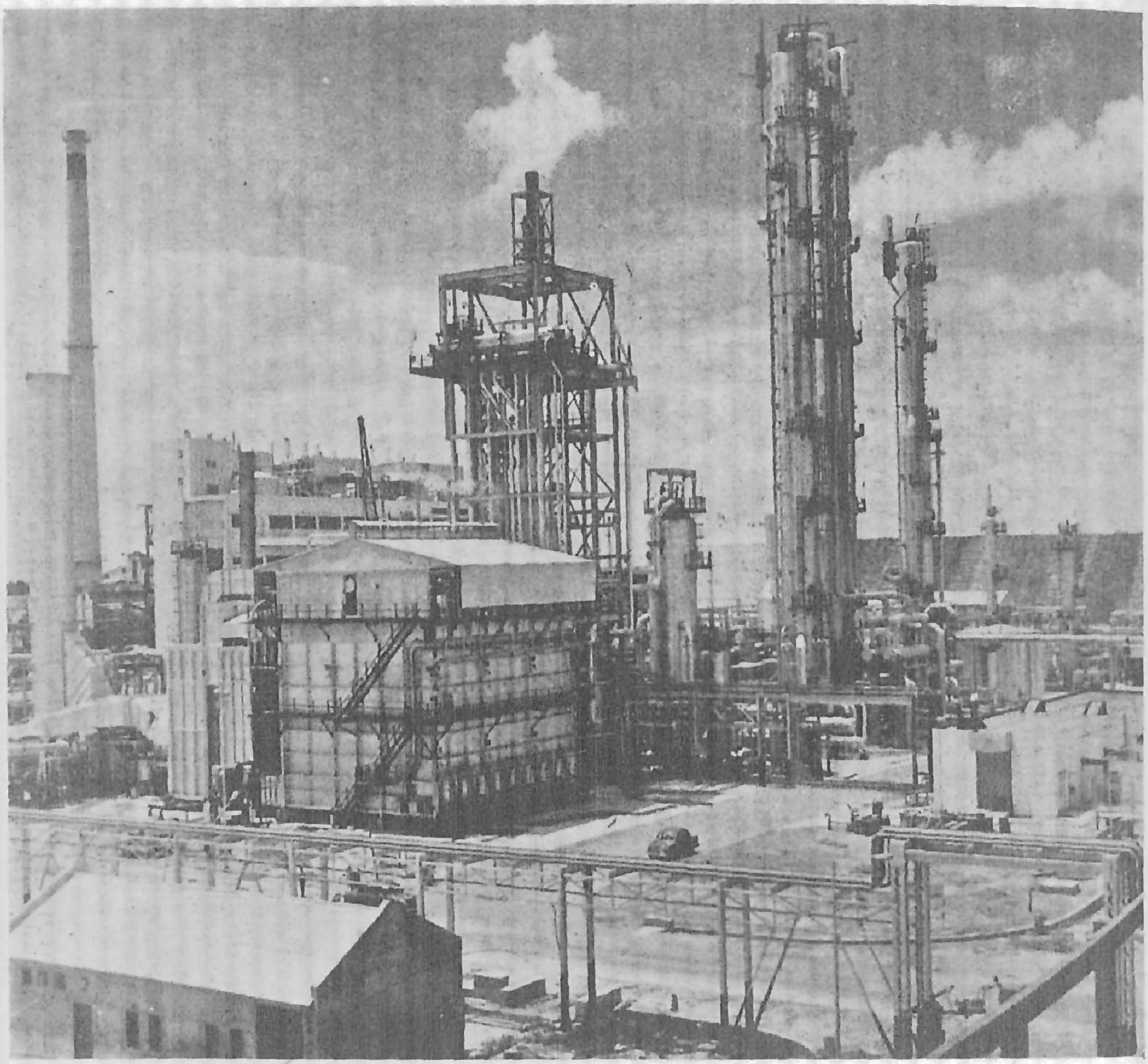


FIG. 77. The naphtha-based ammonia, the urea complex of the fertilizer plant of the IFFCO at Phulpore, Uttar Pradesh. The indigenous engineering and supply contents in this plant are high. (FAI)

headquarters at Beltsville, Maryland. In that capacity, he did an excellent job of co-ordinating research project in the field of specialization conducted by the USDA, State universities and other research organizations.

Parker remained in India as Agricultural Adviser to the Ministry of Food and Agriculture till 1959. This was a period when India was facing great food shortage. At that time (1953), fertilizers were practically unknown to the farmers in northern India. Parker played a key role in advising the government of India to develop a sound policy of agricultural development by emphasizing the importance of chemical fertilizers in agricultural production.

Technical Assistance Programme in Fertilizer Use

The agricultural technical assistance programme initiated in 1951 and further developed by the Government of India and the TCM during the next few years included a wide range of activities. Those concerned with increased and more efficient use of fertilizers had four major objectives: to conduct extensive fertilizer experiments throughout India to obtain data on the response of crops to chemical fertilizers under various conditions; to develop soil-testing methods, laboratories, and services that would help the farmers and the extension workers to decide what fertilizers should be used for best returns; to introduce and test new fertilizers that might be economical to use in India for agricultural production; and to encourage the organization of a fertilizer trade association committed to the service of the public, the Government of India and the fertilizer industry.

Fertilizer Field Experiments

Field experiments on fertilizers started and rapidly extended all over India under the TCM Scheme. They were an extension of the fertilizer trials on the cultivators' fields conducted in Bihar and under the ICAR-Stewart Scheme. Although the treatments were not replicated in place, the data could be analysed statistically by treating each site as a replication of a larger experiment. In addition, the Indian Agricultural Research Institute initiated complex agronomic and fertilizer experiments under carefully controlled conditions at ten locations. In these experiments, the rates of fertilizer and their interaction with crop varieties and irrigation practices were studied.

Field Demonstrations

The world's largest fertilizer demonstration programme was conducted during 1954-1956 in India. There were about 200,000 three-plot demonstrations each year. Yields were taken on many of them and the results from 50,000 demonstrations were summarized and published district-wise, State-wise, soil-wise and year-wise. The data generally confirmed the findings of the controlled fertilizer experiments. The chief result of these demonstrations was to make the cultivators fertilizer-conscious and to create a demand for fertilizers. The initial three-year fertilizer demonstration programme terminated in 1957. It was followed by a comprehensive three-year programme financed by the Government of India.

Soil-Testing Laboratories

India had no soil-testing facilities before the TCM programme. Therefore it was necessary to develop methods and procedures suitable for Indian soils and conditions, laboratories and supporting services.

In 1954-55, twenty soil-testing laboratories were established with assistance from the TCM with respect to equipment and library facilities. The TCM also made available the services of two specialists, one on laboratory methods and the other on field services. Most of the laboratories were located at agricultural colleges. There was a substantial demand for soil-testing services right from the start. The Fertilizer Association of India (FAI) now lists 245 soil-testing laboratories. Some of the agricultural universities operate 10 to 15 laboratories. The laboratories not only process soil samples sent by the farmers and extension workers, but also collect samples and prepare the nutrient-status maps of villages.

New Fertilizers

The third objective, the introduction of new fertilizer materials, involved the introduction of urea, ammonium phosphate, and high-analysis NPK fertilizers. They were imported, stored experimentally at various sites under varied conditions, and tested in agronomic trials. Today, all of these materials are produced in India and urea accounts for more than 75 per cent of nitrogen production in India.

Organic Manures versus Chemical Fertilizers

In the Second Plan period (1956-1960), controversy raged in the Government circles that organic manures alone should be promoted, as chemical fertilizers were harmful to the soil in the long run and were also costly. The most ardent advocate of organic manures was M. S. Sivaraman (b. 1907), Adviser to the Planning Commission, to whom the very mention of chemical fertilizers was like a red rag to a bull. I remember to have attended a meeting presided by Shri V. T. Krishnamachari, Vice-Chairman of the Planning Commission, at which P. N. Thapar as the Secretary, Ministry of Agriculture, I as the Vice-President of the ICAR, Dr Badri Nath Uppal, as the Agriculture Commissioner, and M. S. Sivaraman were present. Sivaraman said that the packets of the seeds of *Sesbania aculeata (dhaincha)* should be distributed among paddy-growers for green-manuring and money should not be wasted on importing and manufacturing chemical fertilizers. Uppal cogently argued the case for chemical fertilizers. He argued that all the rural and urban compost and green manure that the country could produce was hardly sufficient for even a fraction of the total cropped area of the country, viz. 172,306,000 hectares. Thus even for fertilizing the irrigated area of the country and areas with assured rainfall, the use of chemical fertilizers was necessary. Moreover, experiments had shown that a long-term use of chemical fertilizers was not harmful to the soil.

The breakthrough in the use of chemical fertilizers, however, came with the arrival of high-yielding varieties of wheat and rice. Had the reliance been only on organic manures, there would have been no Green Revolution in India. The farmers in Punjab and Haryana use chemical fertilizers for raising the wheat crop in winter; for the monsoon crop they use farmyard manure and green manure. The rationale of this practice lies in the fact that farmyard manure contains a lot of seeds of weeds.

Very sensibly, the Government of India adopted the practical policy of encouraging the use of both chemical fertilizers and organic manures. Sewage water and sludge were extensively used in the suburban villages and the production of rural compost was promoted. Thus in 1979-80, the production of urban compost was 6.401 million tonnes; the production of rural compost was 226.727 million tonnes and 6.428 million hectares was green-manured (Table 1).

TABLE 1. PRODUCTION OF RURAL AND URBAN COMPOST AND THE AREA GREEN-MANURED, 1979-80

State	*Urban compost production*	*Rural compost production*	*Area green-manured*
	(million tonnes)	*(million tonnes)*	*(million hectares)*
Andhra Pradesh	0.250*	44.500*	2.400*
Assam	0.010*	0.450*	0.015*
Bihar	0.130*	12.000	—
Gujarat	0.189	0.990	0.198
Haryana	1.175*	6.500	0.026*
Himachal Pradesh	—	2.500*	0.034*
Jammu and Kashmir	0.016	0.134	0.002
Karnataka	0.767	8.681	0.656
Kerala	0.025*	0.250*	0.010*
Madhya Pradesh	0.185*	7.000*	0.160*
Maharashtra	0.950*	1.400*	0.010*
Orissa	0.025*	10.000*	0.250*
Punjab	0.465*	20.900*	0.450*
Rajasthan	0.170	2.097	0.024
Tamil Nadu	1.300*	8.400	1.500*
Uttar Pradesh	1.377*	91.683	0.668
West Bengal	0.040*	9.000*	0.005*
Others	0.325	0.2492	0.0215
Total	6.401	226.727	6.428

*Anticipated Figures

SOURCE: *Ministry of Agriculture and Rural Reconstruction, Government of Inida, New Delhi*

THE FERTILIZER ASSOCIATION OF INDIA, 1955

The Fertilizer Association of India (FAI) was organized in 1955. It has grown steadily in membership, programme, publications, and influence. It has four types of membership. The growth in membership from 1955 to 1978 is given in the following table :

Membership type	*Number of members*	
	1955	1978
Active	12	50
Associate	5	120
Overseas associate	—	23
Technical and professional associate	—	597

The credit for founding the FAI goes to A. A. Rahimtula, an industrialist of Hyderabad, who was the first Executive Director and Chairman from 1955-1957. In 1957, C. R. Ranganathan of the Indian Forest Service, who as Inspector-General of Forests became the Executive Director and continued till 1972. He propagated the concept of balanced fertilizer use. The office was shifted from Hyderabad to Delhi in 1959. Now all the major and most of the small producers of fertilizers are the members of the FAI. This is one of the few industry associations in which are represented all segments of the industry, viz. public, private, and joint and co-operative sectors.

The FAI headquarters are in New Delhi, and it has regional offices in Bombay, Madras and Calcutta. The scope of its work is indicated in its objectives, which are given as follows:

'To bring together all concerned with the production, marketing, and the use of fertilizers with a view to solving the problems of the industry and the formulation of policies and practices beneficial to the national economy.

'To promote the consideration and discussion of all questions that contribute to sound agricultural practice and to the economic development of the fertilizer and agricultural industries.

'To institute, prosecute, develop, and carry on scientific and economic research regarding the preparation of fertilizers increasing soil fertility, and crop production.

'To improve practices with in the country in the production and distribution of fertilizers.

'To make the cultivators aware of the benefits of fertilizer use.

'To encourage the use of more and balanced plant foods.

'To seek to obtain more efficient use of fertilizers of all types.'

The FAI works closely with several ministries of the Government of India and the States, the agricultural universities, fertilizer distributors and farmers. It participates in studies of the production and use of fertilizers. It conducts an annual fertilizer seminar that draws speakers and participants from many countries of Asia, Europe, and North America.

Much of the work of the FAI is reported in its publications which are:

Journals and Periodicals: Fertilizer News, Fertilizer Marketing News and *Abstract Service* (English monthlies).

Annual Publications: Fertilizer Statistics and *Annual Review of Production and Consumption of Fertilizers* (giving information on production, distribution, consumption, prices of fertilizers, and other related agricultural statistics from India as well as abroad).

Ad-hoc Publications: Fertilizer Handbook, Soils of India, crop booklets, Fertilizer (control)Order, proceedings of seminars, group discussions, and lectures.

The FAI is one of the good trade associations in the world fertilizer industry and is fulfilling the high hopes of its founders.

DR S.K. MUKHERJEE'S VISIT TO USA AND EUROPE, 1956

In 1956 Dr S.K. Mukherjee, a renowned Chemist and Director of the Fertilizer Corporation of India Ltd, paid a visit to USA and some countries in Europe. On return he wrote a report on recent advances in the field of chemical fertilizers in those countries, which had an impact on future development of the fertilizer industry in India. He was the leader of a team of young Indian engineers and scientists who built the fertilizer plant at Rourkela. Under his guidance a new process was developed at Trombay, which helped to produce a superior fertilizer, and stepped up the production capacity of nitrophosphate plant. He convinced policy-makers about the necessity of urea production in India.

FERTILIZER CORPORATION OF INDIA LIMITED, NEW DELHI, 1961

To provide elasticity in operation and freedom from governmental red tape, the Government of India formed the Fertilizer Corporation of India Ltd on 1 January 1961. It ushered in a new era from 1 April 1978 after reorganization. It has two operating units at Sindri and Gorakhpur. The FCI has three of the world's largest coal-based projects, two of which at Talcher (Orissa) and Ramagundam (Andhra Pradesh) are complete and only awaiting commissioning. The third project at Korba (Madhya Pradesh) will be taken up after the successful commissioning of these two projects.

The corporation is a public-sector undertaking, fully owned by the Government of India. It has an authorized capital of Rs 8,000 million. The total issued and subscribed capital on 31 March 1979 is Rs 3741.3 million.

When all the projects in hand (except Korba) are commissioned, the rated capacity of the FCI plants would be 805.000 tonnes in terms of nitrogen and 150,000 tonnes in terms of P_2O_5.

Among the existing units, the ANP fertilizer is being produced at Gorakhpur.

SINDRI MODERNIZED, 1979

The old Sindri plant, which was commissioned in 1951, continued to work profitably up to 1967, after which owing to ageing the plant started suffering losses caused by a gradual reduction in production capacities and additional expenditure on maintenance. Consequently, a scheme was drawn up for having a Rationalization Project and a second Modernization Project at Sindri. These projects would lead to the emergence of a new and bigger complex in place of the old Sindri plant which has been gradually scrapped except for the plant for manufacturing ammonium sulphate. The two projects were commissioned in October 1979.

The Rs 600 million Rationalization Project involves the creation of a capacity of 326,000 tonnes of triple superphosphate (TSP), equivalent to 150,000 tonnes of P_2O_5, almost half of the domestic production of phosphatic fertilizers. A novel feature of this project is the availability locally of gypsum as a by-product to replace the natural gypsum hitherto hauled all the way from Rajasthan. This is made possible by reacting sulphuric acid with rock phosphate to give phosphoric acid and gypsum as a by-product, which will be used in the existing plant for manufacturing ammonium sulphate. Phosphoric acid will be treated with rock phosphate to produce triple superphosphate.

The Rationalization Project comprises a plant that produces daily 880-tonnes of sulphuric acid (in terms of P_2O_5) and 1,100 tonnes of TSP.

The construction work on the Modernization Project began in 1975. This World Bank-aided project has been built at a cost of Rs 1,790 million. In the form of an IDA credit, $91 million (Rs 820 million) has been provided. It has a fuel-oil-based ammonia plant having a capacity of 900 tonnes a day. The remaining ammonia is converted into ammonium sulphate, for which the existing plant in the old Sindri Complex has been renovated. About 66 per cent of the equipment used is indigenous. The project went into commercial production in October 1979.

COAL-BASED PLANTS

A new era dawned for the Indian fertilizer industry consequent upon the decision taken by the Government of India in 1969 to establish 3 coal-based plants in the country, at Talcher, Ramagundam and Korba.

The annual installed capacity of each of these projects is about 300,000 tonnes of nitrogen, with urea as the end-product, amounting to 500,000 tonnes per annum. In addition, one million cubic metres of argon will be produced by each plant.

Talcher Project

The Rs 2,140-million Talcher Project is designed to produce 228,000 tonnes of nitrogen annually by using about 1 million tonnes of coal to be obtained from the nearby South Balanda and Nadira collieries. The total requirement of 55 MW of power will be met by the Orissa power grid, and the water requirement will be met from the Brahmini River.

The Talcher fertilizer plant produced urea from its own ammonia in January 1980 for the first time during the trial run.

When this plant will produce at its designed capacity of 495,000 tonnes of urea per annum, it is expected to boost production of foodgrains in the country by nearly 2.5 million tonnes per year.

Ramagundam Project

The Ramagundam Project in the Telengana region of Andhra Pradesh is identical with the plant coming up at Talcher. Its daily requirement of about one million tonnes of coal will be met from the Singareni Colliery. The power requirement of the project, amounting to 55 MW, will be met by the Andhra Pradesh State Electricity Board. The quantity of water needed is 68,185 kilolitres per day and it will be drawn from the River Godavari.

Ammonia and urea were produced under the Ramagundam Fertilizer project also in the first week of January 1980 (Fig. 73).

Mukerji and Kane Committees on Fertilizer Projects

At the time Sindri was being planned, one big concentrated capacity in that plant was considered to be sufficient to meet the total assessed needs of the country, but soon it became apparent that more such units would have to be set up to keep pace with the expanding requirements of nitrogenous fertilizers. Two committees—one headed by B.C. Mukerji, ICS, and the other by Dr G.P. Kane (then Technical Adviser to the Government of India)—went into details of new locations and capacities for expanding production and came out with recommendations for putting up fresh nitrogen capacities at (a) Nangal, based on the surplus power from the Bhakra System, (b) Trombay, based on the surplus refinery gases and naphtha from the neighbouring Burmah-Shell and Caltex Refineries, (c) Namrup, based on the associated gases from the Naharkatiya oilfields, (d) Rourkela, based on the recovery of hydrogen from the coke-oven-gas fractionation, (e) Gorakhpur, using the surplus naphtha from the Barauni Refinery and (f) Neyveli, based on the locally mined lignite.

Rourkela

The plant at Rourkela with 120,000 tonnes of nitrogen with low-temperature separation of hydrogen from coke-oven gas was planned for production of calcium ammonium nitrate, containing 20.5 per cent nitrogen by the dilution of ammonium nitrate melt (the only product that could be conveniently produced) with powdered limestone. The decision to dilute the product (thus significantly offsetting the advantage of lower production cost) was taken to avoid any possible fire and explosion hazards and to ensure the availability of a free-flowing product to the farmer.

NANGAL

Towards the north of the fertilizer factory is Naya Nangal Township, covering 728 hectares. In this township, residential quarters were built at a cost of Rs 20 million. The cost of the factory, on completion, was Rs 310 million. The production of calcium ammonium nitrate (CAN)—*Kisan Khad*—started from 22 February 1961. The raw materials for manufacturing *Kisan Khad* and heavy water are water, air and electricity. The basic decision to build the Nangal factory on the electrolysis of water was inseparably linked with the extracting of heavy hydrogen for the production of heavy water for the nuclear-power programme (Fig. 74).

The plant initially was designed to produce about 1,200 tonnes of calcium ammonium nitrate fertilizer per day, containing 20.5 per cent nitrogen per day. Since 20 August 1967, the product was upgraded to contain 25 per cent nitrogen and, consequently, the production of the upgraded fertilizer is now 964 tonnes per day, resulting in a considerable reduction in expenses in handling and in the consumption of limestone from 495 to 272 tonnes daily.

There are four important plants at Nangal, viz. the electrolysis plant, the air-liquefaction plant, the ammonia plant and the nitric acid plant.

The electrolysis plant consists of 63 filter-press-type electrolysers, each of which contains 108 cells. The cells are filled with 20-25 per cent solution of potassium hydroxide, and the direct current at 685 volts and 9,500 amps is supplied from the rectifier plant for electrolysing water. The 63 electrolysers are arranged in a cascade of three stages and are designed to produce 26,500 NM^3/hr of hydrogen and 13,250 NM^3/hr of oxygen, consuming about 142,000 kWh of power.

The liquefaction plant is designed to process about 12,000 NM^3/hr of dry air in two streams to yield 95 per cent pure oxygen, and pure nitrogen (containing less than 10 ppm of oxygen) by distilling liquid air. The ammonia plant I is designed to produce about 307.2 tonnes per day of liquid ammonia in 3 streams. Hydrogen from the electrolysis plant (including the depleted hydrogen from the heavy-water plant) and nitrogen from the air-liquefaction plant are mixed in the stoichiometric ratio of 3:1, compressed to 450-600 atmosphere pressure and passed over iron oxide (catalyst) to produce ammonia. The plant to produce nitric acid is designed to manufacture 1,045 tonnes of nitric acid of 53 per cent concentration per day in two streams. Approximately, 160 Te per day of ammonia is consumed in this plant.

The factory had a smooth sailing during the first ten years. On account of the programme with respect to rural electrification and urban industries, grave power shortage developed in Punjab and Haryana. A clamour started that power supply to the Nangal factory should be curtailed. A gradual reduction in the power supply badly hit fertilizer production. To meet this situation, the Government of India decided to launch an expansion project with an additional annual nitrogen-manufacturing capacity of 152,000 tonnes, with the fuel oil as the feedstock.

The expansion project heralded an era of new fertilizer technology in India. It has a capacity to produce 900 tonnes of ammonia per day, of which 600 tonnes is used for the production of 1,000 tonnes of urea and the remaining 300 tonnes is diverted to the old plants to produce 964 tonnes of calcium ammonium nitrate (Fig. 75).

With the commissioning of this project in 1978, the total annual production capacity of nitrogen at Nangal increased from 80,000 tonnes to 232,000 tonnes, whereas the power requirement for the combined facilities (calcium ammonium nitrate and urea) is 36 mW against 164 mW required for the old unit.

The cost of the expansion of the project was Rs 1,320 million, with a foreign-exchange element of Rs 430 million. The World Bank (International Development Association) gave a soft loan of 58 million dollars. The process design, the supervision of detailed engineering and the erection of the ammonia plant was done by a consortium of Messrs Uhde and Lurgi of West Germany and Messrs Topsoe of Denmark, with Messrs Uhde as the leader. Similar work for the urea plant was performed by Messrs Tecnimont, Italy. The detailed engineering of the main plants and the designing and the detailed engineering of the utilities were done directly by the Planning and Development Division, Sindri. The civil works, and the erection of equipment, piping, electricals and instruments were done by the Nangal-site staff.

The feedstock for the expansion plants is fuel oil, with the maximum sulphur content of 4 per cent or low-suphur heavy stock. The total requirement of raw materials is : fuel oil/LSHS, 720 tonnes per day, and coal, 900 tonnes per day.

NEYVELI, 1966

A significant breakthrough in the planning processes came when the earlier decision to produce the bulk of nitrogen as ammonium nitrate and a small quantity of urea at Neyveli was reviewed in 1956 in favour of an all-urea plant. The decision in 1956 to adopt the total recycle process by separating the tail gas for the production of 500 tonnes per day by the urea plant—possibly the largest projected plant in the world at that time—at Neyveli was an important one. The fertilizer plant at Neyveli has a capcity to manufacture 465 tonnes of urea per day and it was commissioned in 1966. The fertilizer plant, which had been initially based on lignite since its inception was converted from lignite into oil gasification on 16 July 1979. The fertilizer unit achieved the production of 104,908 tonnes of urea during 1979-80. The plant has so far produced from the time of its commencement till March 1980 a total quantity of about 969,000 tonnes of urea.

CHAPTER 26

CHEMICAL FERTILIZERS-II

SIVARAMAN COMMITTEE ON FERTILIZERS, 1964-65
LIBERALIZATION OF INDUSTRIAL LICENSING POLICY
RURAL INFRASTRUCTURE, GODOWNS AND SALE POINTS
CREDIT POLICIES AND EXTENSION

FACED by a drought and a deepening food crisis, the Government of India was exploring all necessary avenues for increasing food production. It was realized that production and distribution of chemical fertilizers must be promoted and all hurdles removed. B.S. Sivaraman, I.C.S., Chief Secretary, Orissa, was known for his interest in agricultural production. He was asked by the Government of India to head a Committee on Fertilizers in 1964. The task of the Committee was to examine the long-term and short-term problems connected with distribution of chemical fertilizers and to recommend measures for evolving an effective system of their distribution with a view to bringing about a rapid increase in their use for increased agricultural production. The Committee was also to examine the role of co-operatives in marketing of fertilizers and of extension services in their promotion and popularization. This Committee in its report in 1965 considered the role of chemical fertilizers in agriculture, emphasized their importance and commented:

"World experience has shown that the efficient use of fertilizers can step up production manifold. This is particularly important where land for cultivation per family is limited to a small acreage, as in India. It has been generally accepted that the use of about 93,500 short tons of plant nutrients would be equivalent to adding a million acres of average crop land in terms of additional production. An intelligent and sufficient application of the proper types of fertilizers is, therefore, of strategic importance in our campaign to increase agricultural production. Manures can be organic or inorganic. Both types are necessary for good agriculture. The availability of organic manures is dependent on the extent to which green-manuring crops can be grown in the fields, in addition to the making of compost and farmyard manure. The availability of farmyard manure and compost is limited as compared with the needs of cultivated crops. The cultivation of green-manuring crops has to fit in with the crop pattern and is possible under irrigated conditions. As their cultivation competes with the seasonal cash crops, it is difficult to persuade the cultivators to take up the raising of green-manuring crops in a big way. The only way by which the manurial requirements can be met effectively, therefore, lies in the application of chemical fertilizers to the crops. Soil tests indicate that almost all soils in India must have additional nitrogen; about 85 per cent of the soils need additional phosphorus and nearly 63 per cent of them require potash, if crop yields are to be increased by 50-100 per cent. In India, the low level of soil fertility limits crop production more than any other single factor. Against this background, the programmes of intensive cultivation, particularly under irrigated and assured-rainfall conditions, are being undertaken for achieving better results in agricultural production. However, the intensive cultivation of crops will deplete the soil of its nutrients at a rapid rate. Unless the nutrients are replaced in the soil by massive doses of chemical fertilizers the land will not continue to meet our needs of greater agricultural production *vis-a-vis* the unrestricted increase in our population."

Liberalization of Industrial Licensing Policy, and Participation of the Private Sector

It was left to the Government's revised comprehensive fertilizer policy enunciated in December 1965—which recognized the compulsion of speedily building up the fertilizer-manufacturing capacity and increasing agricultural production in the country if the promises of the "Green Revolution" were to materialize in a substantial measure—to liberalize the entire approach and positively encourage investment in this sector. The investors' interest in the fertilizer industry was stimulated by the abolition of many restrictive requirements, such as the limitations of foreign equity holding and management control. A look at the time series of public- and private-sector financial outlays on fertilizers suffices to establish the position of this revised policy of end-1965 as a landmark.

Table 1. Financial outlay on fertilizers (rupees in million)

Particulars	*Public sector*	*Cumulative*	*Private sector*	*Cumulative*	*Total*	*Cumulative*
Before 1947	8		25		33	
At the end of 1947	55	63	4	29	59	92
At the end of 1950	4	67	12	41	16	108
1951-1955 (the First Plan)	537	604	4	45	541	649
1955-1960 (the Second Plan)	45	649	53	98	98	747
1960-1965 (the Third Plan)	1,138	1,787	82	180	1,220	1,967
1966-1968 (Annual Plans)	945	2,732	1,193	1,373	2,138	4,105
1969-1973 (the Fourth Plan)	1,931	4,663	1,795	3,168	3,726	7,831
1974-1976	3,301	7,964	1,726	4,894	5,027	12,858
1976-1979	13,379	21,343	695	5,589	14,074	26,932

Adapted from the *FAI Silver Jubilee Commemorative Volume*, p. 272, by S.S. Baijal

According to Dr S.S. Baijal, Chairman of the Fertilizer Association of India, an overview of the evolution of the Indian Government's policy towards fertilizers leads to the conclusion that, on the whole, such policy intervention had a positive effect. The fact that during the years since Independence fertilizer production and consumption have gone up at a rapid pace bears testimony to the effectiveness of this policy. With the determination to strengthen the thrust of the Green Revolution of the mid-sixties, the fertilizer sector was given consideration and support by the Government.

India has now fertilizer factories both in the public and private sectors. This is a healthy mix. Monopoly by the public sector would have generated sluggishness. On the other hand, the monopoly by the private sector would have created exploitation of the farmers by the greedy get-rich-quick industrialists and financiers.

Use of Chemical Fertilizers: Progressive Increase

In the First and Second Five-Year Plan periods the use of fertilizers for food crops had just begun to show its impact. In the Third Plan period the use of fertilizers was steadily growing, and 1966-67 saw a tremendous growth rate, which was about 60 per cent over the previous year. This was an eventful year because of the introduction of the fertilizer-responsive varieties of food crops. Trends in production, import and consumption of fertilizers from 1961-62 onwards show that fertilizer production was sluggish during the Third Plan period but the demand went on increasing. From 1968-69 production started picking up but even then there were substantial shortfalls in production, which were met by imports (Fig. 75), During the first three years of the Fourth Plan there has been considerable increase in the production of nitrogenous fertilizers, but in case of phosphatic fertilizers the increase was marginal. Practically the whole of potassic fertilizers are imported as the annual indigenous availability is limited to 1,000 to 2,000 tonnes of muriate of potash only. As the present crop production technology is mainly dependent on progressively larger use of fertilizers the gap between the availability and demand is going to widen from year to year. It will become necessary, therefore, to resort to imports unless, of course, fertilizer production in the country is substantially stepped up.

Raw Materials and Feedstock

Fertilizer raw materials usually require chemical processing in order to convert the nutrient elements into forms that can be readily utilized by plant. Chemical fertilizers thus obtained have minimised the use of indigenous or synthetic manures and have established a place of prominence in plant nutrition. With the advancement of technology in chemical

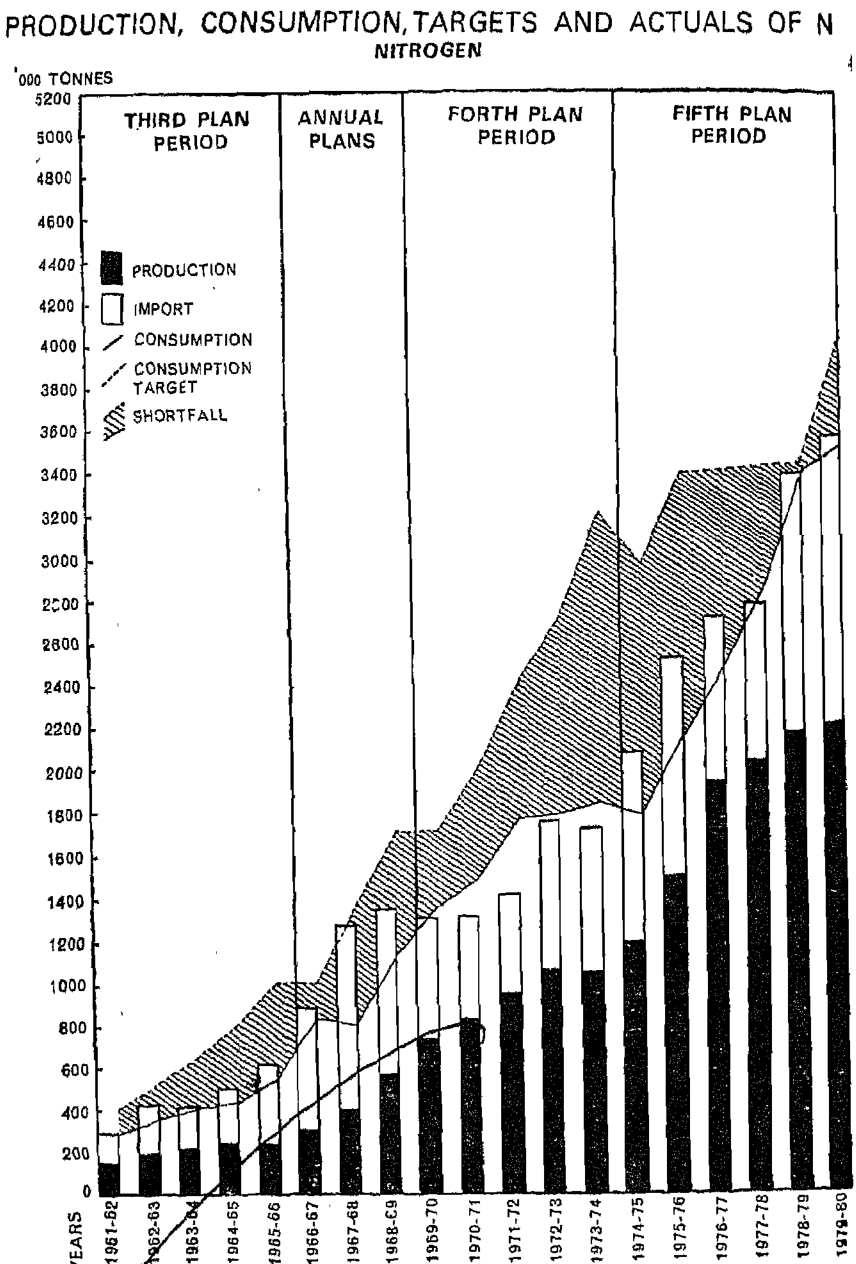


FIG. 78. The production and consumption of nitrogen (N), targets and actuals from 1961-62 to 1979-80. The production and consumption of fertilizers showed a progressive increase from 1965-66 onwards. Still there was censiderable shortfall, which was met through imports. (FAI)

fertilizer industry it has been possible to reduce the cost per unit of plant nutrient. The high content of nutrient elements in chemical fertilizers has further facilitated their transport, storage and application at lower cost, and hence general preference of the farmers for them. The major nutrients, viz. N, P_2O_5 and K_2O, which are required in relatively large quantities have received the highest attention in the manufacturing industries.

NITROGEN

Fixation of atmospheric nitrogen is the first step to make this inexhaustible source available to plants. With the exception of leguminous plants, most plants cannot make use of the free nitrogen of the air, unless it is chemically processed into suitable compounds. It is recognized that the starting material for fertilizer nitrogen is ammonia, for the synthesis of which nitrogen of the air provides one of the components. The other component, hydrogen, is more costly and is obtained from water, or from any fuel material through a series of reactions involving interactions between fuel, oxygen and water. Hydrogen could be produced using a variety of feedstocks, e.g. (a) natural gas; (b) liquid petroleum gas; (c) methane; (d) naphtha; (d) heavier fraction of petroleum, e.g. fuel oil, LSHS (Low Sulphur Heavy Stock) etc.; (f) crude oil; (g) coke-oven gas; (h) coal, coke, lignite; and (i) electrolysis of water by means of electric power. Of the important feedstocks which are economically feasible and whose technologies are well known, natural gas, naphtha and fuel oil stand out prominently. But their indigenous supply being limited, dependence on import has created problems as a result of the oil price rises. The price of crude oil was about a dollar per barrel in 1970, and now it is $ 32 per barrel (Fig. 79). In this context coal as feedstock has certain advantages. There are, however, technological problems with coal but they are being solved.

INDIGENIZATION OF EQUIPMENT

The progressive capability built within the country has been spectacular in respect of equipment required by the fertilizer industry. Now there are virtually no items of major equipment meant for even the most modern fertilizers units which Indian shops are not geared to tackle. Such sophisticated items as high-speed centrifugal compressors, high-pressure shell for reactors and other vessels, complicated heat-exchangers and waste-heat boilers, are all potentially within the capability range of the Indian fabrication industry. Ferrous and low-alloy steel pipes, valves and fittings are all being manufactured within the country, often under the technical collaboration or licences of established foreign specialists in the respective fields. Apart from the ultra-sophisticated items or those of special alloy construction, most of the normal needs of pipes and fittings can now be met within the country. A whole range of electrical components and control

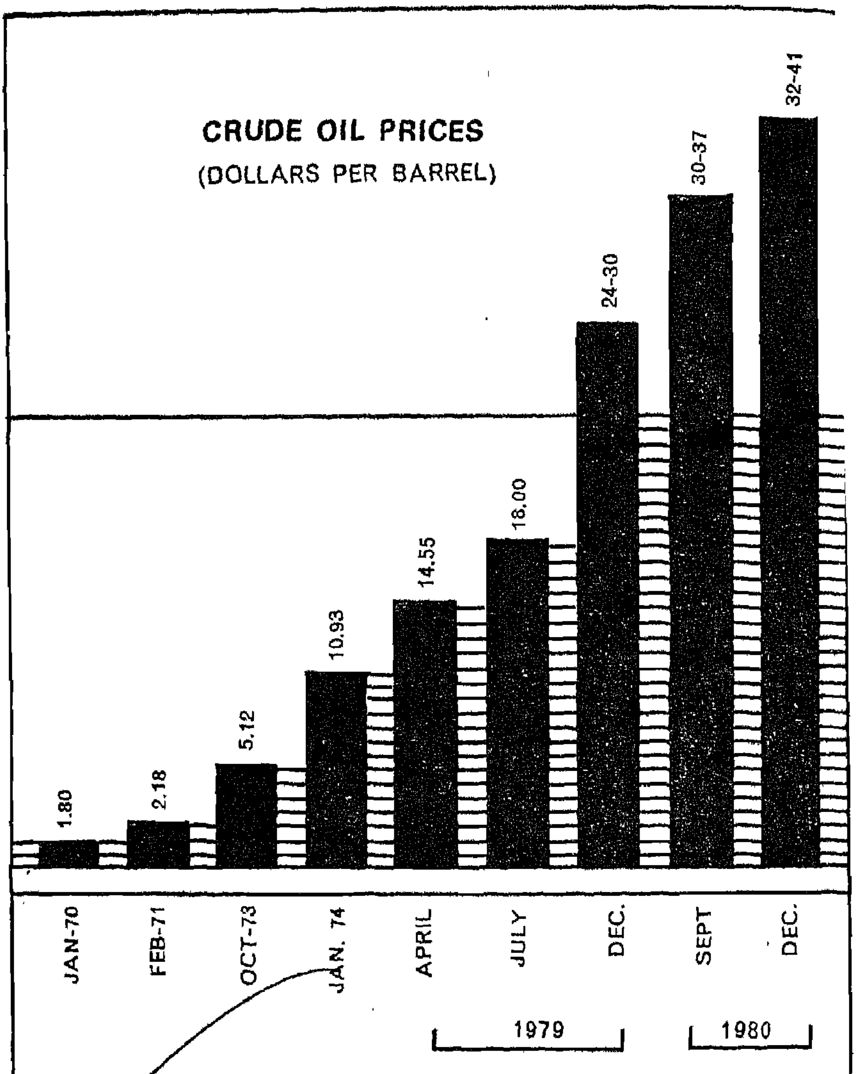


FIG. 79. The price of oil rose from $1.80 per barrel in 1970 to $23.41 in 1980. A sharp rise in the price of oil from 1970 onwards has increased the cost of agricultural production. Hence the production costs of food and fibre have risen all over the world, but the worst sufferers are the developing countries which import oil. As oil is a non-renewable resource, its price will continue to rise. Hence the dreams of cheap food have vanished. The remedy lies in controlling the growth of population and the development of alternative sources of energy.

gear typically required for fertilizer units are now available locally. So are most of the instruments, barring some of the very advanced models.

On the project-execution side, expertise has been built up on design and construction of civil works, even where soil conditions pose special problems of poor bearing strength, high or saline water-table, proneness to earthquake shocks, etc. Other facets, such as moving and handling out-size equipment, erection of tall or heavy structures, and welding techniques on special alloy components, have also been mastered. With familiarity, Indian engineers and operatives are gaining confidence also on skilfully and systematically carrying out the pre-commissioning and commissioning tasks in new plants, balancing and bringing new plants on load, and later operating and maintaining them. The all-round confidence in all these assignments has been built up to a level where some of the consultancy firms or operating companies are now able to offer their services on a whole range of project assignments not only within the country but also abroad, either in collaboration with foreign companies, or in competition with them. Indeed, only a few countries in the world have offered such well-rounded opportunities for familiarizing and mastering such capabilities in the fertilizer field as this country has, considering the dimension of the industry, its diversity both in the range of feedstock handled and the products manufactured, and, above all, the encouragement given to the indigenous talent to associate itself with expertise engaged from abroad, to observe and assimilate the most advanced techniques in each aspect of building up and running the industry.[1]

Pricing Policy

A farmer will use fertilizers only if he finds the use economical. Normal concepts and levels of economic return are, however, irrelevant in the case of fertilizers because of the extent of risks involved in agriculture and its relatively high cost. Consequently, the pricing policy in the case of fertilizers acts as a major instrument of motivation for the farmers to use fertilizers. Up to the end of 1965, the entire local production of nitrogenous fertilizers was acquired by the Pool and distributed by it. The producers were given a retention price fixed on the basis of a cost study by the Ministry of Finance. The Sivaraman Committee on Fertilizers, the recommendations of which led to the far-reaching liberalization of the Government's policies towards the fertilizer industry mentioned in the last section, commented adversely on this accretion to the Pool. In the revised fertilizer policy of 1965-end, although the manufacturers were to be permitted to set their own prices for a period of 7 years, in practice this relaxation did not materialize with respect to urea, calcium ammonium nitrate and ammonium

[1]Ramanathan, K.V. and Rao, D.G. Evolution of the fertilizer industry in India, *FAI Silver Jubilee Commemorative Volume*, pp. 85, 86

sulphate, which accounted for the bulk of the total fertilizer production in the country.

Over the period 1969 to 1972, the world fertilizer prices were low, but the Pool maintained its prices at a level which did not cause hardship to the local producer. After 1972, when the international prices firmed up, the Pool absorbed part of the inflation to retain price stability at the level of the farmer. However, a break in the pattern occurred in 1974, when, following the energy crisis of 1973, the world prices of petroleum products and inevitably of fertilizers, staged their steep ascent. The Government raised the prices of fertilizers by nearly 100 per cent and levied a Pool Equalization Charge on the industry to (a) mop up the surplus profit and (b) partially offset the losses on imports which were occurring at still higher prices. The price escalation of this order put the brakes on the growth of consumption which was consistently brisk. The offtake of nitrogen became stagnant in 1974-75 and the offtakes of phosphorus and potash showed a decline.

Against this background, the emphasis of the policy was soon shifted towards reducing fertilizer prices in stages, so that consumption could be stimulated.

The Rural Infrastructure, Marketing Godowns and Sale Points

Any attempt at rural marketing of a bulk and a seasonal commodity such as fertilizer needs an extensive infrastructural support penetrating into the interior as close to the consuming centre as possible. This policy facilitates advance movement and stocking which are the prerequisites for reaching the material to the consumer in time.

Looking back at the early 1960s, this appeared to be an almost impossible task. The fertilizer industry was in its initial stages of growth and it had yet to make a mark in the rural marketing operations. Over the last two decades, however, this difficulty has been overcome to a large extent. Today, there exists a vast dealer network comprising about 120,000 sale points for agricultural inputs in the country, representing a ratio of one sale point per 6 villages. Admittedly, the coverage is not uniform throughout the country, but a sizeable part of the country has been covered.

In the irrigated areas, the policy should be to have a fertilizer sale point in every village. Where villages have been provided with link roads, this step should be taken without further delay.

Simultaneously, large godown capacities have been created in the countryside at different locations, i.e. rail-heads, *mandis* and in the villages, by traders, co-operatives, warehousing corporations and the industry. About 2 million tonnes of storage facilities have been organized for use by the industry. The fertilizer industry has also co-ordinated its marketing and distribution with commercial banks and with the co-operative credit system to ensure that adequate credit is available to the dealers for the stocking of material during the off-season and to the farmers for buying fertilizers at the time they need it.

Credit Policies

The importance of adequate and timely credit arrangements for a seasonal commodity such as fertilizers hardly needs any emphasis. Almost all studies conducted in India on the use of fertilizer have shown credit to be an important factor affecting fertilizer consumption.

The consignment system operated by the Central Fertilizer Pool in the early years gave the initial impetus to the State Governments and Co-operatives to hold stocks in areas in the interior and well in advance of the season. Over the last two decades, the credit-distribution policy has been directed towards converting the co-operative federations into fertilizer-trading houses operating on commercial lines. In the mid-sixties, the State co-operative federations were almost entirely dependent upon concessional finance from the Central Government or the Reserve Bank of India for raising their distribution credit requirements. As a result of deliberate policy measures, a significant portion of the stocks held by the co-operatives are now financed by the normal commercial banking channels. The idea of inducing a commercial approach in the co-operative sector is sound, as it will help to cut down excessive stocking.

In some States, commercial banks operating in lead districts have been charged with the responsibility for directly financing some of the primary societies delinked from the federations. This policy should promote viable retail societies.

Credit to Farmers

To enable the small and marginal farmers to purchase fertilizers, crop loans are liberally given by commercial banks. This step has enabled them to improve their production.

Extension: the Celebration of Fertilizer Festivals

One of the significant contributions that the FACT has made to the promotion of fertilizers is the concept of the fertilizer festivals. Fertilizer festivals have assumed a role that no other instrument has been capable of in the past in attempting to reach the heart of the farmer. The fertilizer festivals introduced by the FACT have become well known in many parts of India, and even the United Nations have been caught up by this new concept and have made a special study of it, so that it can be introduced into other developing countries.

The Village-adoption Scheme

Another contribution made by FACT to the field of fertilizer promotion is the Village-Adoption Scheme. The theme of the scheme is that any strategy of agricultural development should focus on the village as the basic growth point. The scheme has been recommended for adoption throughout the country.

Agro-service Centres

The organization of agro-service centres in key places is another innovation introduced by the FACT recently. The FACT offers all kinds of agricultural services to farmers free of cost through a team of well-qualified and trained agronomists Facilities have been provided, again free of cost, for testing soil samples.

A new dimension to the concept of agricultural extension in the country has now been set up by the FACT by developing the idea of starting agricultural study centres—the FACT *Krishi Vigyan Kendras*—an effective and sustainable new medium for educating farmers.

Every year, a large number of demonstration plots are arranged by the FACT in the fields to prove the profitability of applying fertilizers.

The marketing network of the FACT is fairly widespread all over southern India, comprising Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. The FACT is also supplying its products to Maharashtra, Madhya Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh and West Bengal.

All these innovations, viz. the celebration of fertilizer festivals, the Village-Adoption Schemes and the setting up of centres of agro-industries, have been taken up by most private fertilizer factories.

At this stage, it is appropriate to mention the development of three important fertilizer-manufacturing ventures, viz. the IFFCO, the NFL, and the Shriram Fertilizers.

Indian Farmers' Fertilizer Co-operative Ltd (IFFCO), 1967

An all-India Co-operative Society was registered on 3 November 1967 under the name Indian Farmers' Fertilizer Co-operative Limited (IFFCO) with the purpose of taking up the large-scale manufacturing and distribution of chemical fertilizers. In the initial formation of the Society, the following 10 States participated: Punjab, Uttar Pradesh, Haryana, Gujarat, Tamil Nadu, Rajasthan, Madhya Pradesh, Andhra Pradesh, Maharashtra and Karnataka.

The principle of share participation was that the product is to be shared by the respective State Co-operative systems in proportion to their shareholding in the Society. Subsequent to the initial formation, Bihar, West Bengal, Orissa, Kerala, Jammu and Kashmir, Himachal Pradesh and three Union Territories—Delhi, Chandigarh and Pondicherry—have also become participants. The Registered Office of the Society is at New Delhi.

CAPITAL OUTLAY

The authorized capital is Rs 2,000 million, of which Rs 810.8 million is subscribed and Rs 807.7 million is paid up. The capital resources of the Society, as on 31 March 1980, are as follows:

	(Rupees in million)
1. Government of India (Loan and Equity)	697.5
2. Co-operative (Equity)	315.7
3. USAID (Loan)	113.9
4. Financing Institutions	179.5
5. Retained Earnings (Provisional)	998.2
6. World Bank (Loan)	768.2
Total:	3073.0

At present, 27,494 co-operative societies are share-holders and have subscribed Rs 318.8 million as the share capital.

PLANTS

The ammonia plant, with a rated capacity of 910 tonnes per day, and the urea plant, with a rated capacity of 1,200 tonnes per day, are located at Kalol Unit. The unit has a capacity of 396,000 tonnes of urea per annum. Besides, a 6-tonne-per day dry ice plant has been set up to convert a part of the surplus carbon dioxide available at Kalol into dry ice. The Kandla Plant has a capacity for producing 415,000 tonnes of NPK per annum (Fig. 76). The feed-stock for the Kalol Plant is natural gas, whereas the Kandla Plant uses mainly imported phosphoric acid. The plants have been in commercial operation from the dates shown below:

NPK	—	1 January 1975
Ammonia	—	1 March 1975
Urea	—	1 April 1975
Dry ice	—	29 March 1978

PHULPUR PROJECT (UTTAR PRADESH)

The third plant of the IFFCO is being set up at Phulpur (Phulpore), with a total investment of about Rs 1810 million (Fig. 77). The project is financed as under:

	(Rupees in million)
1. *Equity*	
(i) Co-operative	220
(ii) Government of India	310
2. *Other Sources*	
(i) IBRD (long-term loan)	981
(ii) Internal resources	299
Total:	1810

Service to Co-operatives

The emergence of the IFFCO as an efficient fertilizer co-operative strengthened the entire co-operative system of the country. Apart from ensuring a regular and guaranteed supply of high-quality fertilizers with liberal supply conditions and sound technical support, the Society assists the co-operatives by providing training for the sales points personnel. The excellent results obtained by the Society also, in turn, improve the financial condition of the otherwise weak lower tiers of the co-operative system, which are IFFCO's shareholders. Credit for the success of the IFFCO goes to Paul Pothen (b. 1916), who had earlier in his career worked as the Chief Engineer of the FACT, and in 1965 as the General Manager of the Engineering and Design Organization (FEDO), where he initiated several steps which helped to achieve self-sufficiency in the field. He became the Managing Director of the IFFCO in 1968. The fertilizer plants at Kalol, Kandla, and Phulpur were set up under his leadership.

National Fertilizers Limited, New Delhi, 1974

The National Fertilizers Limited was incorporated on 23 August 1974, initially with the responsibility for implementing two identical fuel-oil-based fertilizer plants, one each at Panipat (Haryana) and at Bhatinda (Punjab). On 1 April 1978, under the scheme of reorganization of the FCI-NFL, Nangal and the Nangal Expansion Unit as also the marketing offices of the Northern Marketing Zone of the FCI were taken over by the NFL.

The present authorized capital and the paid-up capital of the company, as on date, are Rs 4,000 million and Rs 2623.7 million respectively. The total investment up to 31 March 1980 is Rs 5698.1 million.

The constituent production units of the company are located at Nangal, Bhatinda and Panipat. Whereas the Nangal Expansion Unit commenced commercial production in November 1978, the Panipat and Bhatinda units were declared to be as under commercial production with effect from 1 September 1979 and 1 October 1979, respectively. The total installed capacity is 320,000 Tes of CAN and 1,352,000 Tes of urea, i.e. 705,540 Tes in terms of nitrogen.

The Bhatinda, Panipat and Nangal Expansion Projects are the first of their kind in the country and employ the latest technology for producing ammonia by the partial oxidation of heavy petroleum feedstocks, sophisticated instrumentation and nearly complete automation for process control. The units have also adopted the latest technology with respect to anti-pollution measures.

Raw Materials and Utilities

The annual rated capacity in terms of nitrogen and products of the constituent units is indicated below:

1.	*Nangal*		
	National Fertilizers Ltd,	Nitrogen:	232,000
	Nangal Unit, Naya Nangal (Punjab)	Urea:	330,000
		Calcium ammonium nitrate	318,000
2.	*Bhatinda*		
	National Fertilizers Ltd,	Nitrogen:	236,800
	Sibian Road, Bhatinda (Punjab)	Urea:	511,000
3.	*Panipat*		
	National Fertilizers Ltd,	Nitrogen:	236,800
	Gohana Road, Panipat (Haryana)	Urea:	511,000

Shriram Fertilizers and Chemicals, Kota, 1963-1969

The Shriram Fertilizers and Chemicals was set up in 1963 at Kota, with an integrated complex for manufacturing polyvinyl chloride, caustic soda and calcium carbide.

In 1969, a nitrogenous fertilizer complex was added to its production facilities. The complex had an ammonia plant of 450 TPD capacity and a urea plant of 700 TPD capacity. Since then, this complex has been expanded to 550 TPD ammonia and 930 TPD urea.

The fertilizer plant is based on the naphtha feedstock and the manufacturing of ammonia involves the catalytic steam-reforming of naphtha, its purification and synthesis to produce this chemical. Ammonia and carbon dioxide are synthesized at high pressure and high temperature by using the total recycle process to produce urea.

The original fertilizer project and its expansion are the results of very close Indo-Japanese co-operation. There is no equity participation by the foreign collaborators in the project.

Dr Charat Ram is a director and an ex-chairman of the Board of Fertilizer Association of India.

Potassic Fertilizers

Potassic fertilizers are not manufactured in the country on a commercial scale. The Central Salt and Marine Chemical Research Institute, Bhavnagar, has however developed a technique to recover potassium scheonite from mixed salt. Based on this process, a commercial plant, with a capacity of 3,000 tonnes/annum potassium scheonite, has come up at Tuticorin in southern India.

Impact on Agricultural Production

In September 1980, India had 100 fertilizer factories, out of which 77 are in production, 6 are under implementation, 15 have been approved in principle and 1 is under consideration. They are distributed all over the country, though the largest concentration is along the coastal areas (Fig. 80).

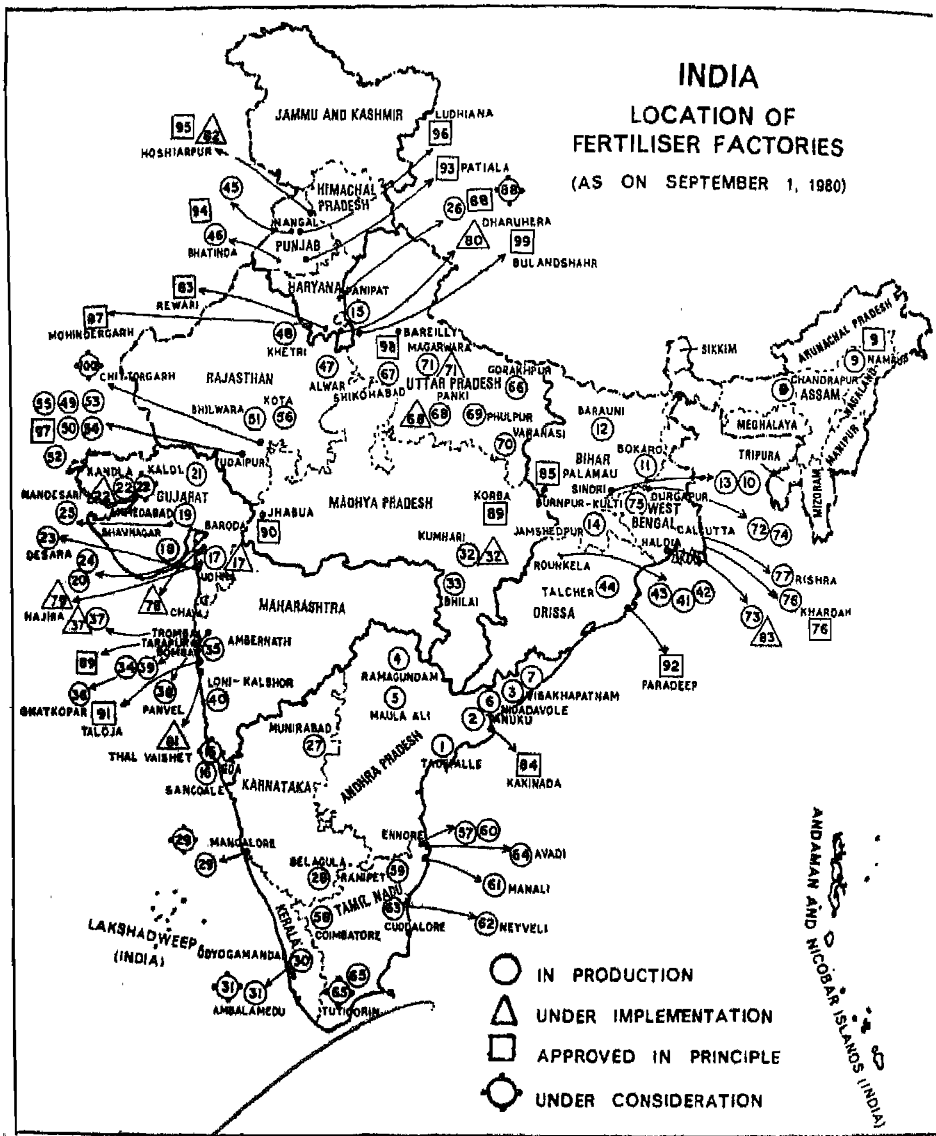


FIG. 80. The location of fertilizer factories in India as on 1 September 1980. (FAI)

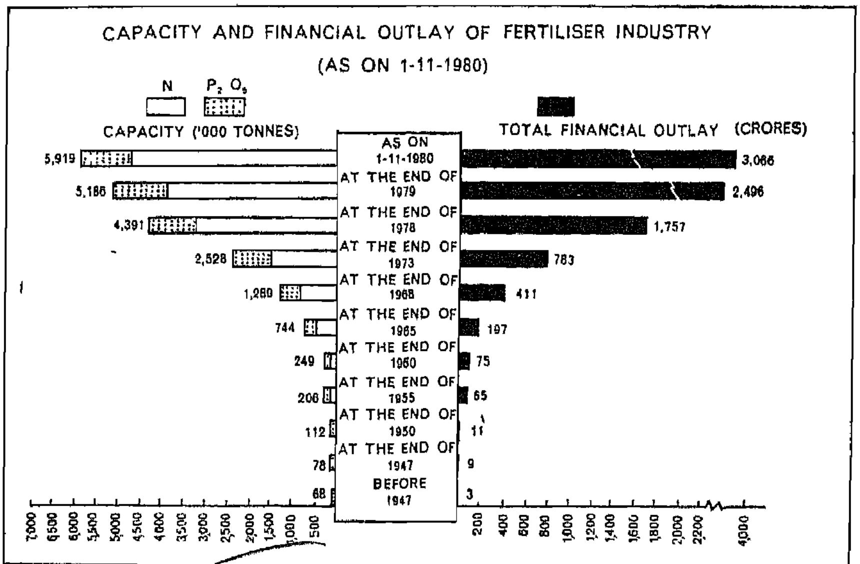


FIG. 81. The capacity and the financial outlay of the fertilizer industry as on 1 November 1980. The financial outlay rose from Rs 1,970 million in 1965 to Rs 30,660 million in 1980 and the production rose from 744,000 tonnes to 5,919,000 tonnes during the same period. (FAI)

The total financial outlay on these factories is Rs 30,660 million, and they have capacity of 5,919,000 tonnes of nitrogen and P_2O_5 (Fig. 81). Up to 1968, the largest production was of ammonium sulphate. The production declined thereafter, being replaced by urea, a more concentrated fertilizer (Fig. 82). The largest production is of nitrogen, the bulk of which is manufactured in the country and some of it is impored.

When one examines the consumption of plant nutrients in the country, the highest consumption is 107 kg per hectare in Punjab, followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Haryana and Gujarat. These are the States in which Green Revolution is most evident (Fig. 83).

Generally, it is true that the production of foodgrains has increased with the increase in the use of fertilizers. No doubt, other factors, such as the increase in irrigation and the use of high-yielding varieties, have also contributed to this increase. But without the adequate use of fertilizers, the varieties would not have given such high yields (Fig. 84).

Test of the New Strategy

The test of the strategy of Green Revolution came during the drought of 1979, which affected over 220 million persons in 148 out of the 395

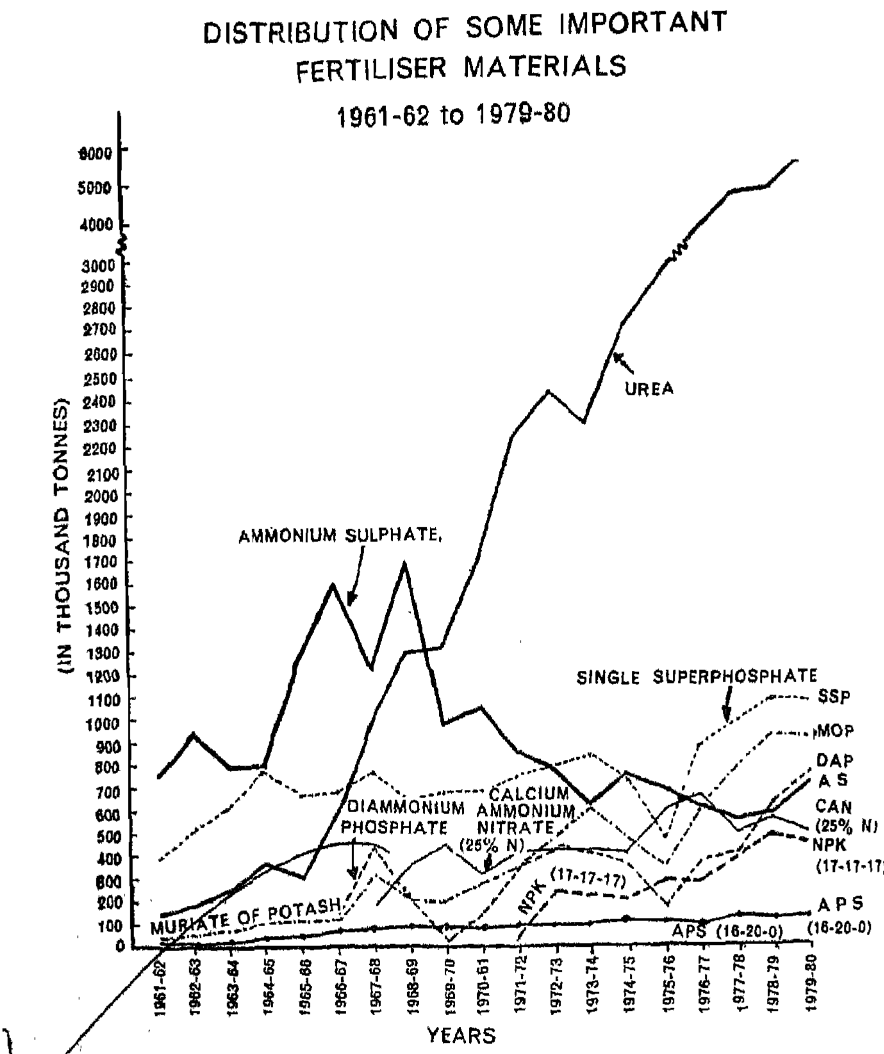


FIG. 82. The distribution of some important fertilizer materials from 1961-62 to 1979-80. Urea, which is a more concentrated fertilizer, replaced ammonium sulphate. (FAI)

districts of the country. Crops on as many as 37 million hectares of the cultivated area were adversely affected. Hence the management of one of the worst droughts of this century at the end of the last decade without necessitating food imports is an index of the progress on the farm front since Independence. A study of the absolute increase in the output of various crops between the triennia ending 1951-52 and 1978-79 shows that the quantum increase in absolute terms has exceeded the level of output in the initial

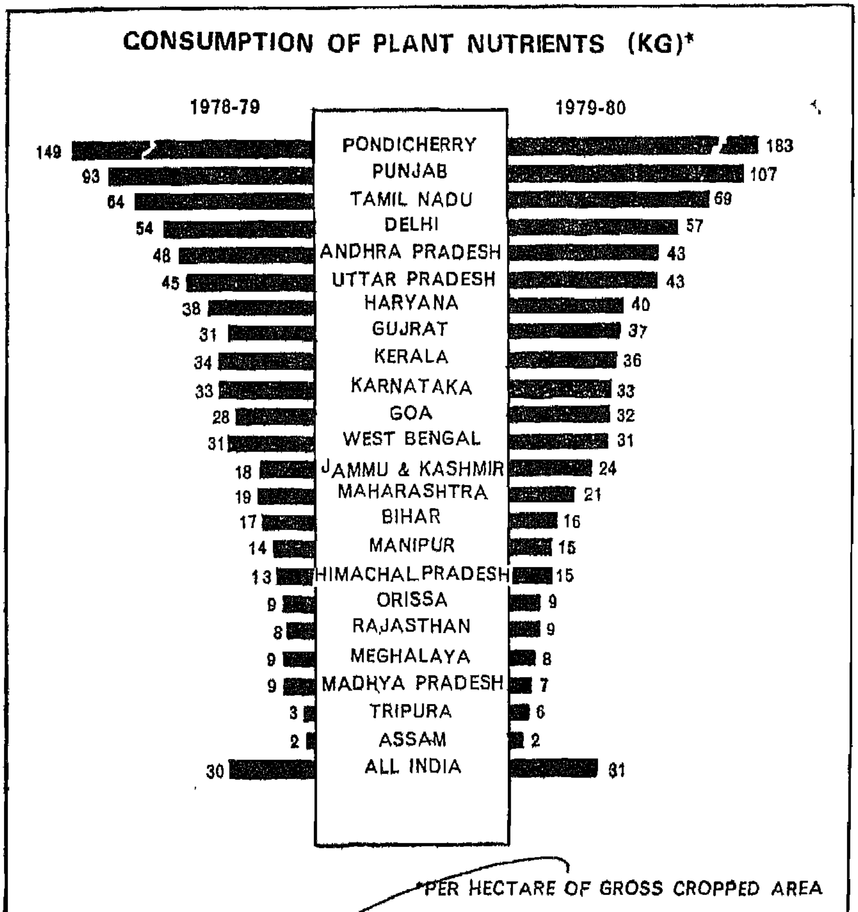


FIG. 83. The consumption of plant nutrients (in kg/hectare) of the gross cropped area. It is the highest in Punjab, followed by Tamil Nadu, Delhi and Andhra Pradesh. (FAI)

triennium with respect to cereal foodgrains, sugarcane and cotton (Table 2), thus indicating that chemical fertilizers and the associated improved technology provide a substantial degree of protection against unfavourable weather.

During the last 40 years, India has made an impressive progress in the development of fertilizer industry. Now India is the fourth largest fertilizer-producing country in the world, with an installed operating potential of 3.90 million tonnes of N and 1.29 million tonnes of P_2O_5 (Fig. 85). Besides, on account of the indigenization of equipment and the development of expertise, India has the capacity of handling fertilizer projects in other developing countries.

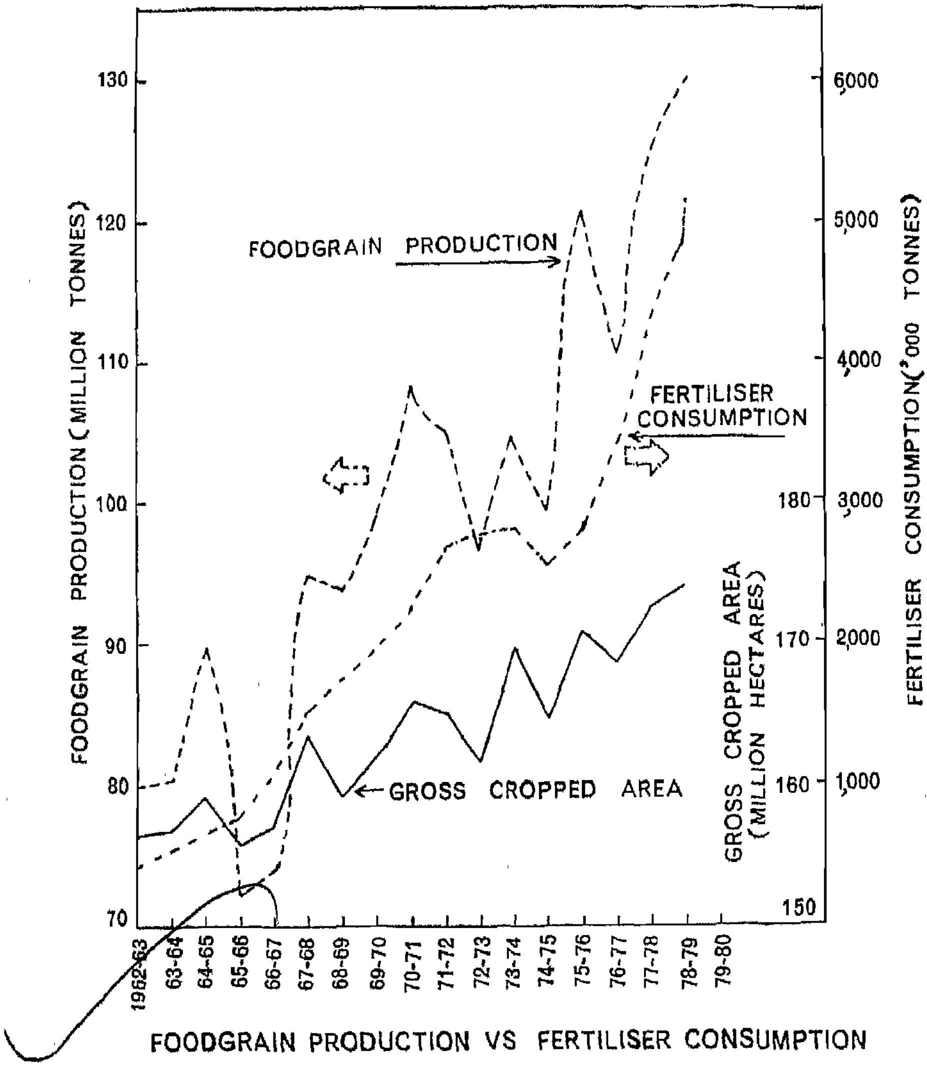


FIG. 84. There is a direct correlation between the use of fertilizers and the production of foodgrains. No doubt, there are other factors also, e.g. the use of the seeds of high-yielding varieties and more irrigation, but without the use of chemical fertilizers, they would not have given such impressive increases in the yields of crops. (FAI)

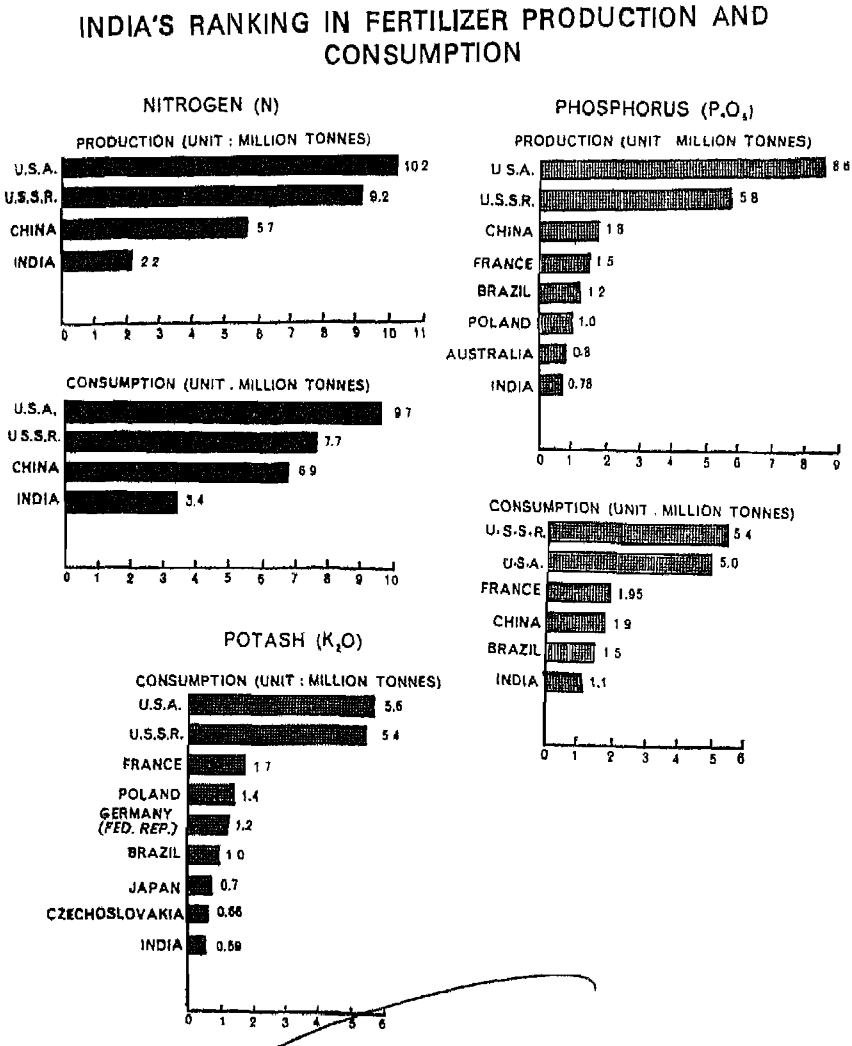


FIG. 85. India's ranking in the production and consumption of nitrogen, phosphorus and potassium. (FAI)

TABLE 2. CHANGES IN CROP OUTPUT FROM 1949-50 TO 1978-79

Crop	*Average annual production*		Increase in production (B-A)	Percentage increase
	1949-50 to 1951-52	1976-77 to 1978-79		
	A	*B*	*C*	*D*
Rice	23,259	49,472	26,213	112.70
Wheat	6,640	31,914	25,274	380.63
Sugarcane (*gur*)	6,958	16,614	9,656	138.78
Cotton (lint)	3,019	7,003	3,984	131.96

NOTE: The figures relating to rice, wheat and sugarcane (*gur*) are in thousand tonnes and those relating to cotton are in thousand bales, each of 170 kg.

SOURCE: M.S. Swaminathan and G.R. Saini.

CHAPTER 27

PLANT PROTECTION

CHEMICALS FOR PEST CONTROL
PESTS AND DISEASES OF CROPS IN INDIA
LOCUST-CONTROL WORK AND DR H.S. PRUTHI
PLANT PROTECTION DURING THE FIVE-YEAR PLANS
MANUFACTURE AND USE OF PLANT-PROTECTION CHEMICALS IN INDIA

THE use of chemicals for the control of pests has a long history. In the past, ash was used for killing pests of vegetables. Millardet in France discovered the fungicidal value of copper sulphate-lime mixture in 1882. It was used for the control of the downy mildew of grapevine. The Colorado beetle was controlled with lead arsenate in the USA in 1892. Subsequently, lime-sulphur, petroleum oils and pesticides of plant origin, such as nicotine and pyrethrum, came into use. The greatest revolution in the use of pesticides, however, came only in the wake of the development of synthetic organic pesticides. Unsuccessful attempts to synthesize pyrethrum were made during the 1920s. In the 1930s, thiocyanates and cyclohexylamines, potential pesticides, were synthesized. A real breakthrough in the use of pesticides came with the discovery by Paul Miller in Switzerland in 1939 that DDT, a chlorinated hydrocarbon, synthesized in 1874 by Zeidler, was very effective in killing flies, bugs, cockroaches and the potato beetle. During the Second World War, this pesticide was used to kill lice and proved an unprecedented success in halting a typhus epidemic in Italy in 1943-44. BHC was synthesized by Michael Faraday in 1825, but its insecticidal properties were discovered later by Dupire and Faucourt in France, and Slade and others in England. In the post-war era, unparalleled benefits were achieved through the use of these two pesticides. These pesticides, DDT and BHC, were quickly tested against a variety of pests in many countries during 1946-50 and were used on a large scale. Simultaneously, other organochlorine compounds, such as chlordane, toxaphene, and methoxychlor, became available during the period 1945-48. Of the synthetic organo-phosphatic compounds, TEPP (tetraethyl pyrophosphate) was approved in Germany in 1944, although dimefox, another pesticide of this group, was produced in the same country four years earlier. Since the introduction of DDT and BHC as pesticides a large number of new pesticides have appeared.

PESTS AND DISEASES OF CROPS IN INDIA

When crop yields are increased through the use of fertilizers, good seed, and improved agricultural practices, it becomes essential that they receive the benefits of protection against insects, nematodes, viruses, fungi and bacteria. Such a protection should be given to the growing crops and to their grain during storage. The introduction of high-yielding varieties and the changed agronomic practices have aggravated the problems of pests and diseases, notable among them in recent years being the brown plant-hopper on rice, *Spodoptera litura* on cotton, maize and tobacco, the scab and codling moth on apple, and the Karnal bunt, *molya* and *Helminthosporium* on wheat.

Rice, the most important cereal, is affected by a number of diseases and pests. The recent spurt of pests such as the plant-hopper, gall-midge, leaf-roller, and diseases such as blast and tungro, have caused great damage. The stem-borer alone is reported to have affected over 35 per cent of the area under rice. Wheat was severely infected by the Karnal bunt in 1981. The use of weedicides for controlling *Phalaris minor* has become a must.

Mustard and groundnut are severely affected by a number of diseases and pests. The major constraint in the production of mustard is the aphid, *Lipaphis erysimi*. White grub is responsible for a lot of damage to the groundnut crop. The damage done by this pest has led to the formulation of the All-India Co-ordinated Project on White Grub.[1] Cotton is attacked by the pink bollworm. The loss due to pests in cotton is estimated at 40.3 per cent. A higher production of cotton can be achieved by adopting extensive plant-protection measures. Pyrilla is the most serious pest of the sugarcane crop in northern India. Sugarcane white-fly and black-bug are also serious pests in certain situations. Sugarcane is also attacked by a number of borers. In the case of maize and sorghum, stem-borers are serious pests.

Plant Protection in the Colonial Period

The Indian Museum, Calcutta, initiated work on economic entomology and published notes on the subject as far back as 1889. The first agricultural entomologist to the Government of India was appointed in 1901. The post was redesignated as Imperial Entomologist on the establishment of the Imperial Agricultural Research Institute at Pusa (Bihar) in 1905. Subsequently, most of the State governments created separate sections of entomology in their departments of agriculture. Until 1946, pest control in India was largely the concern of the State entomologists, mycologists or plant pathologists, in addition to their duties of teaching and research. The establishment of the Directorate of Plant Protection, Quarantine and Storage in the Ministry of Food and Agriculture in 1946 was an important landmark in the field of plant protection in India. This was followed by the establishment of similar organizations in the States.

Mehrotra, K.N. 'Major achievements through research in plant protection', *ICAR Golden Jubilee Symposium*, Sept. 1979, New Delhi

Locust Control, and Dr Hem Singh Pruthi, 1942

Plant protection in the country was placed on a sound footing during the First Plan, with the establishment of four regional plant-protection centres. During the early years, the locust-control operations received greater attention, as locust attacks were frequent, and India was taking part in the international efforts organized by the Food and Agriculture Organization (FAO) of the United Nations for checking the breeding of desert locust. Notable work was done by Dr Hem Singh Pruthi (b. 1897, d. 1969) with respect to locust control. Pruthi got his Ph.D. from Cambridge University in 1925, and worked in the Indian Museum, Calcutta, from 1925 to 1934. In 1934, he succeeded T.B. Fletcher as Imperial Entomologist to the Government of India at the Imperial Agricultural Research Institute, Pusa. He was also in-charge of the Locust-Warning Organization. In 1945, he acted as the Director, IARI, New Delhi, and later on was appointed Plant Protection Adviser to the Government of India, in which capacity he served till his retirement. He died on 23 December 1969 at New Delhi.

Pruthi was an entomologist of international repute, extremely devoted to his subject. Though basically a taxonomist, he published numerous papers on various aspects of entomology. His main contributions were on systematic entomology, insect morphology and development, insect ecology and economic entomology. His book entitled *A Textbook of Agricultural Entomology* is regarded authoritative.

On the economic aspect, Pruthi made significant contributions to the field of locust control. These may be briefly summarized as follows: In 1942, he prepared a concrete scheme for locust control. In 1950, he produced an exhaustive publication, entitled *The Desert Locust Cycle of 1940-46 in India.* Its progress and control included information on three species, namely *Patanga succincta, Schistocerca gregaria* and *Locusta migratoria* in two parts. The first part dealt with locust incidence and swarm movements during the cycle, including such aspects as the breeding seasons and the migration of swarms, meteorological observations, characteristics of locusts of solitary and gregarious phases, biometrical facies of locust populations; methods of locust survey and the sampling of populations. For this purpose, he devised a formula as below:

$$\text{Population/m}^2 = \frac{\text{The number of locusts observed} \times 240}{\text{The number of surveyors} \times \text{the number of km travelled}}$$

In it, he also included observations on air reconnaissance, seasonal and annual situations, and the locust situation in India from 1939 to 1947. He illustrated the seasonal and annual situations with maps. With regard to the locust situation in India, he included such aspects as overwintering, and breeding in spring, early summer, monsoon, and autumn. He gave the extreme points of the breeding areas in different regions, viz. the westternmost part, the Indo-Persian border during 1943, 1944 and 1945; the northernmost part, the Malakand agency in the North-West Frontier Province in 1943; the easternmost part, the Hamirpur District of the United Provinces of Agra and Oudh in 1942; and the southernmost part, the Dhar State in central India in 1941. The second part of this publication dealt with anti-locust organization estimates of damage and expenditure on anti-locust measures and anti-locust works by the Indian Missions outside India.

PLANT PROTECTION DURING THE SECOND TO FOURTH PLANS

The regional centres were strengthened and new centres were set up during the Second and Third Plans for providing a broader base for plant-protection operations. In the Third Plan, prophylactic measures constituted the bulk of the programme. In view of the inadequacies in the supply of plant-protection chemicals and equipment, the distribution system was improved upon. A number of States enacted legislations relating to agricultural pests and diseases. With the launching of intensive cultivation programmes, measures were taken to reorganize the regional plant-protection centres. The Aerial Unit of the Directorate of Plant Protection, Quarantine and Storage (DPPQS), Ministry of Agriculture and Irrigation, was strengthened by providing additional aircraft and staff.

In the Fourth Five-Year Plan more intensive measures were adopted with respect to seed treatment, weed control and post-sowing prophylactic treatment. Steps were taken to strengthen the agro-aviation arrangements, both in the public and private sectors. Important measures taken during this period were the extension of aerial spraying, the helping of small farmers in the eradication of pests and diseases in endemic areas by adopting aero-chemical operations, by carrying out rodent control, by giving technical guidance and assistance to the States under the Natural Calamities Relief Fund for controlling sudden outbreaks of pests and diseases. Consequent upon the expansion of activities, such as aerial spraying, the Aerial Unit of DPPQS was reorganized into a separate Directorate of Agricultural Aviation in January 1971. The Insecticides Act, 1968, and the rules made thereunder came into force from 1 August 1971 to regulate the manufacturing, distribution, sale and transport of insecticides in the country. The provisions of the Act were mainly aimed at preventing hazards to human and animal life.

OPERATIONAL RESEARCH PROJECTS FOR INTEGRATED CONTROL OF PESTS

Increasing concern has been felt all over the world about the poisoning and pollution of the environment due to the indiscriminate use of pesticides. Further, the development of resistance to chemicals in pests, and health hazards due to toxic residues in the food-chain are the other problems that affect plant protection. Hence to evaluate and resort to a judicious combination of chemical, biological and other methods of insect control, the ICAR has taken up Operational Research Projects for the Integrated Control of Pests. To start with, the control of pests of cotton and rice, has been taken up. On cotton, the scheme is in operation in Punjab and in Tamil Nadu; on rice it is in operation in West Bengal, Orissa, Madhya Pradesh, Andhra Pradesh and Kerala. An operational research project on the polyphagous white grub has also been implemented in Maharashtra. These projects are based on a system approach, covering a whole village with an area of over 405 hectares and are aimed to serve three main objectives, viz. to provide a ready demonstration for the farmers for adopting the successful components of the programme, to highlight the constraints in the successful implementation of pest-control operations for corrective steps in the future, and to provide an idea of the cost-benefit ratio of the control operations.

MANUFACTURE OF PLANT-PROTECTION CHEMICALS

In the production of pesticides, a beginning was made in India in 1952, when a factory was installed at Calcutta to manufacture BHC. The production of pesticides in India in 1954 was only 432 tonnes and it rose to over 26,000 tonnes by 1970.

The demand for pesticides is met mainly through indigenous production. A strong foundation for manufacturing pesticides has been laid in the country. The pesticides industry has been classified as a key and priority industry and the Government of India is encouraging the production of more and more pesticides locally. In 1980, 25 major basic manufacturers were engaged in producing 46 different types of pesticidal chemicals, utilizing indigenous know-how and raw materials. BHC, Carbaryl, Malathion and thiocarbamates are the main pesticides manufactured in the country. So far, nearly a 94,000-tonne capacity for the production of various pesticides has been licensed. Out of this capacity, about 76,000-tonne capacity has already been installed. In addition, letters of intent for another 22,000 tonnes have been issued and they are at various stages of implementation. There are a large number of formulating units in the country, with sufficient formulation capacity to meet the growing demand for pesticides in the country.

Depending upon the needs of the State Governments, pesticides are being imported if their production falls short of requirements, or when they are not at present manufactured in the country but are required for the control of specific insect pests, diseases and weeds. There are 70,696 pesticide sale or distribution points in the country, being operated by the State departments (6,648), co-operatives or agro-industries (11,341) and private trade (52,707). Apart from pesticides, there are 25 fungicides, 23 herbicides, 5 rodenticides, 1 bactericide, 3 acaricides, 1 molluscide, 5 plant-growth-regulators and 9 fumigants, which are manufactured in the country.

The world consumption of chemicals for plant protection is: weedicides 42%, insecticides 34%, fungicides 18%, and the rest 5%. In India weedicides have just made a start and their use is likely to increase. Intensive agriculture with the use of costly inputs demand a greater use of weedicides. The factories in which the plant-protection chemicals are manufactured are located in Bombay, Calcutta, Madras, Bangalore, Hyderabad, Baroda and Ahmedabad.

Unlike fertilizers, there is no statutory control on the prices of pesticides. Hence they vary from time to time, depending on the various factors which govern their prices.

Consumption of Pesticides in India

The use of pesticides in India in 1970 was 185 g/ha. It was 1.5 kg/ha in the USA, 1.9 kg/ha in the UK and 10.8 kg/ha in Japan in the same year. The use of pesticides in India is progressively increasing. The consumption of pesticides increased from 3,750 tonnes of technical-grade materials in 1955-56 to 14,600 tonnes in 1960-61, 25,800 tonnes in 1965-66, 49,874 tonnes in 1976-77, 59,000 tonnes in 1977-78, and 60,000 tonnes in 1978-79. This increase is largely due to the intensive cultivation of crops. Large quantities of pesticides are used on cotton and potato.

Role of Plant-Protection Chemicals in Agriculture and Human Health

It is estimated that at present about 900 pesticides have been developed and are being marketed in over 60,000 formulations in different parts of the world. They contribute a lot to the increase in agricultural production by preventing the losses caused by pests. Further, they help to save lives of millions of people by controlling insects and rodents causing diseases such as malaria, typhus, yellow fever and plague. Thus, in spite of their many shortcomings, chemical pesticides continue to play an important role in the protection of agricultural crops, stored foods, domestic and pet animals and in the control of insects which are a menace to human-beings.

CHAPTER 28

FARM MECHANIZATION IN INDIA

IMPORT OF TRACTORS AND INDIGENOUS PRODUCTION
TRACTORS, THEIR ROLE IN THE GREEN REVOLUTION
BENEFITS OF TRACTORIZATION
RELIEVING THE DRUDGERY OF FARM WORK, AND MAKING IT MORE EFFICIENT

FARM mechanization in India started in a significant manner only after World War II. In 1946-47, there were about 5,000 tractors; the number rose to 20,000 in 1956-57 and to 50,000 by 1960.

By 1960 the number of tractors in the world reached about 10 million and over half of them were in North America. In 1959, the number of arable acres to each agricultural tractor was about 16 in New Zealand, 27 in West Germany, 40 to 45 in the UK, Norway and the Netherlands, 100 in Canada and the USA, over 250 in South Africa and Australia, 820 in Argentina, 15,000 in Pakistan and 19,000 in India.

The distribution of tractors in the main countries of the world in 1976 is given below.

TABLE 1. WORLD TRENDS IN MECHANIZATION : TRACTORS PER 1000 HECTARES (1976)

Country	*Tractor population (million)*	*Arable land (million ha)*	*Tractors per 1,000 ha*
World	18,303	1,398	13.1
USA	4,380	186	23.5
Western Europe	7,409	127	58.3
USSR	2,402	227	10.6
Japan	0.800	44	181.8
Africa	0.416	195	2.1
India	0.251	165	1.5

SOURCE: *FAO Yearbook, 1977*

IMPORT AND INDIGENOUS PRODUCTION OF TRACTORS

The policy of the Government of India has been to encourage the indigenous production of tractors. As the production of tractors caught up in the country, their import was gradually curtailed. When the Green Revolution gathered momentum from 1967 onwards, the demand for tractors mounted up. Whereas the indigenous production was only 5,714 in 1965-66, it was 62,275 in 1979-80, and the imports were stopped.

TABLE 2. PRODUCTION AND IMPORTS OF TRACTORS DURING THE FIVE-YEAR PLANS

	Production	*Import*	*Total*	*Average annual growth rate*
I. Third Plan, 1961-66				
1961-62	880	2,997	3,877	
1962-63	1,414	2,616	4,030	
1963-64	1,983	2,346	4,329	
1964-65	4,323	2,323	6,646	
1965-66	5,714	1,989	7,703	
Sub-total:	14,314	12,271	26,585	20.2
II. Annual Plans				
1966-67	8,816	2,591	11,407	
1967-68	11,394	4,038	15,432	
1968-69	15,466	4,726	20,192	
Sub-total:	35,676	11,355	47,031	38.1
III. Fourth Plan, 1969-74				
1969-70	18,120	10,478	28,598	
1970-71	20,099	13,300	33,399	
1971-72	18,100	19,739	37,839	
1972-73	20,802	1,000	21,802	
1973-74	24,425	1,000	25,425	
Sub-total:	1,01,546	45,517	1,47,063	9.2
IV. Fifth Plan, 1974-78				
1974-75	31,088	793	31,881	
1975-76	33,252	1,100	34,352	
1976-77	33,146	2,920	36,066	
1977-78	40,946		40,946	
Sub-total:	1,38,432	4,813	1,43,245	12.9
V. Sixth Plan, 1978-80				
1978-79	54,322	—	54,322	
1979-80	62,275	—	62,275	
Sub-total:	1,16,597	—	1,16,597	24.0

Domestic production of tractors started in 1961-62, with 880 tractors. The licensed installed capacity on a two-shift basis was 8,500 units by two firms—the Tractor and Farm Equipment (TAFE) and the Eicher Tractors India Ltd (Eicher). The capacity of the former was 7,000 units, and of the latter 1,500. The TAFE was permitted foreign collaboration with Massey-Ferguson, UK, in 1961 and the Eicher with the Eicher of the Federal Republic of Germany in 1961.

Later on, other firms came up. The licensed capacity and production of tractors from 1972-73 to 1979-80 is given in Table 3.

TABLE 3. LICENSED CAPACITY AND PRODUCTION OF TRACTORS DURING 1972-73 TO 1979-80

Licensed unit	*Licensed capacity (number)*	*Production*							
		1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Units under production									
1 Eicher Tractor Co. Ltd, Faridabad	10,000	854	1,082	1,226	2,012	2,768	3,952	5,603	7,805
2 Escorts Limited, Faridabad	10,000	3,286	4,751	5,867	4,580	5,020	8,444	11,072	11,692
3 Escorts Tractors Ltd, Faridabad	6,000	1,816	2,781	3,838	5,068	4,575	6,363	6,177	7,885
4 Gujarat Tractor Corporation Ltd, Baroda	7,000	549	478	816	940	1,615	2,101	2,700	1,800
5 Harsha Tractors Ltd, Ghaziabad	10,000	—	5	41	1,047	690	914	930	781
6 HMT Limited, Pinjor	12,000	2,508	4,000	6,800	7,000	4,500	6,457	8,062	8,525
7 Mahindra & Mahindra Ltd, Bombay	10,000	10,210	9,251	8,263	6,655	5,099	2,953	8,154	9,802
8 Kirloskar Tractors Ltd, Nasik	10,000	—	21	731	673	291	256	674	1,400
9 Pittie Tools (P) Ltd, Pune	10,000	—	—	58	34	91	155	336	221
10 Punjab Tractors Ltd, Mohali (Chandigarh)	12,000	—	—	650	1,790	3,340	3,486	4,851	6,733
11 Tractor and Farm Equipment Ltd, Madras	7,000	1,579	2,056	2,798	3,553	5,157	5,865	5,763	5,631
	1,10,000								
Units yet to start production									
12 Auto Tractors, Lucknow	12,000								
13 United Auto Tractors, Hyderabad	5,000								
Total : All units	1,27,000	20,802	24,425	31,088	33,252	33,146	**40,946**	54,322	62,275

1 April 1980

ESCORTS LIMITED, FARIDABAD, HARYANA

H.P. Nanda came as a refugee from the West Punjab (Pakistan) to Delhi in 1947. He was a transporter, and owned a fleet of buses in the West Punjab. Enterprising by nature, Nanda started a Company—the Escorts Limited—at Faridabad. The Escorts were the distributors of various imported tractors, including the Massey-Ferguson Tractors, till 1961. After the Tractors and Farm Equipment Ltd (TAFE), Madras, took up the manufacturing programme for the Ferguson Tractors in India, the distribution of northern and eastern India was terminated. The Escorts then sought collaboration with Poland for the purchase of technology for the URSUS tractors. These tractors were initially imported and then were progressively imported in a CKD condition for assembling them, using a suitable range of Kirloskar engines.

A range of models, Escorts 27, Escorts 27W, Escorts 37, etc., were made during this period. By 1965, the Escorts were manufacturing a large number of components, including gears and shafts, developed ancillary industries for manufacturing most of the components, and were no longer dependent on the components imported from Poland.

The sales of the Escorts tractors advanced steadily and the Escorts was progressively gearing up its production from 1970 onwards for manufacturing the complete Escorts engines also. In 1969, the Escorts also went into a joint venture with the Ford Motor Company, USA, for manufacturing the 47-hp Ford tractor, which quicky became the largest-selling tractor in the higher horse-power range.

HMT ZETOR TRACTOR

Among the more popular makes of the imported tractors was the Czech Tractor, Zetor 2011. It was originally imported into India through the State Trading Corporation. In 1970-71 there were nearly 30 thousand HMT Zetor tractors. This make was popular with the Indian farmers, and it has proved its performance over a period of ten years.

In 1965, the Government of India signed a contract with Messrs Motokov, Praha, Foreign Trade Corporation of Czechoslovakia, to prepare a comprehensive detailed report on manufacture and assembly of 12,000 tractors of model Zetor 2011 and some of the agricultural implements for a plant to be established at Ramnagar. A detailed project report was submitted by Messrs Motokov in March 1967. The India machine-tool industry was hit by recession during 1966-69. Hence the HMT was on the look-out for new products different from machine tools. Simultaneously, the Government of India undertook a survey to assess the demand for tractors in the country. This survey indicated that there would be an increasing gap in the demand and the supply of tractors, particularly in the 20-25-hp range. The HMT offered to meet this demand by undertaking

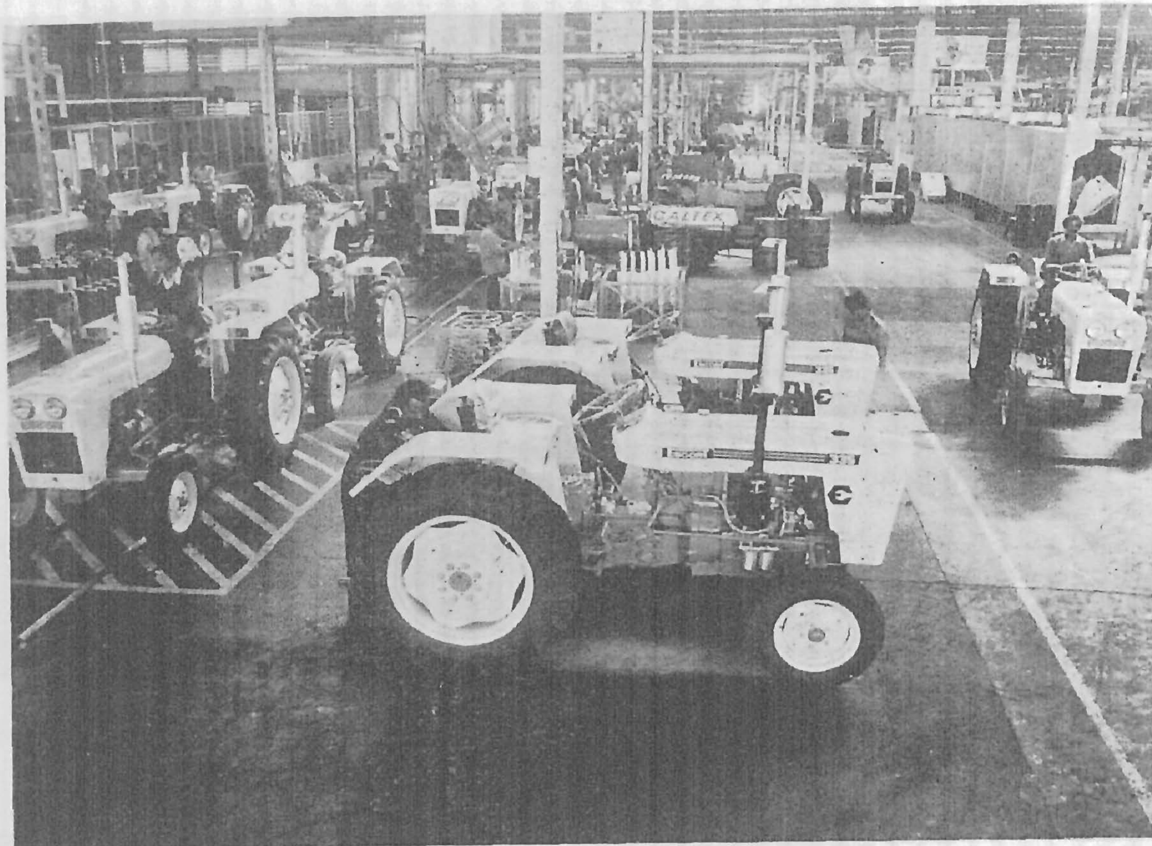


FIG. 86. A view of the Escorts Tractor Factory, Faridabad, Haryana.

FIG. 87. A view of the gears shop of the HMT Tractor Factory at Pinjore, Haryana.

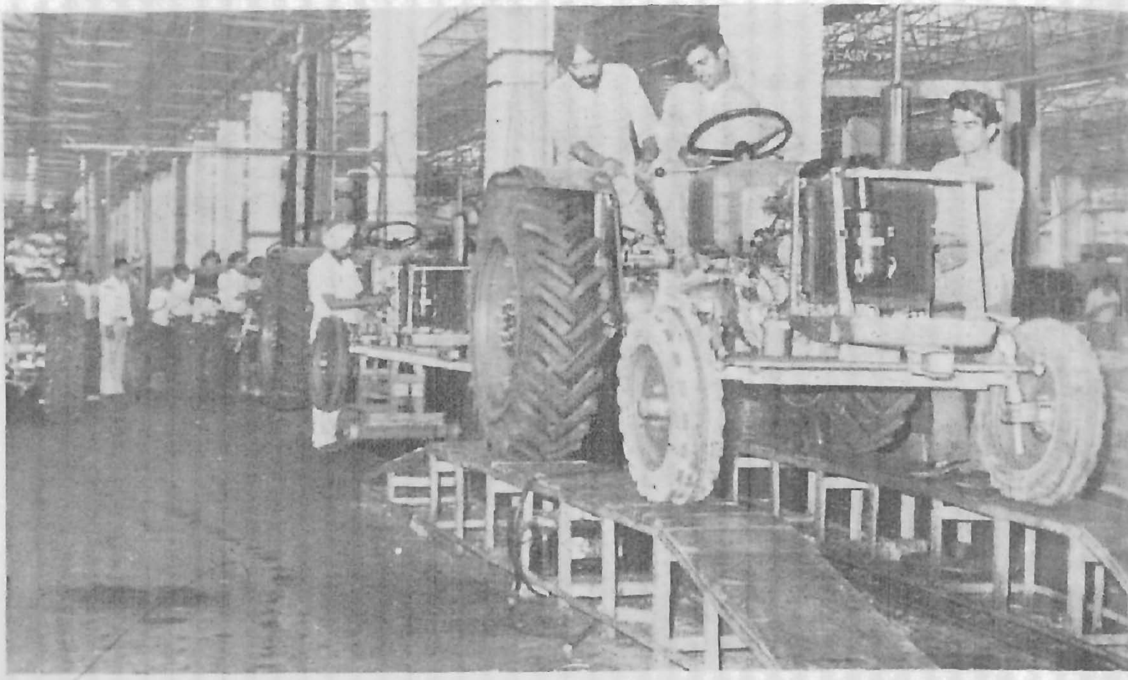


FIG. 88. A view of the tractor-assembly shop of the HMT Tractor Factory at Pinjore, Haryana.

FIG. 89. If fitted at the sides with two iron wheels, tractors can be prevented from slipping and sinking, and muddy rice fields can be ploughed and puddled. With the development of this device, tractors are being used on an extensive scale in rice cultivation.

FIG. 90. Tractors are playing a great role in the agriculture of Punjab. (1) Tractor-drawn seed-cum-fertilizer drills ensure a proper placement of seeds and fertilizer. (2) Trolleys drawn by tractors play a vital role in the transport of foodgrains to the market. (3) Tractors are much used for the levelling of land in Punjab and Haryana.

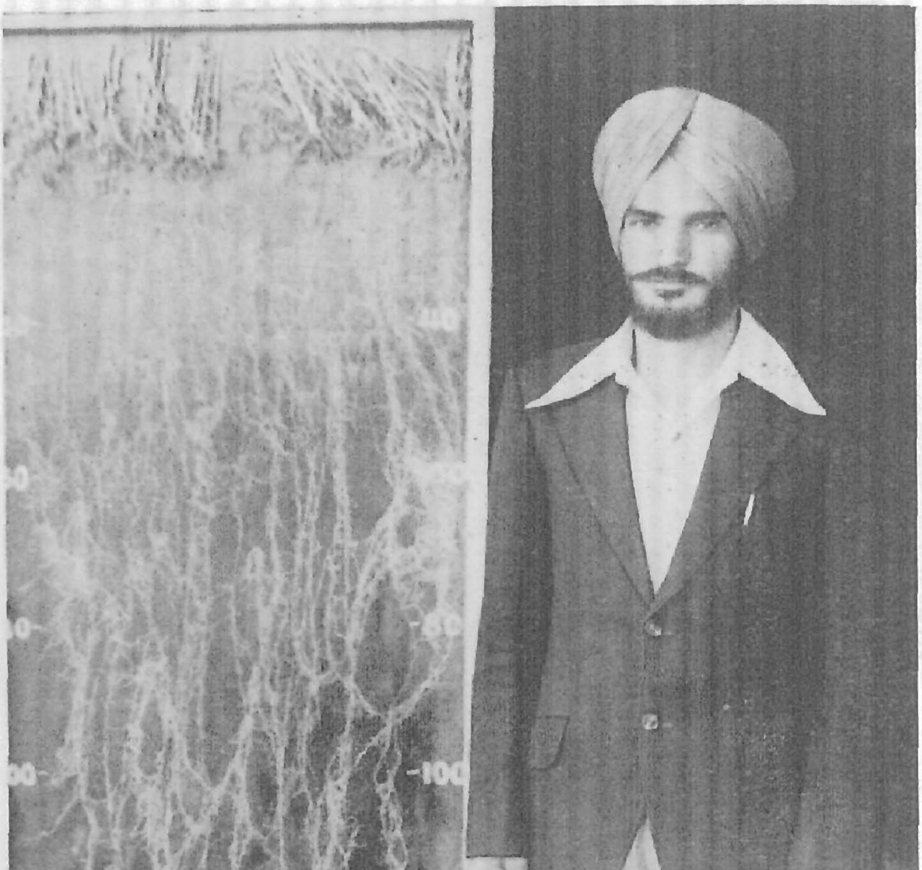


FIG. 91. The man to the right is 1.93 metres tall. The roots of 'Kalyan Sona' wheat to the left are 1.83 metres long, conclusively showing that this wheat variety is a deep feeder in the alluvial soils of light texture. Deep ploughing with the aid of a tractor is hence necessary to break the hard pan to promote the full growth of the roots. (An exhibit in the Soils Museum, Punjab Agricultural University, Ludhiana)

to manufacture the tractor in one of their machine-tool units at Pinjore, Haryana.

Owing to heavy investment in the new project and a ready offer from the HMT, the Government of India entrusted the National Industrial Development Corporation to work out a project report, utilizing spare capacities available at the HMT at Pinjore, and the MAMC at Durgapur. Based upon the above terms of reference, the NIDC submitted its report to the Government in April 1969, recommending manufacture of Zetor 2511 tractors at the rate of 12,000 per annum at the HMT, Pinjore. While recommending Zetor Tractors, it was found that the 20-25-hp tractor was most suitable. Negotiation with Messrs Motokov and their associated factories—Messrs Zbrojovka/ZKL—led to a collaboration agreement signed between Messrs Motokov and Messrs HMT on 20 January 1971 for the manufacture and assembly of the Zetor 2011/2511 tractors a the HMT, Pinjore.

The HMT began the production of tractors in June 1971 under the brand name HMT Zetor. To start with, it was only an assembly operation with almost 100 per cent imported components. However, the rate of production was progressively stepped up from year to year, with a corresponding reduction in the import content. In 1973, it had an indigenous content of 35 per cent, comprising items such as mudguards, dashboards, tyres and rims. The tractor was fully indigenized in about 5 years. All important components of the tractor, such as the engine, the gearbox, the transmission and the hydraulic, are now being made in the plant itself. The yearly licensed capacity of the plant is 12,000 tractors, which is expected to be fully utilized in 1982.

Starting with the HMT Zetor 2511 in the 25-hp range, the HMT has since added two main models to the 35-55/58-hp range. In addition, variants, such as the Hauler, the Rice Special, the Sugacane Special and the Front/Rear Loader have been developed and introduced into the market. Of these, the 35-hp model is the HMT's own development. It was introduced into the market in 1979 under the brand name HMT 3511. This model was the best-seller in 1980, particularly among the farmers who have taken up threshing on the custom-hiring basis.

The HMT's tractor project has led to the development of a large number of small-scale and ancillary industrial units. About 400 small-scale units are supplying material worth about 70 million rupees annually to the HMT.

Besides, the HMT Ancillary Estate at Panchkula, near Chandigarh, now has 26 units working in full swing. The annual turnover at present is worth about 20 million rupees, all of which is booked by the HMT. The ancillary units employ about 500 persons.

To increase the capacity to manufacture tractors from 12, 000 to 15,000 during the next three years, a second line of assembly operation is being set up at Sahibzada Ajit Singh Nagar (Mohali) in the Punjab at a cost of Rs 3.2 million.

Credit

All these tractors are costly and only a few farmers have the means to buy them. The loans from the World Bank for purchasing tractors and the loans advanced by the Land Mortgage and other banks have promoted the sale of tractors.

Development of the Swaraj Tractor, the Vindication of indigenous Technology

The Russian DT 14 was the cheapest tractor in 1964 and could be had for about Rs 7,000. This sturdy machine soon became popular with the farmers in northern India. Moreover, the bulk of the farmers in India own 5 to 10 hectares, and for holdings of this size a 15-20-hp tractor was most suitable. Earlier, hopes were pinned on the Japanese power tillers of about 10 hp, but they never caught up in India. Their failure was mainly due to their low horse-power, on account of which hard alluvial soils could not be ploughed up during the dry months of June and October. Hence the planners' thoughts turned towards the manufacturing of a tractor of 16-20 hp, similar to DT 14.

In May 1965, a mission was despatched by the Government of India to the Soviet Union to negotiate foreign-aid projects in connection with India's Fourth Five-Year Plan. This mission was headed by Asoka Mehta, then Deputy Chairman of the Planning Commission. The mission was composed of civil servants, engineers and scientists, and also included M. M. Suri, Director of the Central Mechanical Engineering Research Institute (CMERI).

Among the projects for which the mission sought support was a Rs 200-million project for manufacturing tractors of 20 hp or less. The Soviet officials indicated to the Indian mission that they could not undertake this project and suggested that India seek the aid of Czechoslovakia. Suri told Mehta that India could develop tractors of below 20 hp without foreign aid. Tractors of 20-50 hp were already being manufactured in India. Since the Indian engineering industry had sufficient unused capacity, Suri was confident that a completely indigenous effort would succeed.

On his return to India, Suri and his colleagues at the CMERI prepared a note detailing the feasibility of manufacturing an indigenously designed tractor. A tractor comprises three major parts: an engine, a transmission, and a chassis. According to the note, different types of internal-combustion engines were manufactured in India to a greater extent than in any other country. Because of limited demand, the production of such engines was uneconomical; the economics of scale would only be obtained if a smaller variety were produced. Producing yet another engine of a different design for the small tractor would only add to the burden on the economy.

The Central Mechanical Engineering Research Institute (CMERI), Durgapur, in West Bengal, where the Swaraj tractor was developed, was founded in 1958. The CMERI is one of the chain of national laboratories under the Council of Scientific and Industrial Research (CSIR). The preliminary work of developing the Institute, namely the erection of buildings, the ordering and erection of equipment, and the recruitment of scientific and technical staff, took a long time. When G. S. Chowdhury became the Deputy Director in-charge in 1962, the Institute's professional staff was composed primarily of scientists, including only two mechanical engineers. During his tenure, Chowdhury enlarged the staff of scientists and engineers. The association of technologists with scientists resulted in a more practical approach to problems and was productive. In June 1964, Chowdhury was replaced as Director-in-Charge by M. M. Suri, an innovative person, who had achieved reputation as an inventor in the fields of the diesel-engine design and of transmission.

Dr Hussain Zaheer of the CSIR, who had brought Suri to the CMERI and supported his efforts to strengthen the Institute's autonomy, retired, and a new Director-General was appointed. Suri's relationship with the new Director-General, who sought to concentrate authority in the parent body at the expense of autonomy of individual research laboratories and their directors, soon deteriorated.

The team working on the tractor project consisted of two production engineers, one production and design engineer, one design engineer, one industrial planner, a foundry expert, a meteorologist and two automotive engineers. In all, five prototypes were prepared and extensively tested at the CMERI and outside at Ludhiana (Punjab) and at Budni (Madhya Pradesh). The first test revealed the weak points of this tractor. After only a few minutes of trial, many parts began to fail. But the leader of the project team learned his lessons fast and every new prototype was an improvement upon the earlier ones.

The import of foreign technology is favoured by businessmen who believe in quick profits, by foreign manufacturers who want an outlet for their manufactures, and by over-cautious administrators who cannot and will not take the risk of an experiment with indigenous technology about which they are not sure. In promoting the development of the Swaraj tractor with indigenous technology, the Punjab State Government showed an unusual courage and foresight. The Government was influenced by other considerations in its interest to manufacture an indigenously designed tractor. For one thing the availability of inexpensive small tractors would contribute to the increase in agricultural productivity. This "commercialisation" of agriculture would help to create capital which would, if invested appropriately, create employment in small industries in urban areas. The production of small tractors would create urban employment in another somewhat more direct way. The manufacture by PTL of an indigenously designed small tractor entails the widespread use of small firms to manufacture component parts; it also requires the use of specially trained village and small-town mechanics to maintain the tractors in service.

The Punjab State Industrial Development Corporation created a firm, The Punjab Tractors Ltd, with headquarters at Chandigarh, to which the team from the CMERI has been assigned. In November 1971, the team of engineers completed the plans for a building to house the Swaraj project on a piece of land located at Mohali (now called Sahibzada Ajit Singh Nagar), 11 km from Chandigarh. In 1973, the building programme of the factory was complete and production was underway. It was estimated that 200 tractors would be on the market in the first quarter of 1974 and about 1,600 by the end of the calendar year 1974.

Suri's association with the team has continued through the firm of Consultant's, Suri Associates, which he formed. The Suri Associates prepared a very comprehensive and systematic project report in three volumes, entitled *Swaraj Tractors*.[1]

The assembling and manufacturing of certain critical parts is carried out within the workshops. The engines are manufactured by the Kirloskars, according to the pattern supplied by the Punjab Tractor Ltd (PTL). Other components come from Bombay, Bangalore, Hyderabad, Shahabad, Faridabad and Ludhiana. The tractor has about 2,000 parts, and of these 1,365 are never manufactured by the tractor factories. The Swaraj purchases more than 80 per cent of the components from the ancillaries in Punjab.

The main credit for the success of this project goes to Chandra Mohan, Managing Director, with many years of experience in production engineering, and research, design and development of a variety of engineering products. Earlier, he was Assistant Director at the CMERI and worked with M.M. Suri. The Punjab Tractors Ltd started with the production of 650 tractors in 1974-75, and in 1979-80 it sold 6,733 tractors. The Farmers' decision to purchase tractors is governed by such factors as the after-sales service, the availability of spare parts, and the moderate price. The Swaraj satisfied all these requirements.

Transition from Bullock Economy to Tractor Economy

The distribution of tractors in the States is revealing. The largest numbers of tractors are in Punjab, Uttar Pradesh, Haryana, Delhi, Rajasthan (Ganganagar District) and Gujarat. Even in 1966, these States had

[1]Aurora, G.S. and Morehouse, W. 'The Dilemma of Technological Choice in India: The Case of the Small Tractor', *Minerva*, Vol. XII, No. 4, Oct 1974.

more tractors than others (Fig. 92). Significantly, these are also the Green Revolution States of India. These are also the States in which land holdings have been consolidated, or the holdings are larger.

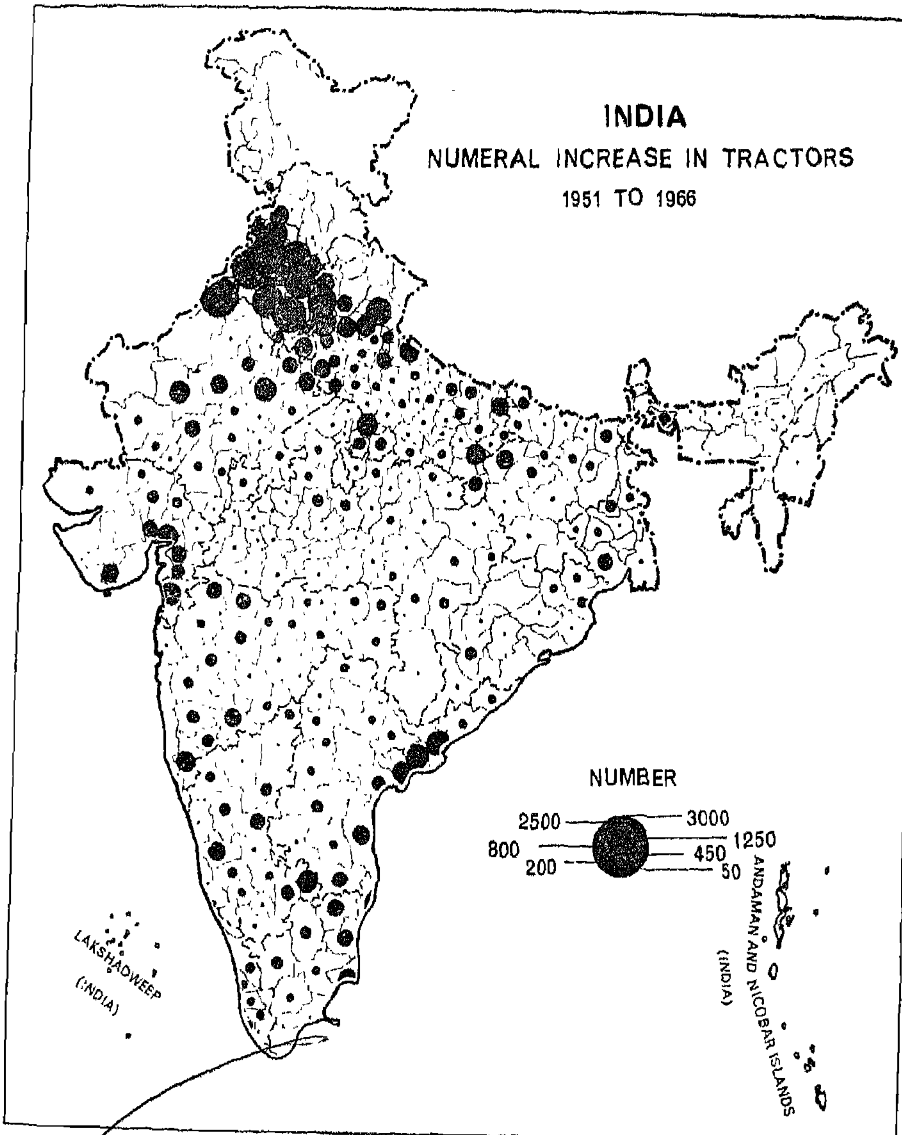


FIG. 92. A map, showing the numeral increase in tractors in India from 1951 to 1956. There was already a large concentration of tractors in Punjab, Haryana, western Uttar Pradesh, the Ganganagar District of Rajasthan, some districts of Gujarat and Andhra Pradesh. The number of tractors has greatly increased since 1966 in these areas, which are the areas of Green Revolution. (After Dr Jasbir Singh, Geography Department, Kurukshetra University)

Tractors contributed to the Green Revolution, which in turn promoted the sale of tractors. In 1966, the starting year of the Green Revolution, Punjab had 10,688 tractors; in 1972, the number rose to 42,400; in 1981, it was 1,24,000. In Uttar Pradesh, tractors are largely used in the western part, particularly in the *Tarai.* In this area, the number of tractors was 10,139 in 1966 and 104,500 in 1981. In Haryana and Delhi, there were 5,256 tractors in 1966 and 66,010 in 1980. The lowest numbers of tractors are found in West Bengal, Orissa, Kerala, Assam, Jammu and Kashmir and Himachal Pradesh. In the last two States, the hilly terrain is the restrictive factor and the same would apply to large areas in Assam and Kerala. West Bengal and Orissa are agriculturally backward. Details regarding the numbers of tractors are given in Table 4.

TABLE 4. STATE-WISE NUMBER OF TRACTORS

	1966 (%)	1978 (%)	*Tractors per 1,000 hectares* 1978	*Estimated stock, Jan* 1981
North Zone				
Punjab	19.7	24.8	12.43	1,24,000
Haryana	9.0	13.6	7.47	68,000
Uttar Pradesh	18.8	20.9	2.78	1,04,500
Rajasthan	7.8	7.4	1.56	37,000
Jammu and Kashmir	0.2	0.2	1.15	1,000
Himachal Pradesh	0.1	0.1	0.93	500
Sub-total	55.6	67.0		3,35,000
West Zone				
Gujarat	6.0	5.0	1.58	25,000
Madhya Pradesh	4.7	4.8	0.81	24,000
Maharashtra	6.1	4.3	0.67	21,500
Sub-total	16.8	14.1		70,500
South Zone				
Tamil Nadu	6.1	3.6	1.17	18,000
Karnataka	4.8	3.6	1.04	18,000
Kerala	0.8	0.8	1.03	4,000
Andhra Pradesh	3.6	4.3	0.95	21,500
Sub-total	15.3	12.3		61,500
East Zone				
Bihar	3.9	4.3	1.02	21,500
Assam	1.7	0.5	0.47	2,500
Orissa	1.2	0.7	0.31	3,500
West Bengal	2.9	0.7	0.28	3,500
Sub-total	9.7	6.2		31,000
All India	100	100	1.82	5,00,000

SOURCE: *Livestock Census 1966 and 1972.* Tractor sales from 1972-73 to 1980-81 have been added to 1972 Census to arrive at the 1981 figures.

The number of tractors in relation to the cultivated area provides us with a barometer for judging the state of agriculture in a State. Punjab, the leading State in agricultural production in India has the largest number of tractors, and it has also the highest growth rate.

Tractor Ownership and Size of Farms

There is a common misunderstanding that tractors are purchased by farmers with large holdings. I know a number of ex-soldiers who hardly own 2 hectares and they operate tractors. They earn their livelihood by custom-service, by ploughing land and by threshing wheat. They provide relief to the owners of uneconomic holdings unable to maintain even a pair of bullocks.

A survey of tractor ownership and the size of farms was carried out in 31 villages in Punjab in January 1971 by Messrs M.M. Suri Associates.

Table 5. Tractor ownership and size of farm in 31 villages in Punjab (January 1971)

Size of farm (in hectares)	*Number of farms surveyed*	%	*Tractors owned among sample surveyed*	*Index* $\frac{T}{F}$
0-8.5	3,298	68	20	0.5
8.5-17	1,304	27	50	3.7
Above 17	228	5	28	12.3
	4,830	100	98	

Source: *Project Report Swaraj Tractor* (M. M. Suri and Associates, Pvt. Ltd), New Delhi, 1971)

The results of this survey (Table 5) show that the largest number of tractors is owned by farmers with land holdings ranging from 8.5 to 17 hectares. At the same time, a significant number of tractors are also owned by farmers whose holdings are below 8.5 hectares. This diffusion of tractor ownership among the owners of land below 17 hectares has been rendered possible by the consolidation of scattered and fragmented holdings.

Farmers who rely for their income on custom-hiring and threshing prefer larger tractors of 35 hp and above.

Tractorization and the Labour-Employment Problem

Some people with no practical experience of farming have deep-rooted false ideas that mechanization will aggravate the rural-unemployment problem by displacing labour. Their attention needs to be drawn to Punjab and Haryana, which have the largest number of mechanized farms and no unemployment of rural labour. In fact, it is the migrant labourers from Uttar Pradesh and Bihar who are now sustaining agriculture in Punjab.

Thus the Green Revolution in Punjab has substantially helped other States, too, by providing employment to unemployed and partially employed farm-workers. Though the employment of a tractor on a farm does displace some workers in its immediate field of operation, mechanization, on the whole, raises productivity and creates more employment opportunities through multi-cropping and intensified cropping. Now there is no slack season in the intensively cultivated areas and farmers keep busy throughout the year.

The National Commission on Agriculture sponsored three separate studies on the effects of tractorization, one each at the National Council of Applied Economic Research (NCAER), New Delhi, the Institute of Economic Growth, New Delhi, and the Administrative Staff College of India, Hyderabad. A common feature of these studies is that tractorization displaces mainly bullock labour and its impact on manpower is much less. The NCAER study had a sample of 21,162 households in 14 districts of Punjab, Haryana, Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Gujarat and Maharashtra. The NCAER study has shown that the negative effects of mechanization are more than neutralized and offset by positive gains, higher incomes and better standard of living. Moreover, numerous new types of jobs are created, viz. those for mechanic shops for repairing and servicing tractors, shops for the sale of tractors and spare parts, and of drivers.

Increase in Productivity and Yield

The NCAER study shows that there are definite and positive increases in average yield ranging from 7 to 72 per cent but averaging 20 per cent in most major crops (Table 6).

TABLE 6. AVERAGE YIELDS PER HECTARE (TONNES)

	Tractor owner	*Tractor user*	*Bullock farm*
Sorghum (*jowar*)	1,456	1,069	0,845
Index	(172)	(127)	(100)
Sugarcane	899	794	747
	(120)	(106)	(100)
Rice	2,922	2,568	2,445
	(120)	(108)	(100)
Wheat	2,169	2,070	1,819
	(119)	(114)	(100)
Pearlmillet (*bajra*)	1,397	1,329	1,230
	(114)	(108)	(100)
Chickpea	1,033	0,703	917
	(113)	(77)	(100)
Cotton	906	870	843
	(107)	(103)	(100)

Mechanization enables the farmers to change their cropping pattern and to shift to more profitable crops as they now have the flexibility and means to sow the crops they want. Thus the impact on output is considerably higher than the direct crop-to-crop increases and the value of crop output thus goes up by 63 per cent as is evident from Table 7.

Table 7 also gives the State-wise break up which shows that the pattern of increase is not even and that the benefits of mechanization are far greater in the rice-growing and dryland states than in the more mechanized States of the Punjab, Haryana and Uttar Pradesh.

Farm mechanization is not a luxury but a necessity. There is a positive relationship between farm power and productivity. Whenever tractors have been used, labour has been made more effective, and accordingly the cost of production has been reduced. After harvesting a crop, there is a race against time to prepare the land and sow the next crop in time. A delay of 15 to 20 days can convert a possible bumper crop into an average or mediocre one. For example, to reap a bumper wheat crop, the sowing of the wheat varieties, 'Kalyan Sona' and 'PV 18', should commence from the first week of November. By sowing them early, these varieties escape exposure to the mid-season rust epidemics and high temperatures near maturity. Delaying beyond the optimum sowing period results in a progressive decline in the yield.

Mechanization enables, to a great extent, the utilization of scarce resources. By levelling the land properly, water is utilized more effectively. Deep ploughing with discs and cultivators prepares the land better for sowing.

TABLE 7. VALUE OF OUTPUT PER CROPPED HECTARE (RUPEES)

State	*Tractor owner*	*Tractor user*	*Bullock farm*
Punjab	3,048	2,819	2,593
Index	(118)	(109)	(100)
Haryana	2,546	2,074	2,171
	(117)	(96)	(100)
Uttar Pradesh	3,121	2,762	2,625
	(119)	(105)	(100)
Tamil Nadu	4,355	3,043	2,435
	(179)	(125)	(100)
Andhra Pradesh	3,611	2,736	2,461
	(147)	(111)	(100)
Gujarat	1,626	1,579	837
	(194)	(189)	(100)
Maharashtra	9,484	7,359	3,965
	(239)	(186)	(100)
All States	3,970	3,196	2,442
	(163)	(131)	(100)

SOURCE: NCAER Study, Implications of Tractorization for Farm Employment Productivity in India.

Proper depth of the seeds and placement with respect to fertilizer with drills optimizes the use of costly chemical fertilizers. Multi-cropping is necessary to utilize the scarcest commodity of all — land. This object can be accomplished most efficiently only by increasing the mechanization of Indian farming. Never was the necessity of mechanized threshing realized more than the time when the first bumper harvests of the high-yielding varieties of the Green Revolution started pouring in. The conventional methods of bullock-treading in conjunction with winnowing could not cope with the harvest, and so mechanical threshers driven by diesel engines, electric motors and tractors were necessary. Most of the threshing is now done with tractors on a custom basis.

Deep Tillage Beneficial for Crops with Long Roots

Some people have a wrong notion that deep ploughing is harmful, as the fertility of the soil is restricted to the top soil. In many unirrigated areas in India, repeated ploughings for centuries with the traditional plough have resulted in the growth of hard compacted layers below the soil (Fig.93). These compacted layers have restricted the infiltration and movement of water and the penetration of roots. Hence it is necessary to go in for mechanized deep ploughing and subsoiling to prevent the top few inches of the soil from being overworked. Many people do not know that the roots of the Mexican wheats are about 1.8 metres long (Fig. 91). Cotton, sugarcane, maize and tobacco are also long rooted. Deep ploughing with tractor-drawn implements, such as discs and chisel ploughs, breaks the hard compacted layer which forms below the top soil by the continued ploughing

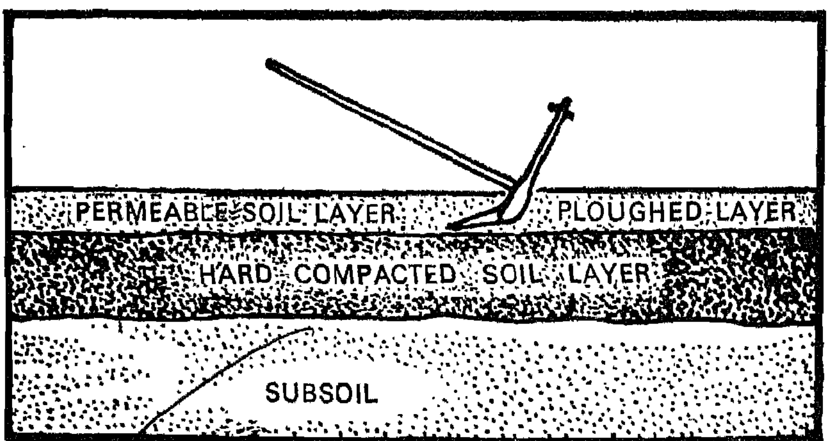


FIG. 93. Repeated ploughings over a long time with the traditional plough have resulted in the growth of hard compacted layers which restrict the infiltration of water into the soil and its movement in it, and the penetration of the soil by the roots.

with the *desi* plough.[3] Thus the roots of the above-mentioned crops are enabled to draw nutrients from the deeper layers of the soil. If mechanization in India can result in deserts, as some people apprehend, by now Bihar would have become the wheat-bowl and Punjab and Haryana large expanses of deserts.

Proper Utilization of Inputs

Mechanization has also led to the proper utilization of inputs, like fertilizers, pesticides and water. This aspect is, however, not fully appreciated. It is well established that with the use of modern equipment, the utilization efficiency of these inputs is substantially increased. For instance, a farmer having a tractor and a blade terracer manages to grade his land to a much better level in course of time. Proper grading helps in reducing water losses during irrigation. Among many other useful aids are the seed-cum-fertilizer drill and well-designed plant-protection equipment. With a seed-cum-fertilizer drill fertilizer is properly placed below the seed. As soon as the seed germinates, nutrients are available to the plant within easy reach.

More Tractors and Fewer Bullocks Mean More Milk

At a time when animals are competing with human beings for food, reducing the number of bullocks through mechanizations is imperative. Estimates show that fodder crops for animals cover one-seventh of the cropped land area. Leaving aside buffaloes and cows, the remainder of the fodder crops are accounted for by bullocks. Assuming a half-half distribution would mean that bullocks have staked their claim to one-fourteenth of the cropped agricultural land in India. If the number of bullocks is reduced by encouraging the farmers to have more tractors, farmers will be able to keep more dairy animals. In fact, milk production in Punjab has increased, mainly because farmers having more tractors and fewer bullocks have, apart from growing high-yielding varieties of wheat and rice, taken up the cultivation of fodder crops like berseem. This, however, does not mean that bullocks will vanish from the rural India. In fact, we are short of bullock power, too, and machines have to supplement animal power.

Benefit to Small and Marginal Farmers

Owners having less than 2 ha are unable to keep bullocks. Before the Green Revolution such persons used to lease out their land on crop-sharing basis to the big farmers, who had surplus bullock power. Now these persons get their land ploughed by tractors on a custom-hiring basis. Thus, they are under no compulsion to share their crop and enjoy the full

[3]Dakshinamurti, C., A. M. Michael, Shri Mohan, *Water Resources of India and their Utilization in Agriculture*, New Delhi, 1973, p. 225

TABLE 8. STATE-WISE CUSTOM HIRING (IN HOURS)

State	*Own farm*	*Custom-hiring*	*Total*
Punjab	311	326	637
Haryana	316	185	501
Uttar Pradesh	317	238	555
Tamil Nadu	133	363	496
Andhra Pradesh	133	363	496
Gujarat	141	598	739
Maharashtra	31	976	1007
All States	197	433	630

SOURCE: NCAER Study, Implications of Tractorization for farm Employment, Productivity and Income

produce of their land. The incidence of custom-hiring in six States is given in Table 8. Only 31 per cent of an average tractor's utilization in India is on a farmer's own land and 69 per cent is on custom hiring on small farmer's land.

Table 8 indicates that in Punjab, which has the largest number of tractors, there is considerable custom-hiring. In dry areas of Gujarat and Maharashtra also, there is high incidence of custom-hiring. The beneficiaries are mostly small farmers who are unable to keep bullocks.

EMPLOYMENT OF THE EDUCATED RURAL YOUTHS

Another benefit of the use of tractors has been that educated young men from the rural area are now being attracted to their farms, for it is convenient to work with tractors which are far more efficient than bullocks. With mechanization, agriculture has been relieved of back-breaking drudgery. Thus the exodus of the educated young men from the rural areas to the cities has been partially checked. This is a trend which should be encouraged.

HIGH PRICES OF TRACTORS

Prices of tractors have escalated enormously during the last ten years. Their prices as in January-February 1981 are given in Table 9. In spite of high prices, they are finding a ready market. This is largely on account of facility of loans provided by banks. Besides, once the farmers get accustomed to a new technology and they find it efficient, they continue using it ignoring economics.

THE FUTURE

The diesel tractor is the most useful invention of the twentieth century. It is a source of power which can be used for diverse agricultural operations, such as ploughing, spraying against pests and diseases, threshing and trans-

TABLE 9. PRICES OF INDIGENOUS TRACTORS IN JANUARY AND FEBRUARY 1981

Tractor	*Make/Model*	*Horse-power*	*Price (Rs) (as on 17 Feb. 1981)*
1 Eicher	Goodearth 241	26.5	40,810
	242	—	43,425
2 Escorts	E-335 ADDC	35	57,810
	E-335 MDC	35	51,000
	E-345 ADDC	35	58,610
	E-350	—	—
	FORD 3600	47	80,640
3 Harsha	T-25	25	54,585
4 HMT Zetor	2511	25	50,686
	3511	35	59,477
	5711	52	73,584
	5911	—	79,687
5 Hindustan	Super	50	73,204
	G-453	—	—
6 International	B-275	35	60,390
	IH-444	44	64,814
7 Kirloskar	D-4006k	43	75,840
	D-6006k	75	2,46,601
8 Pittie	4500	39	61,391
9 Swaraj	*Sartaj*	*18*	*37,100*
	724	25	51,090
	735	35	59,947
10 TAFE	MF-1035	35	63,819
	TAFE-504	50	67,826
	MF-245	47	91,351

SOURCE : Agricultural Engineering Today, Bi-monthly Magazine of Indian Society of Agricultural Engineers, New Delhi, March 1981

portation. They help farmers level pitted and undulating land hitherto lying unutilized (Fig. 90). There are not many who realize the magnitude and importance of this work. Farmers have levelled sand-dunes in Rajasthan, turning a desert into productive land. In the riverain areas, tractors have reclaimed land covered with tenacious deep-rooted weeds, thus providing a new source of crop production—a new Lyallpur on the soil of India. If tractors are withdrawn, India's agriculture would collapse, as it would in other parts of the world. The mounting energy crisis due to the tremendous rise in the price of oil has put food production in jeopardy. India can, however, produce enough power alcohol and keep its tractors working.

CHAPTER 29

FROM THE BULLOCK-DRAWN *PHALA* TO THE THRESHER AND THE COMBINE

THE wheat crop is harvested by landless labourers, who take it up as a part-time job and thus build up their food-supplies for the year. Women participate in harvesting in large numbers and cut the crop with hand sickles (Fig. 94) and tie the cut wheat plants into bundles. The bundles are carted to the threshing-floor plastered with mud. The bundles are then neatly laid on the threshing-floor. In Madhya Pradesh, a stake is fixed in the centre of the threshing-floor, to which a team of eight to ten bullocks is tied. The bullocks tread over the wheat plants and thus the grain gets separated from the chaff.

Wheat is threshed in most parts of India with *phalas* or threshing-frames. The grain is trodden out by the feet of cattle, assisted by the dragging of the *phala* over the outspread bundles. The *phala* consists of a hurdle covered with brushwood and weighted with bricks or clods. The bullocks yoked to the *phala* are driven round and round on the threshing-floor. In a short time, the brittle straw gets broken up into short pieces and the grain is freed from the chaff. One pair of bullocks with the *phala* would tread out the produce of a hectare in ten days. The grain is separated from the chaff by being thrown into the air with a pitch-fork, when the hot winds, which prevail at this time, carry the dry chaff to a distance, whereas the grain falls back on the threshing-floor. The winnowing-basket *(chhaji)* is used to clean the grain so obtained. This process acts in a very imperfect manner, as merely the remaining chaff is removed, whereas small stones and small clods fall down along with the grain. The grain gathered in heaps remains exposed to rain and dust. The chaff (*bhusa*) is used as a cattlefeed and is especially valuable when mixed with chickpea chaff, then it is known as *missa*. When grown with chickpea, the mixed crop is threshed together and the resultant grains are ground together and eaten. In some villages in Haryana and western Uttar Pradesh, cement-concrete rollers or discs with spikes, called Olpad threshers, are used for threshing (Fig. 95). The Olpad threshers were first developed in Gujarat in 1950.

INTRODUCTION OF THE THRESHING-MACHINE INTO NORTHERN INDIA

Threshing-machines had been invented in England and Scotland in early nineteenth century, but had not been introduced into India. In 1841, Mr Tonnochy, Deputy Collector of Bulandshahr in Northern Provinces, as Uttar Pradesh was then called, informed the Secretary of the Royal Agri-

Horticultural Society of India, Calcutta, that a progressive zamindar of his district, Mohammed Ihad-ullah Khan of Khanpur, had requested him to procure for him a three-horsepower threshing-machine from James Milligan of Carlisle and had placed the necessary funds at his disposal. Tonnochy alluded to Dr Jamieson's *Dictionary of Mechanical Science Arts, Manufacturers,* etc. for particulars regarding the machines of different powers and the quantity of grain they were capable of threshing within a given period of time; and thought the quantity stated was quite sufficient to render the machine of the utmost value to the agricultural interest of India "for nothing bears more heavily on the agriculturist and retards his progress in a greater degree than the time, labour and expense attending the treading process which for the *rabi* harvest alone occupied both men and cattle for no less a time than 40 or 50 days, with ruin staring the farmer all this time in the face, it not infrequently happening that a heavy fall of rain, or the early setting in of the rainy season, either destroys his grain by a general flooding of the country or so damages it, as to render it unfit for market."[1] No information is available regarding the practical results which accrued from this experiment, but Tonnochy believed that its successful operation at one place would be the means of its general introduction into the estates of large landlords.

STEAM-THRESHING IN INDIA, 1907

In 1907, steam-threshers were in use in Bihar by the British planters, who had factories along the banks of the Ganga. They grew wheat on vast stretches of riverain land flooded by the river. A thresher was supplied to the Imperial Agricultural Research Institute, Pusa, by Messrs Marshall, Sons & Co. Ltd, Gainsborough, which was specially designed for use in India. It was built of seasoned teak and was mounted on large travelling wheels which enabled it to be readily moved from place to place. With a threshing drum 0.6 m wide, it required a portable engine of five horsepower to drive it, but at Pusa an old eight-horsepower engine used for pumping was employed. The characteristic feature of the thresher was a double-roller straw-chopping apparatus by which the straw, after leaving the threshing-drum, was converted into *bhusa.* In connection with this apparatus, there was a separate attachment (supplied or not as desired) fixed in front of the machine which consisted of a large sifting riddle, with a blower working underneath, designed to intercept any grain which may have passed over with the straw. The thresher was fitted with a self-feeding arrangement, consisting of endless canvas conveyors, by which the grain was carried to a revolving barrel fitted with spikes which, with the assistance of oscillating forks fixed overhead, fed it evenly into the threshing-drum.

[1] *Proceedings of the Agri.-Hort. Soc. of India,* July 1841, Calcutta

The grain was delivered into sacks cleaned and graded into three qualities, or all of one quality, as desired. A special drum could be supplied for threshing other crops, such as paddy or rapeseed. The cost of the thresher, landed at Calcutta, with the improvements above described, was about Rs 4,500.

This thresher was used for threshing wheat, barley, oats, paddy and pigeonpea (*Cajanus cajan*) at Pusa. The total amount of cleaned grain delivered in eight hours was 41 tonnes. Coal and wood were used as fuel on different days. The consumption of coal averaged 448 kg, and of wood 896 kg a day.

According to E. Shearer, the Imperial Agriculturist, 'The straw-bruising apparatus worked quite satisfactorily producing *bhusa* in every way equal to that given by treading. Except for jamming in moist weather, it gave no trouble and this was remedied by lighter feeding. The sifting riddle working in connection with this recovered quite an appreciable quantity of grain, especially in moist weather when threshing is imperfect, and quite repays its cost. The self-feeder worked admirably and largely gets over the very great difficulty of training coolies to feed evenly and uniformly. It is probable that it increases the daily outturn by at least 25 per cent. The grain delivered was clean sample, quite free from the dirt found in that removed from the threshing-floor'.

Shearer points out the risk of fire in regard to the working of threshers in hot dry weather. 'This may arise either from overheated bearings or from a spark from the engine or even a hookah falling on to the dry straw. In several instances in Bihar, threshers have been completely burned down in this way, and some planters for this reason will only have machines built on an iron framework. The risk of fire, however, is not very great if reasonable precautions are taken. At Pusa, the practice is to stop the engine at the end of every hour to examine and oil all the bearings. The engine is set up in such a way that no sparks will blow towards the thresher or the straw, smoking in the neighbourhood is strictly prohibited, and as a final precaution, a score or so of earthen pots or empty kerosene tins are always kept alongside filled with water.'[2]

Reaping Machines for Wheat in Punjab, 1908

The Canal Colonies of Punjab suffered from the scarcity of labour at harvest time for wheat. The average daily rate of harvest labour was Re 1 per man, payable in kind, and the cost of reaping, Rs 5 per acre (Rs 12.36 per hectare). This was regarded as exorbitant at that time. Reaping in the Punjab meant, in addition to the cutting of the grain, the binding of the cut crop into bundles, and carrying them to the threshing-floor. The

[2]Shearer, E. Steam Threshing in India, *Agric. J. India*, Vol. 2 (Pt 3), 1907

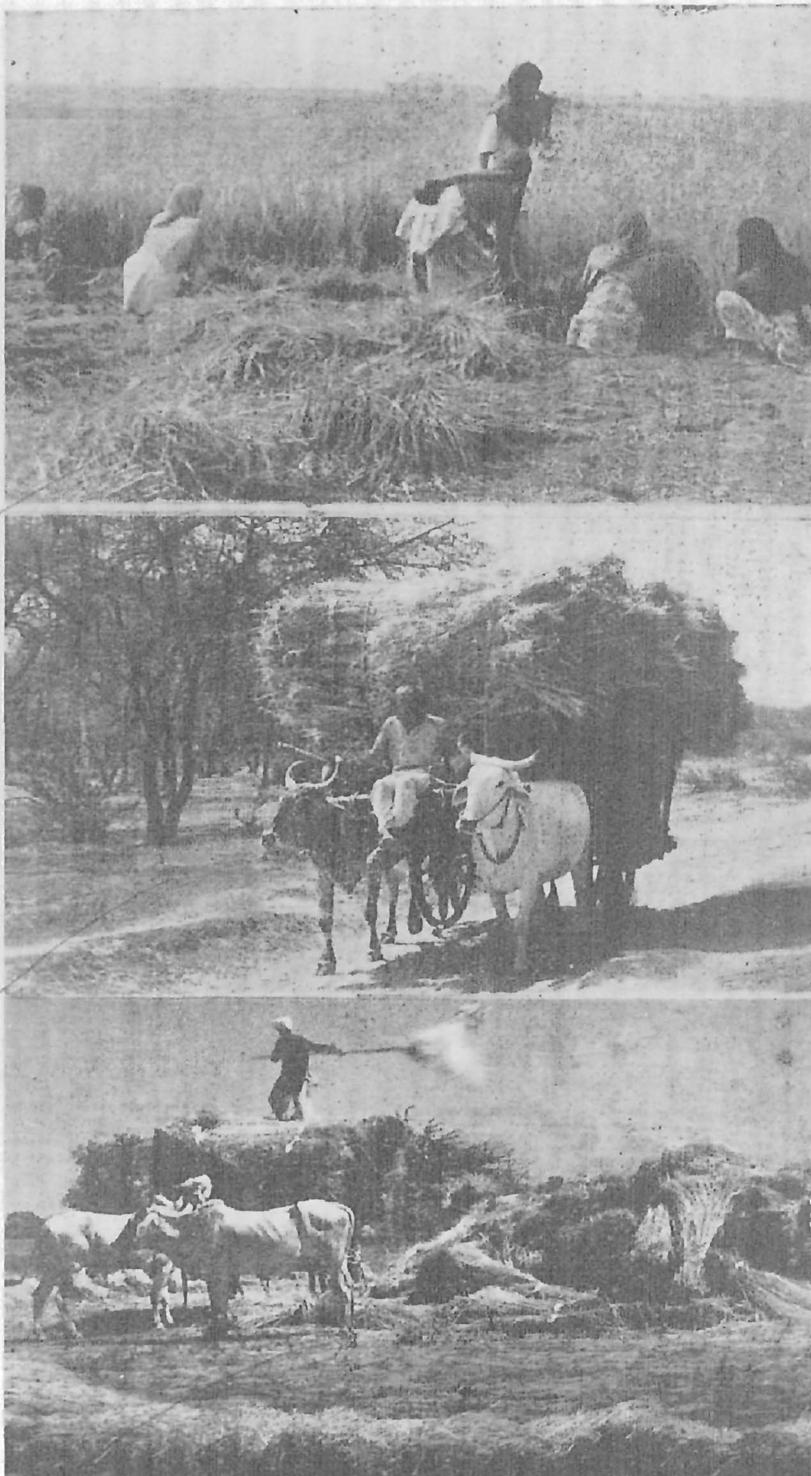


FIG. 94. Women harvesting the wheat crop (*top*). A farmer transporting the bundles of wheat from his field to the threshing-floor (*middle*). The bundles of wheat being laid on the threshing-floor (*bottom*).

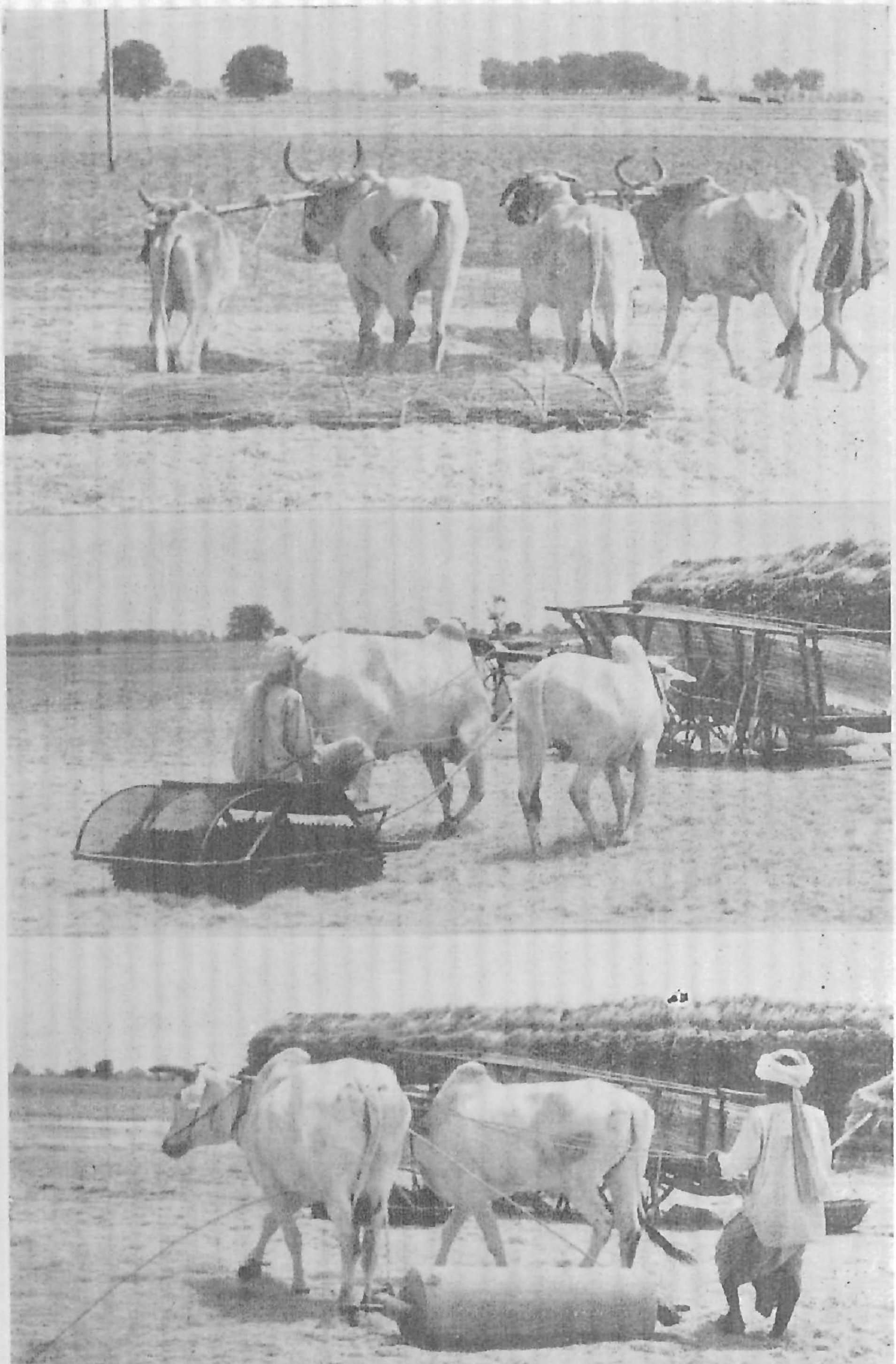


FIG. 95. Various methods of threshing wheat with bullock power in Haryana. (1) *Phalas*, a bundle of thatch tied to a plank, was in common use before the Green Revolution. (2) The farmers, who cannot afford threshers or tractors use Olpad threshers (discs with spikes for threshing wheat) in Haryana. (3) A farmer, using a concrete roller for threshing wheat.

FIG. 96. After threshing, the wheat straw is raked with forks. It is an arduous work which is no longer seen in Punjab consequent upon the use of threshers.

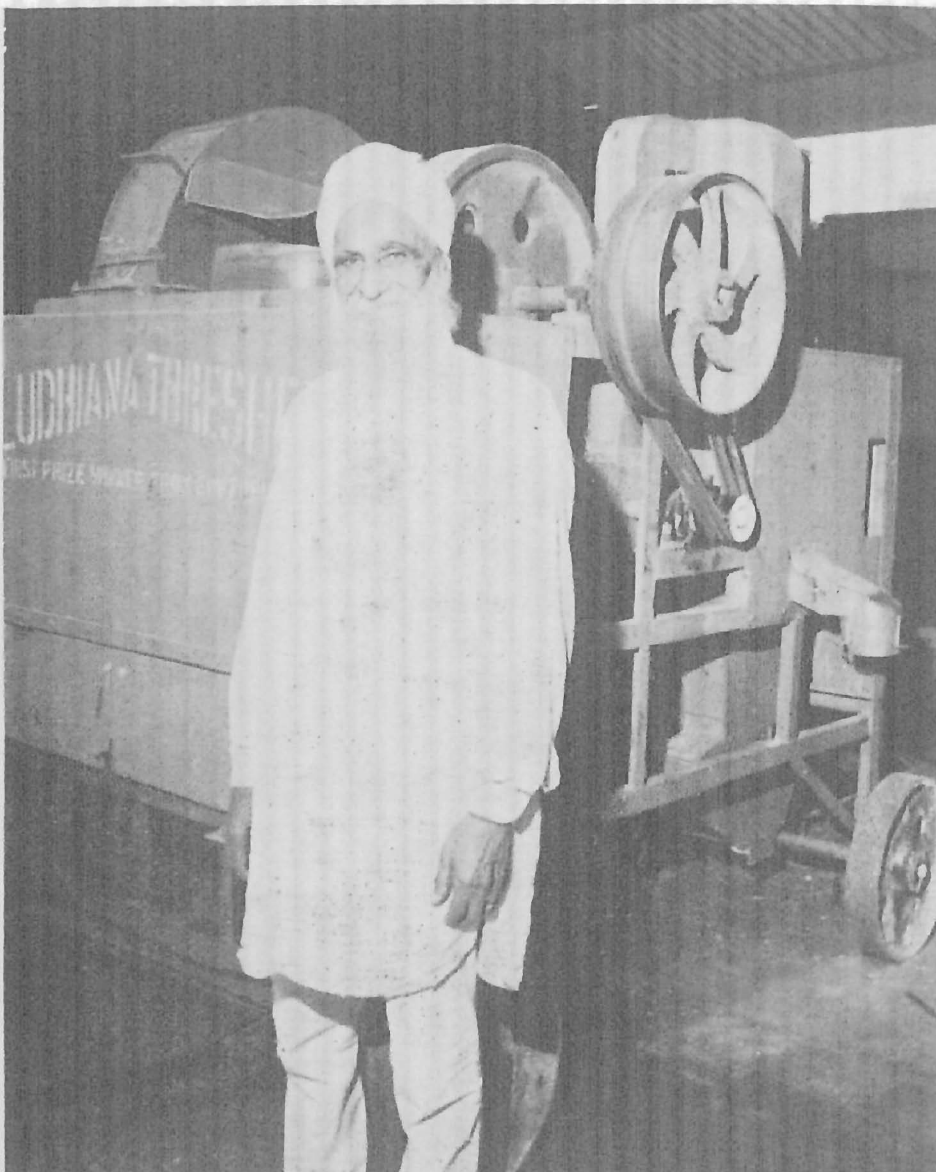


FIG. 97. Sardar Sundar Singh, an artisan of Ludhiana, who pioneered the manufacturing of the wheat-thresher, in collaboration with Shri S.K. Paul, Agricultural Engineer of the Punjab Government, in 1958.

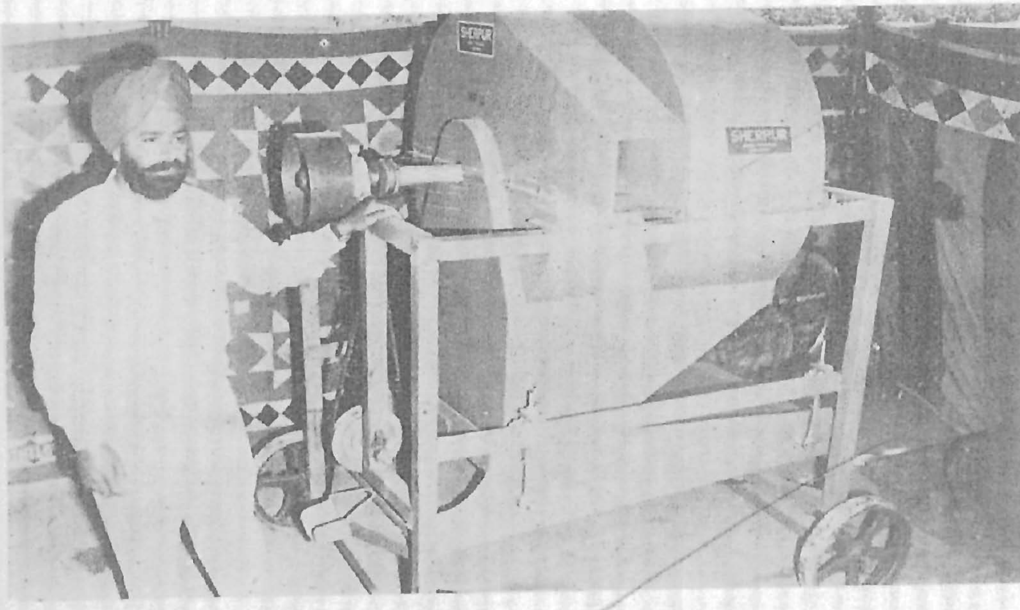


FIG. 98. The peg-tooth-type Sherpur thresher on display at the Farmers' Festival at the Punjab Agricultural University.

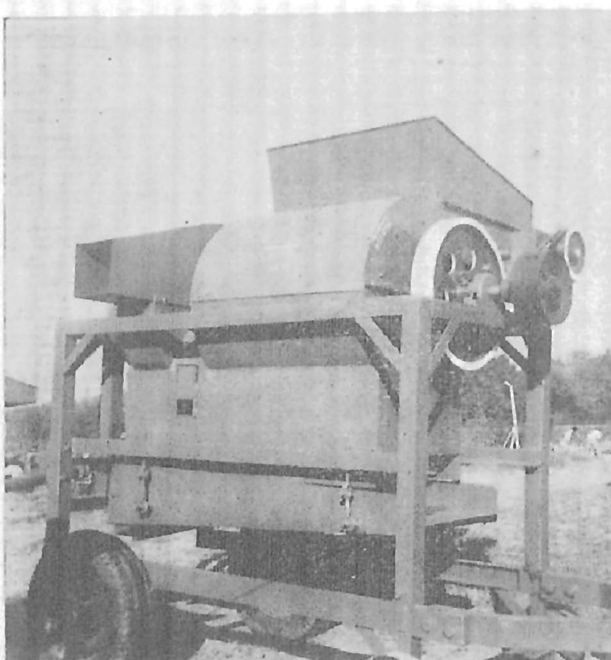


FIG. 99. The bulkfeed Sherpur thresher, developed by the Union Forgings Ltd, Ludhiana, in 1975. It threshes 8 to 10 quintals of wheat a hour. It is commonly used for custom threshing by the owners of tractors. (Photo: S.R. Varma)

FIG. 100. Tractors are extensively used in Punjab for threshing wheat. (1) An owner of a tractor carrying his thresher on a trolley to the threshing-floor (*above*). (2) A tractor threshing wheat. Pyramids of *bhoosa* (wheat-straw) dot the countryside of the Punjab during May (*below*).

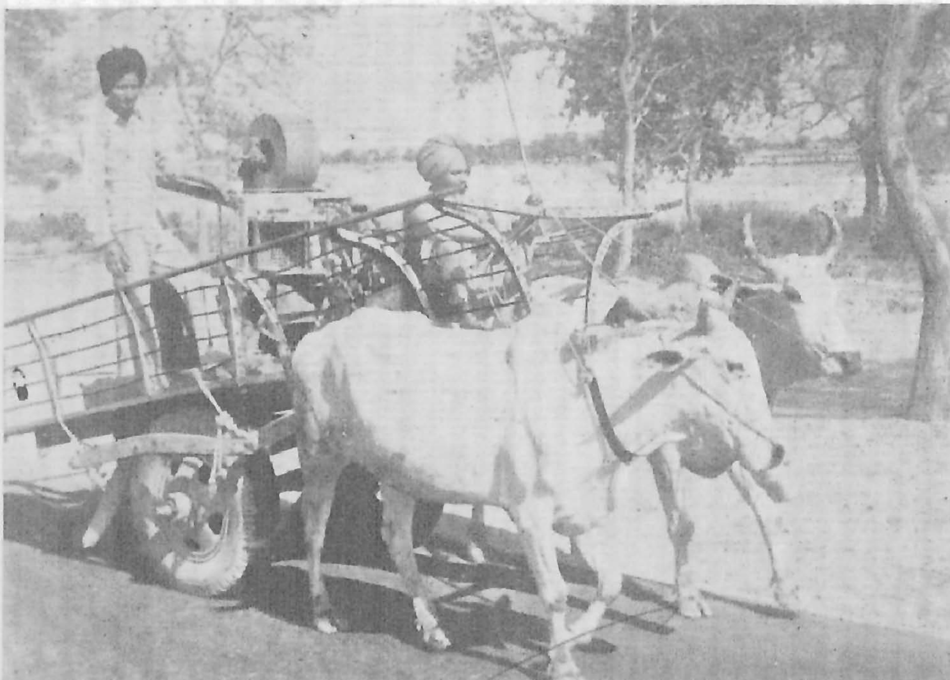


FIG. 101. Some blacksmiths and masons in Punjab have adopted custom threshing with the aid of portable diesel engines. (1) A blacksmith carrying his diesel engine and thresher in a bullock-cart with pneumatic tyres *(above)*. (2) A small thresher, worked with a diesel engine, threshing wheat *(below)*.

FIG. 102. Combines are necessary in the districts of Punjab where rice-wheat rotation is adopted, particularly when there is a shortage of labour. Rice should be harvested by October-November, so that land is available for the timely sowing of wheat. Now combines are no longer imported and are manufactured in India. Swaraj 8100 Combine manufactured by the Punjab Tractors Limited, Mohali, harvesting paddy.

high cost of labour led to search for reaping machines. Trials were made with bullock-drawn reapers in the Lyallpur District. S. Milligan, Deputy Director of Agriculture, Punjab, concluded from these experiments, that on the whole the results were encouraging and it was well established that the adoption of machines of a suitable type will prove a success in the Canal Colonies.[3]

Trial of Steam Threshers at Lyallpur, 1912-1914

We next hear about the trial of steam threshers in the Lyallpur District from 1912 to 1914. Two Ransome Threshers were given a trial. In this machine, wheat was threshed and partly bruised in the first or feeding cylinder and the grain was taken out by passing down sieves before the straw was finally bruised. Both drums were simple cylinders fitted with beaters which were set helically on the drum and made to revolve through a concave fitted with abutments. The degree of fineness of the *bhusa* was governed principally by setting the concave nearer to or farther from the cylinder.

The 30-inch Thresher

This machine was worked near Buchiana to the east of the Lyallpur District, and was taken to about 10 places, working for 2 or 3 days at each place. The arrangements for the work of this machine were made by Rai Sahib Sewak Ram, of Gangapur. Users were charged half rates only, i.e. 2 annas a maund (Rs 3.38 a tonne, coal and oil being supplied by Messrs Octavius Steel & Co.). The outturn of grain per hour worked out at 4.62 maunds (171 kg), the total number of working hours being 160.

The 48-inch Thresher

This machine was worked on the same lines as the above near the Agricultural Station, Lyallpur, and was taken to 8 centres within 10 miles (16 km) of the Farm. A traction engine was used in the earlier stages of the trial to drive the machine, which ran very unsteadily and caused some belt trouble. Later on, an 8-hp low-pressure steam-engine was obtained and the work progressed much more smoothly. The average outturn was 10.48 maunds (388 kg) per hour, with a total of 180 working hours. The highest average for one day was 12.74 maunds (471 kg) per hour, the machine working for 8½ hours.[4]

Threshing Experiments in U.P., 1923-1929

At Cawnpore in 1923 to 1926, Low experimented with two threshers

[3]Milligan, S. Reaping machines for wheat in the Punjab, *Agric. J. India*, Vol 3 (Pt 4), 1908

[4]Roberts, W. (1915) 'Trial of steam threshers at Lyallpur', *Agric. J. India*, Vol.10

of the same type, namely a 30-inch Ransomes NIL Straw-Chopping Thresher, driven by a 4-hp steam-engine, and later, in 1927, a new 30-inch Ransomes Mosquito Straw-Chopping Thresher, driven by an 8-hp portable steam-engine. The cost of threshing per maund of grain worked out in both cases at 11 annas and 3 pies (Rs 18.90 a tonne). The old out-fit was purchased in 1913 and the new one in 1926.

In the *rabi* season of 1928-29, a similar experiment was conducted by C. Mayadas, Professor of Agriculture, on the Agricultural College Farm at Cawnpore with a 22″×38″ McCormic Deering Thresher, fitted with a *bhusa*-making attachment and driven by a 15-30 -hp kerosene International Motor Tractor. Mayadas concluded that the cost of threshing wheat and other similar cereals was considerably less with improved machinery than with old methods. 'The actual gain to the *kisan* in the cost of production of wheat by using modern threshing machinery is considerable. The use of such machinery releases a large amount of bullock and hand labour which can be profitably employed for preparing the land for growing other crops, such as early fodders and cotton.'[5]

THRESHING BY TREADING WITH TRACTORS, 1956-59

Before the development and introduction of power threshers into India in the late 1950s, four-wheel tractors were also used for threshing cereal crops such as wheat and paddy. The crop was spread in a thin layer over the threshing-floor and the tyres treaded the crop and helped to cut down the time required for threshing significantly. This unconventional use of tractors led to faster and uneven wear on the tyre treads, and there were fire hazards too.

THRESHERS

With the introduction of the tractor as a source of mobile power, many kinds of implements and machinery have been introduced into the Green Revolution areas of the country. These are trailers for transportation, and cultivators, disc plough and rotavator for cultivating land. For applying chemical fertilizers, tractor-mounted liquid-fertilizer applicators and seed-cum-fertilizer drills have been developed. Of these, the seed-cum-fertilizer drills, which place seed and fertilizer at a proper level have proved to be most useful, particularly for sowing wheat. For the potato crop, planters and harvesters have been developed. Similar machines have been developed for planting and harvesting sugarcane. The most useful machines which have been developed to meet the challenge of bumper crops of wheat are the threshers, which have changed the rural scene in Punjab, Haryana, the *tarai* of the Nainital District in Uttar Pradesh and

[5]Mayadas, C. (1930) 'Observations on the economics of threshing', *Agric, J, India,* Vol. 14

in the Ganganagar District in Rajasthan.

The main types of threshers and their working mechanisms are described in the following account.

Hammer-mill or Beater-type Threshers

The threshing mechanism in this type of thresher comprises radially arranged arms (beaters), made of mild-steel square section, with a weight welded at the top. The beaters revolve inside an enclosed casing. Ribs are provided on both inner sides of the upper half of the casing. The lower half, known as concave, has rectangular openings. The crop is inducted into the threshing-drum through a feeding-chute. Threshing is effected by the rubbing and repeated impacting of the material by the beaters till the material falls through the concave. The beaters revolve at a top speed of 1,600 to 2,000 rpm. Clearance between the beaters and the concave for the threshing of wheat is kept at about 18 to 20 mm. Owing to the "hammer-mill" action of the thresher, the crop to be threshed should be dry. This type of thresher is a dual-purpose machine, as it combines the functions of a thresher and a straw-bruiser.

A large number of such threshers are currently in use in the country to thresh wheat and other *rabi* cereals. These are, however, unsuitable for threshing paddy, as the *bhusa*-making is an integral design feature of these machines, In the case of paddy, the straw cannot be bruised owing to the high-moisture content and is also not required to be bruised finely. These machines are made in various sizes and capacities and are operated by prime-movers of 5-40 hp. The grain-output capacity of a typical thresher of this type varies from 20 to 25 kg per hp-hr.

Drummy Threshers

These threshers have only the provision for threshing but not of separation and cleaning of the grain. The aspirator fan and sieves are not provided in this type of thresher. A paddle-type centrifugal blower is, however, provided for partial cleaning of the grain falling through the concave. The chief advantages of these threshers are their simplicity and low cost. They are worked with the same electric motors that run the tube-wells.

Complete Threshers

These threshers are designed for complete threshing, separating and cleaning of the grain. An aspirator fan and set of two oscillating sieves are provided for the purpose. The material falling through the concave enters a closed chamber, from where the *bhusa* is sucked in by the fan and the grain is left on the upper sieve. The *bhusa* is ejected from the outlet of the fan and the grain after the cleaning on the sieves is elevated by a bucket-type elevator and bagged.

Spike-tooth Type Threshers

This type of thresher has a cylindrical drum, with 5 to 6 rows of spikes (pegs), mounted on the periphery of the drum. The shape of the spikes used in the threshers manufactured in Punjab, Haryana and other areas in India is entirely different from that used in the Western countries in such machines. Threaded mild-steel bolts are used in place of the spikes. In the closed concave-type machines used for wheat and other *rabi* cereals, the crop is threshed as a result of the impact and rubbing action generated in the machines. Separation is effected through aspiration of the material falling through the concave. Cleaning is effected on a set of oscillating sieves, with which these machines are provided. Hence the separation and cleaning system of this type of thresher is the same as that of the beater-type thresher. The spike-tooth thresher is, however, simpler in construction in so far as the cylinder and the aspirating fan are mounted on a common shaft. The drive to the oscillating sieves comes from the main shaft with the help of a crossed V-belt. The output capacity of a typical thresher of this type ranges from 25 to 30 kg of grains per hp-hr. Hence this machine is more efficient from the energy-utilization point of view than the beater-type thresher. It is also simpler in construction and light in weight. The design of this type of thresher was first developed at the design, development and testing centre at the Agricultural Institute, Allahabad, during 1963-65. The crop is fed through a feeding-chute in the case of smaller threshers (up to 15 hp) and through a bulk-feed hopper in the case of larger ones. It requires less of effort to feed the material owing to the radial-feeding.

The Ludhiana Threshers: Sundar Singh and S.K. Paul

Till 1950, only a few stationary power-threshers of rasp-bar or peg-tooth type, imported from Western countries, were used on some government farms and a few privately owned large farms. These threshers were expensive and large and did not make *bhusa*. In 1953, Sardar Pratap Singh Kairon, then Development Minister of Punjab, ordered that a power-operated machine suited to Indian conditions be developed, for threshing and winnowing wheat. The task was entrusted to the Department of Agriculture, Punjab. S. K. Paul, the Agricultural Engineer (Implements) in the Department of Agriculture and Sardar Sundar Singh, Proprietor, Messrs Friends Own Foundry and Workshop, Ludhiana, joined hands to develop a prototype of India's first power threshers for wheat which combined the functions of threshing, winnowing and *bhusa*-making. This prototype was developed in the mid-1950s and a limited commercial production was started by Messrs Friends Own Foundry and Workshop in 1958. In the early 1960s, many other small-scale manufacturers started making the power-threshers developed by S. K. Paul and Sundar Singh in different sizes. This machine, popularly known as 'Ludhiana threshers', revolutionized the threshing of wheat in Punjab and found acceptance in the neighbouring wheat-growing regions as well.

Another small-scale manufacturer of Ludhiana, Messrs Standard Agricultural Engineering Company (SAECO), owned by Gainda Singh, also took up in 1961 the manufacturing of the Ludhiana thresher, with slight modifications.

SHERPUR THRESHER (PEG-TOOTH TYPE)

The Farm Implements Design and Development Centre, established with the financial support of the Ford Foundation at the Allahabad Agricultural Institute, Allahabad, resolved that there was a need for the design and development of more efficient power-threshers for wheat and paddy. As a result of the intensive research and development work carried out at the Design and Development Centre, a peg-tooth cylinder-type thresher was developed during 1964-65. This machine had a threshing cylinder with spikes and an aspirator fan to separate the *bhusa* from the grain. It works on a principle similar to the one used in the beater-type thresher, developed earlier in Punjab. This design was much more compact and more efficient in energy utilization. This project was piloted by E. C. Peter, the Development Engineer, at the Design and Development Centre, Allahabad Agricultural Institute, Allahabad. This design was brought to Punjab by 1965 and initial testing was done at the Punjab Agricultural University, Ludhiana, by Dr S. R. Verma. It took another 2-3 years to modify this machine and develop the present-day peg-tooth type of thresher before its commercial manufacture in Punjab. Today, it is estimated that over 70 per cent of all the power-threshers manufactured in Punjab are those of the peg-tooth cylinder type. These machines tested at the Farm Machinery Testing Centre of the Punjab Agricultural University, Ludhiana, have shown that their work output and energy utilization are considerably higher than those of the original beater-type threshers. Sardar Inderjit Singh, a progressive farmer, and a refugee from Lyallpur Canal Colony, paid a visit to the USA to gain experience of technology of mechanised farming. On return from USA, he took up the manufacturing of this thresher at his factory, known as Union Forgings, in the Village of Sherpur, near Ludhiana, in 1963. This machine, manufactured in different sizes and with different design features, has now more or less completely replaced the original Ludhiana thresher in Punjab and is finding wide acceptance in Rajasthan, Haryana, Uttar Pradesh, Madhya Pradesh, and Bihar (Fig. 98).

The bulk-feed thresher in which bundles of crop are thrown into a hopper, provided over the threshing cylinder, is now popular with the farmers who carry on custom-threshing (Fig. 99). Apart from threshers, Inderjit Singh manufactures a range of agricultural implements, viz. rotavators, potato planters, chaff-cutters and multi-crop seed-cum-fertilizer drills.

The Toka-type Thresher

The development of the *toka*-type of chaff-cutter-type thresher, popularly known as 'Syndicator', also took place in 1969. Its development was in response to difficulties faced by the farmers in threshing their crop as a result of untimely rains in April and May for two years in succession. The credit for the development of this design goes to the Ramgarhia artisan of Punjab. When the beater-type and spike-tooth cylinder-type threshers were found to be incapable of handling wet wheat, it was thought necessary by these innovative artisans to combine the principle of the chaff-cutter into a threshing machine, so that the wet wheat crop could be handled without creating the problem of clogging the machine. Hence the *toka*-type design was developed. The chaff-cutter-type threshers are manufactured in the towns of Goraya, Phagwara, Jullundur, Moga, Samrala and Ludhiana in Punjab. It is estimated that nearly 20-25 per cent of the threshers currently being manufactured in Punjab are of the *toka*-type.

Thresher-safety Devices

Today, about 600,000 power-threshers are reported to be in use in the country. The limb injuries suffered during the feeding of the crop by the thresher-operators is a serious problem. The agricultural engineers of the Punjab Agricultural University, Ludhiana, conducted a Census Survey in 1976 and found that about 300 persons were injured while feeding the crop into the power threshers each year. This danger to the limbs prompted them to design safe crop-feeding systems and devices. Based on the work done by Dr S.R. Verma, Dean, College of Agricultural Engineering, and his associates, the Indian Standards Institution (ISI) has formulated standards, giving specifications of different safe feeding devices. The majority of the threshers use a feeding-chute, which has a base length of 95 cm. A cover length of 45 cm is fitted to the thresher at a proper slope to facilitate the easy feeding of the crop. Such a chute affords complete safety to the operator and protects his hands against accidents caused by the fast-revolving components.

Introduction of Combine Harvesters

With the increase in the area under wheat, the Punjab farmer faced the problem of labour shortage during the wheat-harvesting season. This shortage is largely because the younger generation of the Harijans of the Punjab got employment with the Government and in the private sector on a liberal scale and gave up agricultural work. The migratory labour from Bihar, Uttar Pradesh and Rajasthan has not fully filled the gap. On account of double cropping, the paddy crop has to be harvested quickly, so that land becomes available for sowing wheat. Sometimes, extensive damage is caused to the wheat crop by untimely rains and hail. Thus the need of the combine-harvesting was felt. A tractor-operated "Vicon" combine, with a 5-foot (1.5-metre) cutter was demonstrated on the Campus of the Punjab Agricultural University in April 1970 by a Dutch Company, Messrs Vicon Limited, Neiuw Vennep, Holland. This Company organized a large number of demonstrations in Punjab during the wheat-threshing season of 1970, and sold about two dozen machines in Punjab in the subsequent year. By 1973, the Vicon Company started the indigenous manufacture of the tractor-operated combines in their own factory at Bangalore. Today, about 1,200 such combines are reported to be in use in Punjab. About 2,500 of these machines are reported to be currently in use in India.

Another milestone in the field of mechanized harvesting of wheat was the introduction of the self-propelled combines. Messrs ESPI Trading Company, Faridabad, imported a few hundred self-propelled combines of E-512 make from the German Democratic Republic. Most of these combines were bought by the Punjab Markfed, Punjab Agro-Industries Corporation and some private entrepreneurs. In all, about 200 combines were sold in Punjab by 1972. All these machines were used for custom-cum-hiring.

The problems of the Punjab farmers multiplied year after year owing to the constant increase in the yield per hectare and the gross area under wheat production. Thus the Punjab farmers demanded more combine harvesters. However, the import of combines was banned by the Government of India, ignoring the genuine problems of the wheat-growing farmers in the northern part of the country.

Swaraj 8100 Self-propelled Combine

During 1980, a 14-foot (4.27-metre cutter bar self-propelled combine-harvester was developed by Messrs Punjab Tractors Limited, Mohali. The project was piloted by Chander Mohan, Managing Director, and G.S. Rihal, Manager of Research and Development Wing of the Company. Thus India's first self-propelled combine-harvester of a totally indigenous make was successfully developed and tested during 1980. It has been given the brand name Swaraj (Fig. 102). It is reported that during the wheat-threshing season of 1981, about 40 such combines had been sold in Punjab. These combines are capable of harvesting wheat and paddy successfully. The new factory of Punjab Tractors Limited, with a capacity for producing 300 combines per year, has been constructed and has gone into production since May 1981.

Threshing with *phalas* has disappeared from Punjab. Threshing is now done with threshers, operated with tractors, diesel-engines or electric motors.

Portable diesel-engines are carried in bullock-carts with pneumatic wheels, by carpenters and blacksmiths who carry on this work during the threshing season and gather enough foodgrains to last them for a year (Fig. 101). However, most of the threshing is done with tractors, and during the threshing season a number of tractor-trolleys can be seen carrying threshers to the fields (Fig. 100).

As a result of mechanical threshing, the entire wheat crop, which is about 300 per cent as compared with the crop in 1965 and earlier, is threshed in about a month and reaches the market by the middle of May. Before the Green Revolution, the threshing season extended up to middle of July and a good deal of the crop was damaged by rain. Now, because of mechanical threshing, the work is done much faster. In fact, it is the compulsion of handling a much larger crop which has led to the development of threshers. The greatest service which the tractors are rendering is in the threshing of wheat.

CHAPTER 30

GREEN REVOLUTION IN INDIA-I

HIGH-YIELDING VARIETIES PROGRAMME, 1966
THE MEXICAN DWARF WHEATS SPARK THE GREEN REVOLUTION
THE ROLES OF DR N. E. BORLAUG AND DR M. S. SWAMINATHAN
THE IMPACT OF DWARF WHEATS ON PRODUCTION

THE Intensive Agricultural Programmes (IADP and IAAP) had shown that it was possible to increase food production in India even with the existing varieties of food crops. Our best varieties of wheat and rice, given adequate doses of fertilizers, could give 20 to 30 per cent more production. However, the defect with these varieties was that they could not stand high doses of chemical fertilizers and had a tendency to lodge. When the crop was nearing maturity, the slim stems of wheat and rice could not bear the weight of heavy ears of grain, and consequently they lodged. As a result, the production suffered. How was this defect to be removed? It was felt that these varieties be dwarfed, so that with shorter and stiffer straw they could escape lodging and thus give higher yield. We had heard that such varieties had been developed in Mexico, which in 1942 was facing the problems of food shortages and rising population in the same way as we were experiencing in India.

GREEN REVOLUTION IN MEXICO, 1943-1965

In 1942, agriculture in Mexico was in a deplorable condition. Mexico was importing more than 50 per cent of the wheat that it consumed, as well as a considerable percentage of its maize. Wheat yields were low and static, with a national average yield of 750 kilograms per hectare, even though most of the wheat was grown on irrigated land. The use of chemical fertilizers was almost unknown.

In 1943, a co-operative agricultural research and training programme was launched in Mexico. This was a pioneer co-operative project between the Mexican Ministry of Agriculture and the Rockefeller Foundation, initiated at the request of the Mexican Government, for assistance in increasing the production of maize, and beans. The man chosen by the Rockefeller Foundation to organize the programme was Dr J. George Harrar, Head of the Department of Plant Pathology, Washington State University. (In 1961, Harrar became the President of the Rockefeller Foundation.) Harrar's team consisted of two plant breeders, a soil scientist, a plant pathologist, an entomologist and a botanist, with a background in library science.[1]

[1]Uribe I. George Harrar sets off the Green Revolution, *The Yearbook of Agriculture*, 1975, USDA, Washington

DR NORMAN E. BORLAUG

The scientist chosen by the Rockefeller Foundation for the Mexican programme in 1944 was Dr Norman E. Borlaug, who later on became the Director of the Wheat Department of the International Maize and Wheat Improvement Centre (CIMMYT), Mexico. He was born on a farm at Cresco, Iowa, in 1915. He had his university education at the University of Minnesota and obtained his Ph.D. in Plant Pathology in 1942 under the world-famous Plant Pathologist Dr Elvin Charles Stakman. Before joining the Wheat-Improvement Project, he worked in the Forest Department in Hopkins Experimental Forest Service in Massachusetts. Amiable, industrious and field-oriented, Borlaug has an inspiring personality. He provided an excellent leadership to the CIMMYT staff.

Borlaug thus narrates his experience of wheat-improvement work at the CIMMYT. 'I have had the privilege and good fortune to have remained a part of it for the past 26 years. From the outset, all factors limiting wheat production were studied; consequently there were interdisciplinary researches between genetics and plant breeding, agronomy, soil fertility, plant pathology, and entomology. Cereal chemistry and biochemistry were added later.

'After preliminary work in 1943, plant breeders, soil scientists, plant pathologists and entomologists, working as a team, began a concentrated attack on the various aspects of wheat production in 1944.

'An in-service (intern) training component was added to the research programme to train a new generation of Mexican scientists—while they were assisting with the development of the research programme. Provision was also made for fellowships to enable the most promising of these young scientists to study abroad for advanced degrees, hopefully in preparation for positions of leadership in Mexican agriculture.

'Research from the outset was production-oriented and restricted to that which was relevant to increasing wheat production. Researches in pursuit of irrelevant academic butterflies were discouraged, both because of the acute shortage of scientific manpower and because of the need to have data and materials available as soon as possible for use in the production programme.

'To accelerate progress in varietal development, two generations of all segregating materials were grown each year. One generation was sown close to sea level in Sonora at 28 degrees north latitude in the fall when the days were progressively shorter; the second was sown near Toluca, at 18 degrees latitude and 2500 meters above sea-level during the summer when days were progressively longer. Through the use of this technique we developed high-yielding, day-length-insensitive varieties with a wide range of ecologic adaptation and a broad spectrum of disease resistance—a new

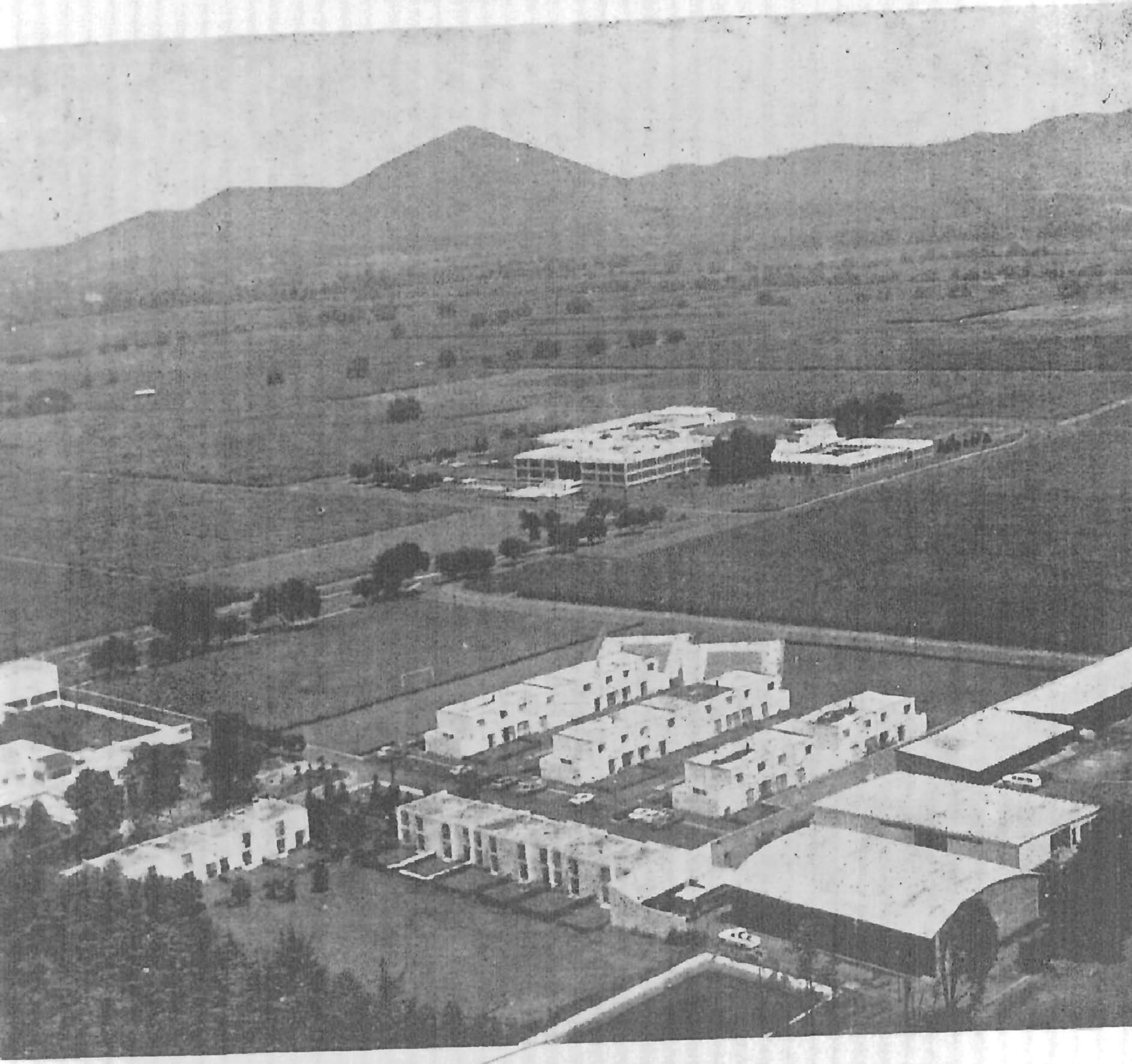


FIG. 103. The International Maize and Wheat Improvement Centre (CIMMYT), Mexico, where the high-yielding dwarf varieties of wheat were devel ped.

FIG. 104. Dr Norman E. Borlaug, who had a leading role in the development of dwarf, high-yielding wheat varieties at the CIMMYT, Mexico. (Portrait by G.S. Bansal, Hall of Fame, MSR Library, Punjab Agricultural University, Ludhiana)

FIG. 105. Dr. M.S. Swaminathan (b. 1925) played an important role in ushering in the Green Revolution in India and made outstanding contributions to the basic science of cytology and genetics. As a science administrator, he improved the service conditions of agricultural scientists and instituted the Agricultural Research Service.

FIG. 106. The author, with Dr Sukhdev Singh, Director of Research, and Dr Khem Singh Gill, Head of the Plant Breeding Department of the Punjab Agricultural University, Ludhiana, in a demonstration plot. It is such demonstration plots which made an impact on the wheat-growers in Punjab, and the cultivation of the high-yielding Mexican wheats spread rapidly.

FIG. 107. The 'Kalyan Sona' variety of wheat was selected independently at the Punjab Agricultural University, Ludhiana, and the Indian Agricultural Research Institute, New Delhi, from the material received from the CIMMYT, Mexico. Dr D. S. Athwal named it 'Kalyan' after his native Village of Kalyanpur and the IARI scientists named it 'Sona'. In Pakistan, this variety was given the name of 'Mexi-Pak'.

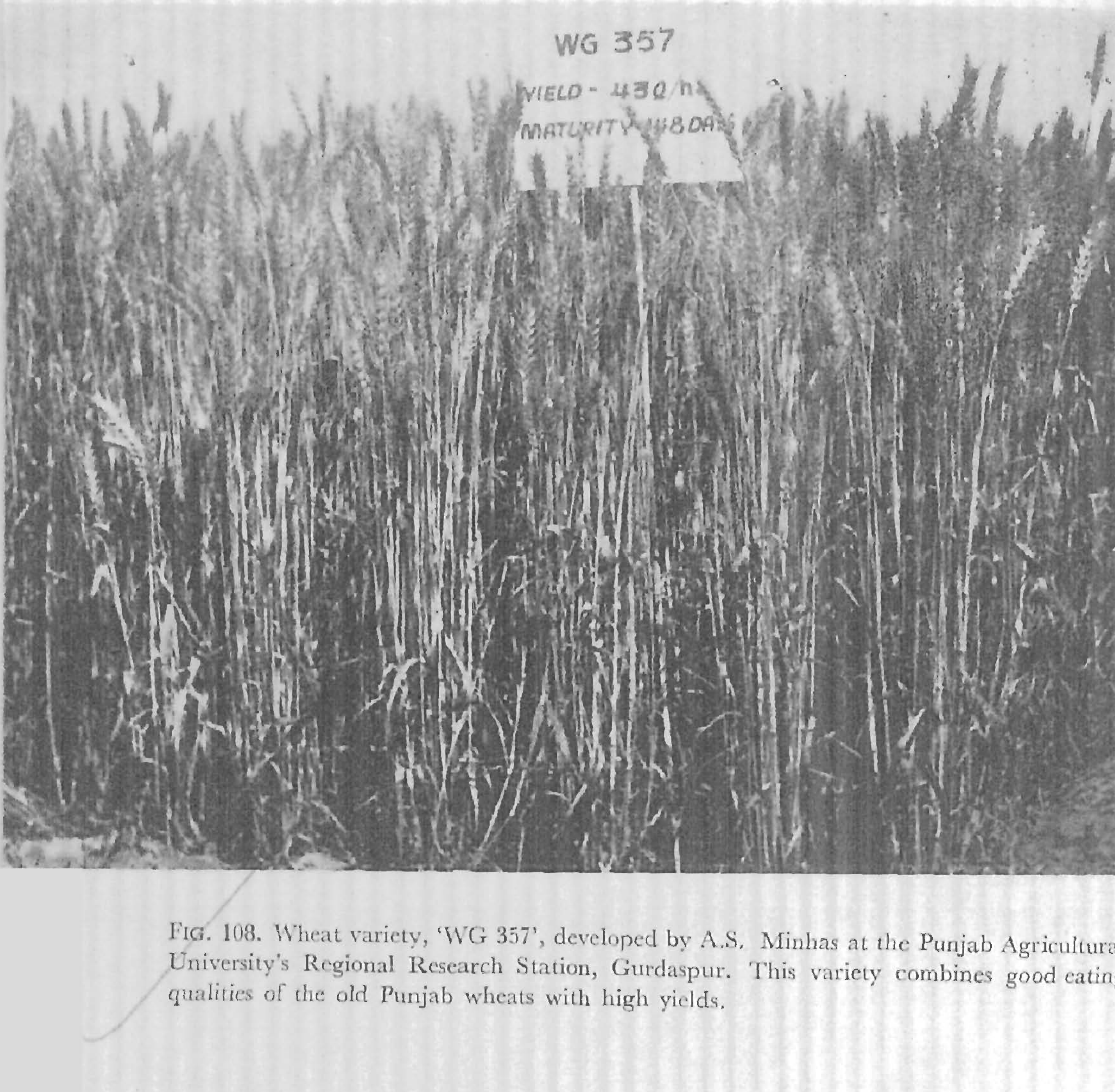


FIG. 108. Wheat variety, 'WG 357', developed by A.S. Minhas at the Punjab Agricultural University's Regional Research Station, Gurdaspur. This variety combines good eating qualities of the old Punjab wheats with high yields.

combination of uniquely valuable characters in wheat varieties'.[2]

The wheat breeders at CIMMYT, in addition to collecting samples of Mexican varieties, imported seeds from the major wheat-producing countries of the world, including the United States, Canada, Argentina, Australia, and several African countries. They made selections, crossed them and had the first improved varieties available for distribution by the autumn of 1948. By 1955, 75 per cent of the Mexican wheat crop was derived from them.

'Norin 10', Dwarf Wheats from Japan

Borlaug produced high-yielding wheat varieties by adopting some new concepts in plant breeding. The most important concept adopted by him is that of an efficient plant type capable of responding to very high doses of fertilizers and irrigation. He was able to do so by incorporating dwarfing genes into these varieties. The short-strawed germplasm from'Norin 10' crosses developed by Dr O.A. Vogel, of the Washington State University, was obtained by Borlaug in 1953; it was crossed with various Mexican and Colombian wheats, and dwarf lines were released in 1961. "These wheats", wrote Albert Moseman in 1964, "yielded up to 120 bushels per acre in the Yaqui Valley of Mexico and now occupy more than 85 per cent of Mexico's wheat acreage." By 1965, the Mexican wheat production showed a per-acre yield as much as 400 per cent as compared with that in 1950 and was becoming well known internationally.[3] Borlaug is the first wheat breeder to succeed in the use of dwarf parents in the evolution of commercial wheat varieties. Further, he bred with a view to producing lines which were insensitive to day length. The result is that the varieties produced by him have unprecedented adaptability and are fit to be grown over a wide area in the world. He also achieved stability in resistance to diseases by incorporating greater variability through multi-lineal approach. The wheat varieties produced by him are remarkably resistant to common wheat diseases.

From 1945 to 1965, the production of maize, the basic food crop of Mexico, increased four times.The production of cotton jumped from 107, 360 tonnes to 605,000 and became Mexico's major export commodity, providing funds for the industrialization of the country. Wheat production increased six times. In 1945, Mexico imported 10,175,000 bushels of wheat; by 1965 she was exporting it, yields per acre having tripled.

[2]Borlaug, N.E. *The Green Revolution, Peace and Humanity*. Lecture on the occasion of the Award of the Nobel Peace Prize for 1970, Oslo, Norway, 11 December 1970

[3]Socolofsky, H.E. 'The World Food Crisis and Progress in Wheat Breeding', *Agricultural History*, Vol. XLIII, No. 4, Oct. 1969

Nine Factors in the Green Revolution in Mexico

Though crop improvement was the key factor in the Mexican Green Revolution, there were also other factors which contributed to it.

These spectacular increases in productivity,according to Dunbar, may be accounted for by at least nine events : the Mexican Revolution, land reform, expansion of rural education, extension of roads, extension of irrigated area, provision for agricultural credit, improvement of crop varieties, use of farm machinery and use of fertilizers.

The Mexican Government encouraged the agricultural revolution by building roads and irrigation facilities. The highway system, including paved, surfaced and unsurfaced roads, increased from 6,138 to 34,967 miles (3,814 to 21,727 km) from 1929 to 1964. In 1926, the Calles administration created a National Irrigation Commission which, with the assistance of American irrigation engineers, began the reclamation by the Government of Mexican arid land. Between 1926 and 1958, this agency and its successor, the Ministry of Hydraulic Resources, brought under irrigation 5,554,561 acres (2,247,853 hectares), most of it in the north and north-west. On this land today is grown 80 per cent of Mexico's wheat and 95 per cent of its cotton.

Another factor in the Mexican agricultural revolution as in the American has been the provision for agricultural credit. Again, President Calles was a pioneer. His government in 1926 created the National Bank of Agricultural Credit to provide loans to farmers through local co-operative associations. Since the credit facilities offered by this bank were unsuited to the needs of the *ejido* farmers, Cardenas created the National Bank of Ejidal Credit.

Closely allied to the increase in productivity was the increased use of power-driven machinery and the consumption of fertilizer. "By the end of the 1950, Mexico had more tractors than any other Latin American country. The use of fertilizers was five times as much in 1958 as it was eight years earlier."[4]

Dr M. S. Swaminathan

An Indian scientist whose contribution to the Indian Green Revolution is outstanding is M. S. Swaminathan. Monkombu Sambasivam Swaminathan (b. 1925) belongs to an agricultural family of the Village of Monkombu in Kerala. His father, Dr Sambasivam, who had settled as a medical practitioner at Kumbakonam, was a leading surgeon of south India. Swaminathan graduated from the agricultural college at Coimbatore in 1947. He narrowly escaped joining the Indian Police Service, for which he had successfully competed in a test, held by the Union Public Service

[4]Dunbar, R. G. The Role of Agricultural History in Economic Development, *Agricultural History*, Vol. XLI, 1969

Commission. After a lot of deliberation, he opted for a career in science. In 1949, he joined the Department of Genetics of the Netherlands Agricultural University, Wageningen, as a UNESCO fellow. In 1950, he joined the School of Agriculture at Cambridge. In 1954, he joined the Central Rice Research Institute at Cuttack and was in charge of Indica-Japonica rice-hybridization programme. Soon after, he came to the Indian Agricultural Research Institute as Assistant Cytogeneticist, and later on became the Head of the Botany Division. His studies on induced mutagenesis in wheat, rice and barley are well known. As a leader in research and as an administrator, he made a mark, and his talents and achievements were widely recognized by numerous awards, including Magsaysay and Borlaug awards. He succeeded Dr B.P. Pal as the Director, Indian Agricultural Research Institute and the Director-General of the Indian Council of Agricultural Research. His contribution to the introduction of dwarf Mexican varieties of wheat into India will be ever remembered.

'Soon after joining the Indian Agricultural Research Institute in October 1954', states Swaminathan, 'I started a programme for the development of dwarf mutants in good wheat varieties like 'NP 809' and 'NP 824'. However, all the short wheat mutants had also unfortunately a short ear like *compactum* and *sphaerococcum*. Therefore, they did not have much applied value. In 1960, I read about the Norin dwarfing genes introduced from Japan by Dr Samuel C. Salmon, who was a Scientific Adviser in the administration headed by Gen. McArthur when Japan was under the occupation of the United States after World War II. The first wheat variety developed outside Japan having the Norin dwarfing gene was 'Gaines', bred by Dr. O.A. Vogel, of the Washington State University. 'Gaines' was released for cultivation in 1961 and soon established a world record for yield. I had been in correspondence with Dr Vogel and had obtained some of his material. Unfortunately, however, these had a winter habit and, therefore, needed long days for flowering. 'Gaines', was hence not suitable for cultivation under our conditions. In the *rabi* seasons 1961-62, I noticed in the international rust nurseries distributed by the U.S. Department of Agriculture and which had been grown at IARI by Dr M.V. Rao, beautiful dwarf strains where the ears were long but the plant was short. These fascinated me and by checking the record I found that these dwarf spring wheat entries had originated from Mexico in the programme of wheat breeding headed by N.E. Borlaug. The yield potential of these strains was good and soon after the wheat harvest in April 1962, I sent a detailed proposal to Dr B.P. Pal, who was then Director of the IARI, requesting him to invite Dr Borlaug to India for a visit and also arrange for getting dwarf wheat material in a spring background from Mexico. In my letter, I stressed that unless we shift to dwarf wheat breeding programme, it will not be possible to get full benefit from the fertilizer and water components of the package programme introduced under IADP. I had also mentioned in my letter that under conditions of greater soil fertility and more frequent irrigation the problem of rusts and other diseases will become serious. I had heard Dr Borlaug at the American Institute of Biological Sciences meeting held at Madison, Wisconsin, in September 1953 on the question of developing multi-line varieties of wheat with a more enduring form of resistance. Therefore, in my letter to Dr Pal, I pleaded for:

(i) Initiation of a dynamic dwarf wheat breeding programme with material obtained from Mexico, and

(ii) Intensification of research on the breeding for disease resistance, so that high-yielding-cum-high-stability varieties could be developed.

'For achieving the above aims, I requested that the Government of India may send an invitation to Dr Borlaug through the Rockefeller Foundation, for visiting India and for providing us with breeding material consisting of Norin dwarfing genes in a spring wheat background. I also proposed the initiation of a programme for the identification of diverse genes for disease resistance. Since Government funds were not available readily at that time, I formulated a programme for PL-480 funding which materialized in 1964 and led to the collection of very valuable data and material.

'Dr Pal approved my proposal and sent a request to Dr Ralph W. Cummings, the Field Director of the Rockefeller Foundation, through the Ministry of Agriculture, for material from Mexico and for arranging a visit by Dr Borlaug. Dr Borlaug visited in March 1963.'[5]

The IARI scientists also took the initiative in the wheat season of 1962-63 to invite renowned wheat breeders, namely Chowdhury Ram Dhan Singh, Dr S.M. Sikka, Dr T.R. Mehta, Dr W.M. Myers (of Minnesota), and other scientists to examine these dwarf wheat varieties and to seek their reaction with respect to the future potential of these varieties in India. At the same time, Dr Borlaug was requested to participate in a group discussion in the Botany Division and, among others, Chowdhury Ram Dhan Singh was also present during these discussions.

In the course of his visit to the IARI in April 1963, Dr Borlaug was taken by the IARI scientists to other important wheat centres also in the country, including Jaipur, Ludhiana, Pantnagar and Kanpur, to acquaint him fully with the conditions of wheat cultivation in India. Dr M.V. Rao personally took Dr Borlaug to Jaipur, Pantnagar and Kanpur. It is in the course of his visit to the IARI and to these different centres that Borlaug was greatly impressed with the potential which the dwarf varieties offered for increasing wheat production in India.

[5]Note, dated 20 February 1981, received by the author from Dr M.S. Swaminathan

Following his discussions with the IARI scientists and others, Borlaug, on his return to Mexico, sent 100 kg of seed of each of the dwarf and semi-dwarf wheat varieties and of 613 promising selections in advanced generations. These seeds were received for testing at the IARI. The IARI, in turn, organized a multi-location testing programme at Delhi, Ludhiana, Pusa, Kanpur, Pantnagar, Bhowali and Wellington. It is from these materials that a number of scientists working at different places made selections and the two varieties, which ultimately became very popular, were 'Kalyan Sona' (it was selected independently at Delhi and Ludhiana) and 'Sonalika', which was selected at Delhi by the IARI scientists.

While there was such an understanding and a ready response from the Indian scientists, Borlaug's experience was different in Pakistan and Egypt. In a personal communication to the author, he wrote, 'I should point out that there were more than 100 lines of Mexican dwarf wheats growing at the experimental stations in Lyallpur, Pakistan, and at Sakha, Egypt. The main experimental plantings of these wheats did not, however, look promising because the senior scientists and directors at both stations had not permitted the young scientists—who had studied in Mexico with me and who knew how these wheats should be cultivated—to use the correct amounts of fertilizer and the proper irrigation practices. However, in both countries in a well-hidden remote corner of the experiment station, never visited by either the senior wheat scientists or directors, the young Mexican-trained scientists had planted small plots of two of the new Mexican varieties with proper rates and date of sowing, adequate fertilizer and proper irrigation. These plots were beautiful—as well adapted as they were in Mexico.[6] Later on, situation improved in Pakistan, and the Pakistani scientists selected promising strains, from the Mexican material supplied by Borlaug. Their variety 'Mexi-Pak' is the same that is known as 'Kalyan Sona' in India.

Mexican Dwarf Wheats at the Punjab Agricultural University, Ludhiana

The Plant Breeding Department of the Punjab Agricultural University, Ludhiana, under the leadership of Dr D.S. Athwal selected two promising strains, 'V 18' and 'S 227', from the material received from Dr Borlaug, and multiplied their seed at Keylong in the inner Himalayas in 1964. 'V 18' was designated as 'PV 18' and it gave an average yield of 4,690 kilograms per hectare, compared with 3,291 kilograms per hectare of 'C 306'—the best local wheat variety at that time. It has profuse tillering capacity, thick straw and broad and erect dark-green leaves. The highest yield obtained from 'PV 18' from one plot in Ludhiana was 6,914 kilograms per

[6]Extract from a letter dated 2 February 1981 received by the author from Dr N.E. Borlaug

hectare. The strain 'S 227' was still segregating and further selections were made from it for rust resistance, amber grain colour and grain size. This led to the identification of 'Kalyan Sona' (identified simultaneously at the IARI, New Delhi), which along with 'Sonalika' ('S 308') has an amber colour, bold grain and a yield potential as good as that of 'PV 18'.

The Punjab Agricultural University's scientists made efforts to rapidly multiply their seeds by raising a second summer crop in the Lahaul Valley in the Himalayas. This strategy led to quick seed multiplication and speedy expansion of area under these varieties.

Dr R.L.Paliwal of the agricultural university at Pantnagar also made some promising selections from this material at Pantnagar.

Dr R.G. Anderson, Dr Bill Wright and Dr B.A. Krantz, of the Rockefeller Foundation, also carried out critical studies with these varieties and their studies were specially useful in determining the agronomy of dwarf wheats. The Agronomy Division of the IARI, specially the team led by the late Dr S.S. Bains and Dr R.L.M. Bhardwaj, played a notable role in evolving suitable agronomic practices for the dwarf wheats.

Massive Import of Mexican Wheat Seed

Credit for the massive import of the Mexican wheat seed goes to C. Subramaniam, who was Minister for Food and Agriculture, Government of India, during 1964-67. It was on his initiative that nearly 250 tonnes of wheat seed was imported in 1965.

In 1966, the Government of India sent a team of three scientists—Dr S.P. Kohli of the IARI, Dr S.M. Sikka of the Ministry of Agriculture, and Ujagar Singh Kang—to Mexico for getting a bulk shipment of seeds of improved varieties. These three scientists visited a number of farmers' fields in Mexico and arranged for the import of 18,000 tonnes of seed of dwarf varieties 'Lerma Rojo 64' and 'Sonora 64', which made it possible to spread them quickly in the country.

'Never before in the history of agriculture has a transplantation of high-yielding varieties coupled with an entirely new technology and strategy been achieved on such a massive scale, in so short a period of time, and with such great success', observes Borlaug. 'The success of this transplantation is an event of both great scientific and social significance. Its success depended upon good organization of the production programme combined with skilful execution by courageous and experienced scientific leaders. It was the first time in history that such huge quantities of seed had been imported from distant lands and grown successfully in their new home. These importations saved from three to five years' time in reaping the benefits from the Green Revolution.'

As a result of this massive import of seed and sound extention arrangements under the Intensive Agricultural Programmes, the area under dwarf wheats, which was about 4 hectares in 1964, rose to 4 million hectares in 1971.

IMPACT OF DWARF VARIETIES ON PRODUCTION OF WHEAT IN INDIA

North-western parts of undivided India which included Punjab and Sind constituted the wheat bowl of the country. The area under wheat was 13.5 million hectares and production 10 million tonnes. The yield per hectare was about 7 quintals. On partition of the country in 1947, the Indian Union was left with only 60 per cent of the total area in undivided India. The area was almost made to pre-partition level and yield was even bettered slightly by 1960-61 (12.9 million hectares and 0.9 tonnes/ha respectively). This was chiefly due to developments which took place in Punjab, e.g. the consolidation of holdings, and development of irrigation by canals and tube-wells. Research efforts which made this achievement possible mainly related to conventional varieties. The position remained more or less static up to 1966-67. As a result of increase in area under dwarf Mexican varieties and adoption on a large scale of better agronomic techniques, the production in 1967-68 increased to 16.5 million tonnes, raising the yield to 1.1 tonnes/ha. The upward trend in production and yield per hectare has continued since then. In 1971-72, the area was 19.1 million hectares and the production 26.4 million tonnes, giving an average yield of 1.4 tonnes/ha. In 1973-74 the area under high-yielding wheats was 10.91 million hectares as compared with 4.80 million hectares in 1968-69.[7]

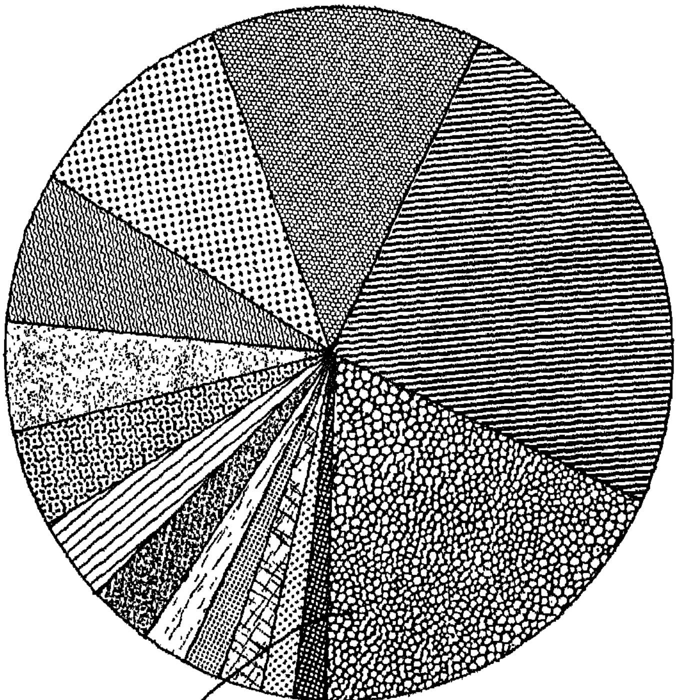
TABLE 1. PRODUCTION OF WHEAT IN INDIA

	Year (Agricultural)	*Wheat (in'000 tonnes)*
Before the Green Revolution	1963-64	9,849
	1964-65	12,252
	1965-66	10,394
	1966-67	11,393
Green Revolution Era	1967-68	16,540
	1968-69	18,651
	1969-70	20,093
	1970-71	23,832
	1971-72	26,410
	1972-73	24,735
	1973-74	21,778
	1974-75	24,104
	1975-76	28,846
	1976-77	29,082
	1977-78	31,380

SOURCE: *Annual Economic Surveys, Government of India*

[7] *Report of the National Commission on Agriculture*, Part I, 1976, p. 283

MAJOR WHEAT PRODUCING
COUNTRIES OF THE WORLD
BASED ON THE AVERAGE 1976 TO 1978



REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%	REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%
	USSR	103.2	24.9		AUSTRALIA	13.1	3.2
	USA	54.2	13.0		PAKISTAN	8.7	2.1
	CHINA (F)	43.0	10.3		ITALY	8.2	2.0
	INDIA	29.9	7.2		ARGENTINA	8.1	1.9
	CANADA	21.5	5.2		ROMANIA	6.5	1 5
	FRANCE	18.2	4.4		UK	5.5	1.3
	TURKEY	16.6	4.0		OTHER COUNTRIES	78.8	19.0

TOTAL WHEAT PRODUCTION IN THE WORLD: 415.6 MILLION TONNES (3 YEARS' AVERAGE).
(F)F.A.O. ESTIMATE

Fig. 109. The major wheat-producing countries of the world, based on the average 1976 to 1978, Economic and Statistical Adviser (ESA), Ministry of Food and Agriculture, Government of India.

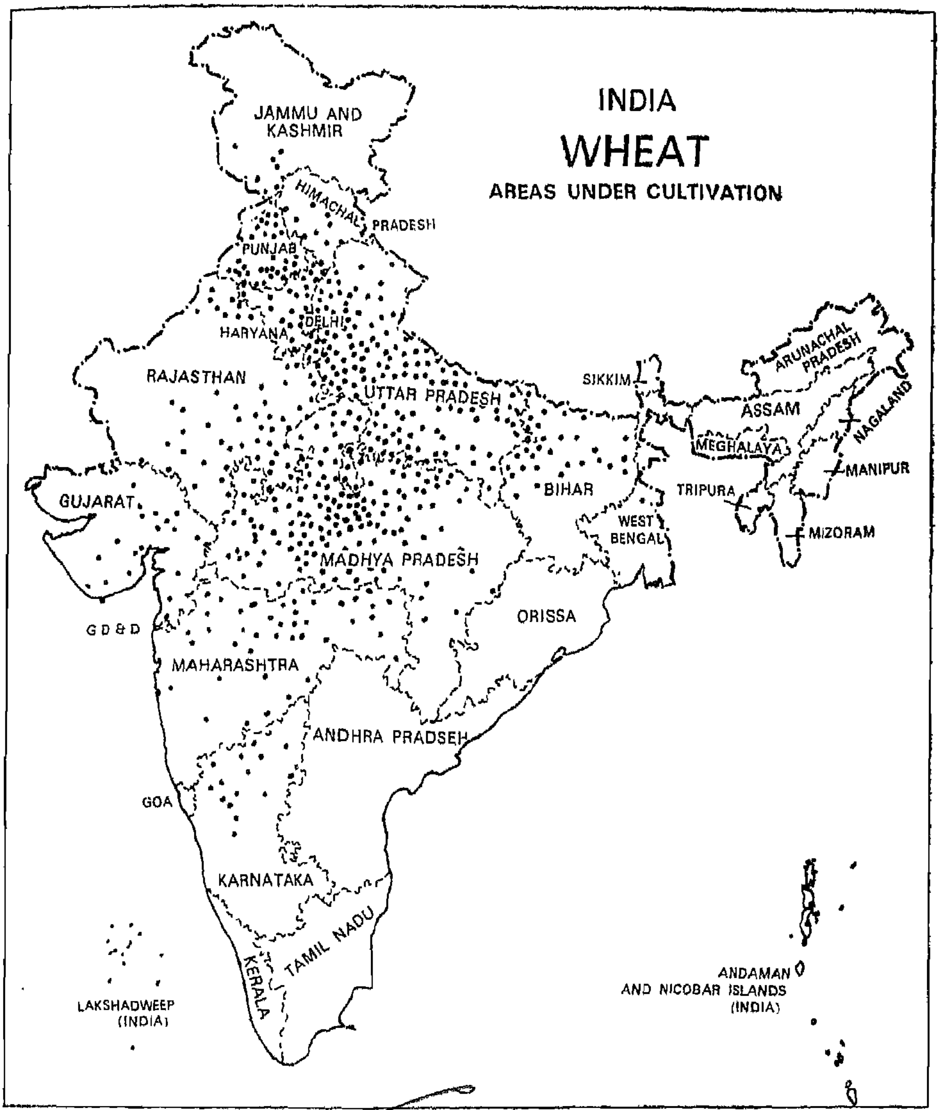


FIG. 110, A map of India, showing the area of wheat, 1964-65. Each dot represents 20,000 hectares, (ESA)

After the USSR, the USA and China, India is the fourth largest producer of wheat in the world (Fig. 109).

From 1968-69 to 1977-78, wheat production almost doubled. Production of wheat from 1963-64 to 1977-78 is given in Table 1. The setback experienced in 1973-74 was largely due to a spurt in the price of fertilizers, diesel and other inputs. This was corrected in the following year

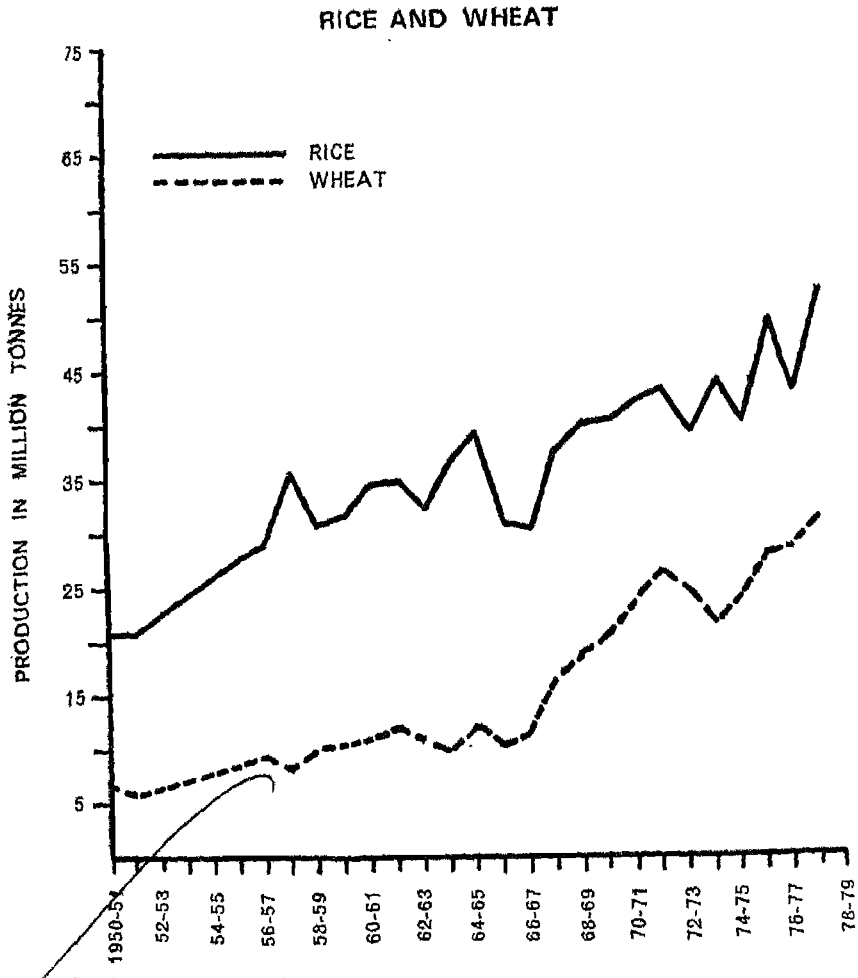


FIG. 111. Trends in the production of rice and wheat in India from 1950-51 to 1978-79.

by the Government of India by raising the procurement price of wheat.

Spread of Wheat Cultivation in West Bengal

Another interesting development in the wheat programme is the spread of Mexican wheats in areas which conventionally grew rice. West Bengal is the case in view, where wheat area grew from 41.2 thousand hectares in 1965-66 to 500 thousand hectares in 1971-72 and production increased from 34,000 tonnes to 1,152,000 tonnes during the same period.

Co-ordinated Wheat Improvement Programme

Some resistance to the acceptance of Mexican wheats developed in

TABLE 2. AREA, PRODUCTION AND YIELD IN WEST BENGAL

Year	*Area* (*thousand hectares*)	*Production* (*thousand tonnes*)	*Yield* (*tonnes/ha*)
1965-66	41.2	34.0	0.83
1966-67	55.4	45.4	0.82
1967-68	79.0	71.1	0.90
1968-69	150.0	200.0	2.00
1969-70	240.0	400.0	1.67
1970-71	360.2	868.1	2.41
1971-72	500.0	1,152.0	2.30

SOURCE: *Report of the National Commission on Agriculture*, Part I, 1976

India, as their reddish colour and their taste was not liked by the consumers. The *chapatis* made from these red wheats were not as tasty as those made from local white wheats. To meet this problem the Indian breeders developed 'Kalyan Sona 227' and 'Sonalika S 308', which have amber colour and bold grain. 'WG 377' and 'WG 357' developed by A.S. Minhas at the Punjab Agricultural University's Regional Research Station, Gurdaspur, have good yield potential and excellent grain quality. Now newly developed Indian strains are going back to Mexico to assist in making better tortillas (usually made of maize).[8] Reports of harvests from two to ten times as much as that obtained from traditional varieties have melted the resistance of even the most illiterate farmer. In 1968, 18 per cent of the area and 36 per cent of the total production was due to dwarf wheat and new technology. This agricultural breakthrough, with similar developments matched in rice and maize production, presents a whole new batch of problems, now that self-sufficiency in food production has been achieved. Now the problems are of storage and transportation.

Paying a tribute to the Indian scientists, Dr Borlaug stated in his lecture on the occasion of the award of Nobel Peace Prize to him, 'The All-India Co-ordinated Wheat Improvement Program, which is largely responsible for the wheat revolution in India, has developed one of the most extensive and widely diversified wheat research programs in the world. Its success has generated confidence, a sense of purpose, and determination. The current agronomic research on wheat in India equals the best in the world. The breeding program is huge, diversified, and aggressive; already it has produced several varieties which surpass those originally introduced from Mexico in 1965. The first group of new Indian varieties, already in extensive commercial production, were derived from selections made in India from partially selected materials received from Mexico. A second group of varieties, now being multiplied, are selections from crosses made in India

[8]Socolofsky, H.E. 'The World Food Crisis and Progress in Wheat Breeding', *Agricultural History*, Vol. XLIII, 4 Oct. 1969

between Indian and Mexican varieties. The rapidity of creation and distribution of these new varieties has already diversified the type of resistance to diseases and therefore minimizes the menace of destructive disease epidemics if and when changes occur in parasitic races of the pathogens.

'The only protection against rust epidemics, in all countries, is through resistant varieties developed by an intelligent, persistent and diversified breeding program, such as that being currently carried on in India, coupled with a broad disease-surveillance system and a sound plant pathology program to support the breeding program. From such a program a constant flow of new high-yielding disease-resistant varieties can be developed to checkmate any important changes in the pathogens. The Indian program is also developing competence in research on the biochemical, industrial, and nutritional properties of wheat.[9]

The Green Revolution in India is neither a stroke of luck nor an accident of nature. Its success is based on sound research, careful planning, and a gigantic administrative effort. No single individual can claim credit for it, for it is the result of a team work in which a number of scientists and administrators participated. At the same time, there are some persons who played in it an outstanding role and deserve all honour and respect. The Green Revolution is the culmination of an international effort to conquer the problem of hunger. In this effort, America provided outstanding scientific leadership in developing the programme of high-yielding varieties of wheat. Japan contributed the dwarfing 'Norin 10' genes. Mexico provided land for the setting up of the International Maize and Wheat Improvement Centre (CIMMYT) and also gave administrative support to the programme. Indian agricultural scientists not only adopted the technology imported from Mexico, but also made many improvements. The Indian administrators made arrangements for the supply of credit to the farmers and organized the extension network. The politicians made sound policy decisions and agreed to give incentive support price to the farmers. The industrialists manufactured tractors, threshers, pumping-sets, diesel engines, electric motors and fertilizers for use by the farmers. Finally, the farmers, who learnt the new technology, made Green Revolution a reality by their hard work.

[9]Borlaug, N.E. *The Green Revolution, Peace and Humanity*. Lecture on the Occasion of the Award of the Nobel Peace Prize for 1970, Oslo, Norway, 11 December 1970

CHAPTER 31

GREEN REVOLUTION IN INDIA-II

THE IMPACT OF JAPANESE AGRICULTURE ON INDIA THE HIGH-YIELDING VARIETIES OF RICE FROM THE INTERNATIONAL RICE RESEARCH INSTITUTE, PHILIPPINES, AND THEIR IMPACT ON RICE PRODUCTION IN INDIA

RICE is the world's most important food crop, and one-third of mankind depends on it for more than half of their food. Ninety per cent of the total area under rice lies in the tropical and subtropical countries. In India, rice is the staple food of nearly three-fourths of the population. Next to China, which accounts for 35.5 per cent of the world production of rice, India is the second biggest producer of this crop and accounts for 20.3 per cent of world production. The annual production of paddy in India is about 74.3 million tonnes (Fig. 112). The other important rice-producing countries are Indonesia (6.6 per cent), Bangladesh (5.1 per cent), Japan (4.4 per cent) and Thailand (4.2 per cent).

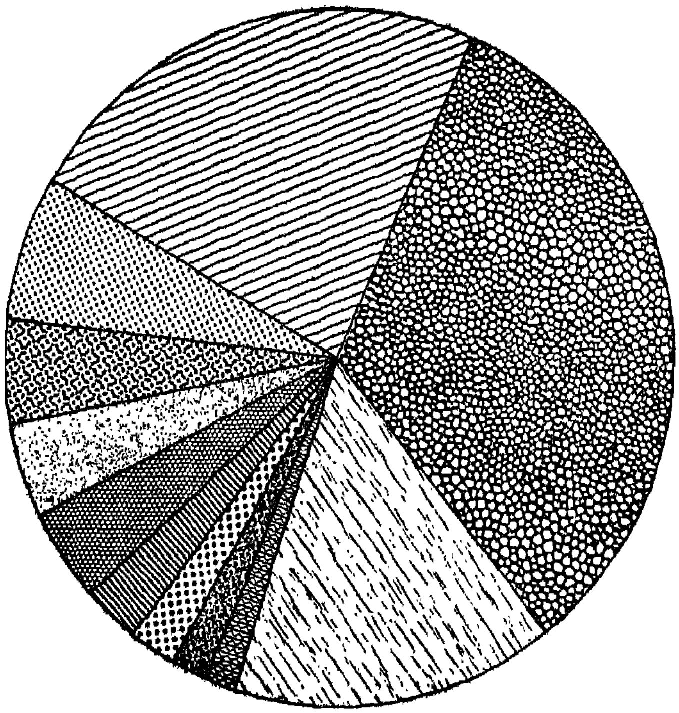
The concentration of rice production in India is in the eastern and southern States, viz. Bihar, West Bengal, Assam, Orissa, eastern Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Kerala (Fig. 113). Punjab and Haryana have recently emerged as important rice-growing States and supply a substantial quantity of this foodgrain to the Nation's food bowl.

In India, generally three crops of rice are raised in a year. The average area under rice during 1969-70 to 1971-72 was 37.5 million hectares. The proportion of rice crops in different seasons was as follows:

Crop sown in February-May	15.8% of all-India rice crop
Crop sown in June-September	79.5% of all-India rice crop
Crop sown in October-January	4.7% of all-India rice crop

The mono-season belt accounts for 46.4 per cent of all-India area under rice (of which Uttar Pradesh, Bihar and Madhya Pradesh account for 38.3 per cent), whereas the multi-season belt accounts for 53.6 per cent (of which Orissa and West Bengal account for 12-13 per cent each and the north-eastern States, Andhra Pradesh and Tamil Nadu, 7-8 per cent each). The all-India yield of rice is 1.11 tonnes/ha. Rice production is throughout referred to in terms of cleaned rice, which is about two-thirds of paddy. The yields in the Punjab and Haryana are 152-160 per cent of the all-India yield. Uttar Pradesh, Bihar and Madhya Pradesh have the poorest of yields, around 70 per cent of the all-India yield. The main problem in these areas is that July and August are the only months of adequate rainfall to sustain this crop. Even in these months, there are spells

MAJOR PADDY PRODUCING
COUNTRIES OF THE WORLD
BASED ON THE AVERAGE 1976 TO 1978



REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%	REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%
	CHINA (F)	130.4	35.5		BURMA	9.8	2.7
	INDIA	74.3	20.3		BRAZIL	8.6	2.4
	INDONESIA	24.1	6.6		PHILIPPINES	6.8	1.9
	BANGLADESH	18.7	5.1		USA	5.3	1.5
	JAPAN	16.1	4.4		OTHER COUNTRIES	56.4	15.4
	THAILAND	15.3	4.2				

TOTAL PADDY PRODUCTION IN THE WORLD 365.8 MILLION TONNES
(3 YEARS AVERAGE) (F) F.A.O ESTIMATE

FIG. 112. The major rice producing countries of the world, based on the average 1976 to 1978, (ESA)

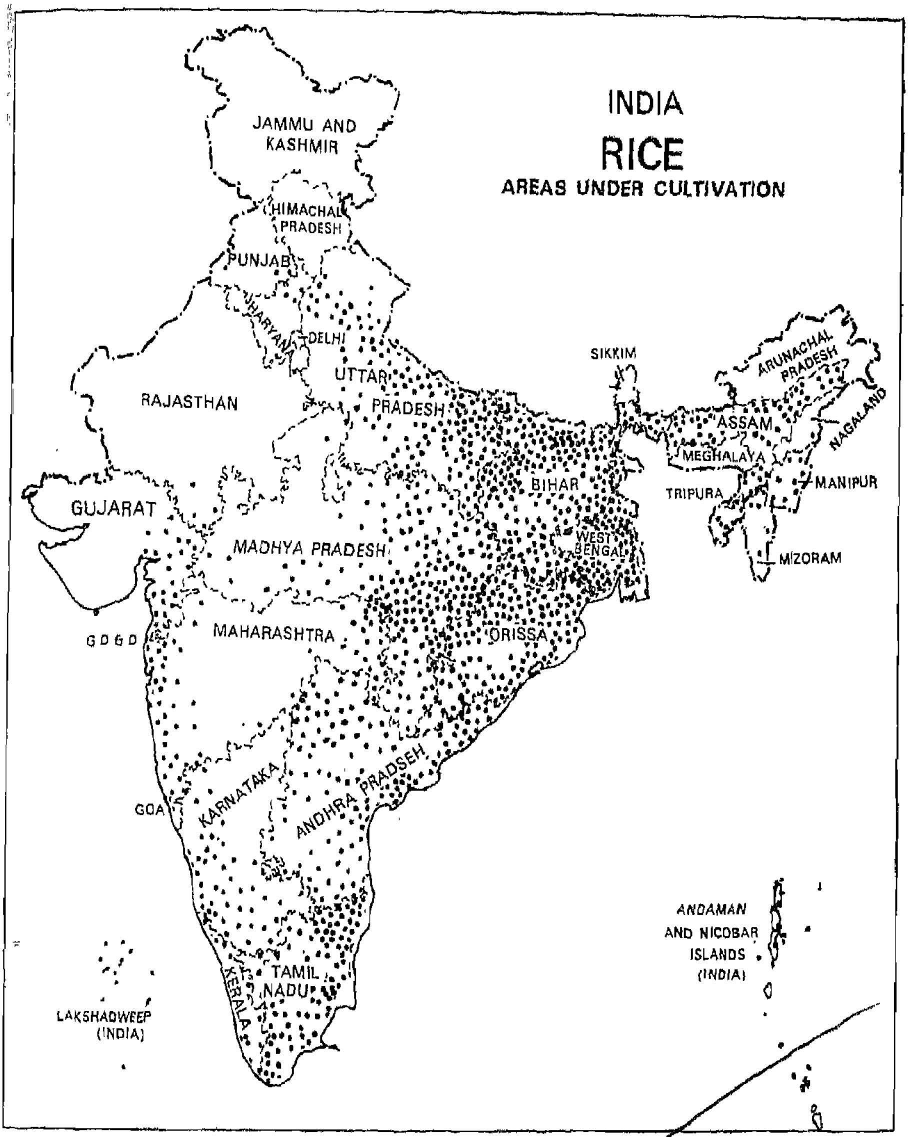


FIG. 113. A map of India, showing the area under rice, 1964-65. Each dot represents 20,000 hectares. The concentration of rice production is in the eastern and southern States. (ESA)

of excessive rainfall, causing serious drainage problems and floods in eastern Uttar Pradesh and Bihar.[1] Besides, if a farmer applies chemical fertilizers to his fields, they will flow out to the fields of his neighbours owing to floods. Hence there is no incentive for use of fertilizers.

To understand the developments which have taken place in the production of rice in India, one has to look beyond to Japan and the Philippines.

Modernization of Agriculture in Japan, 1968-69

Japan somewhat resembles India in the density of population and the smallness of holdings. Japan contributed a scientific method of paddy cultivation, popularly known as the Japanese method, to Indian agriculture. Hence the pattern of agricultural development in that country is of interest to India.

The Meiji Restoration of 1868 was the beginning of accelerated change in Japan. The Satsuma and Choshu revolutionaries abolished feudalism, reduced the Emperor to the position of a nominal head of State, divided the islands into perfectures, creating a centralized administrative system, and planned a universal system of education. They gave the ownership of land to the farmers and landlords and made it free of restrictions on alienation. Therefter, those who owned it were free to mortgage or sell it.

During the Meiji Era (1868-1911), Japan made great strides in modernizing its agriculture and industry. To support the development of industry, an agricultural surplus was necessary. Following the German experience, the Government of Japan organized agricultural schools and State agricultural experiment stations, and employed German and American agricultural experts and engineers. The initial research consisted largely of field tests and experiments comparing the performance of different varieties and the effects of different practices. The Japanese Government invited instructors from Britain to the newly opened Komaba Agricultural School (founded in 1877 and redesignated the University of Tokyo College of Agriculture in 1890). Instructors from the USA were brought to the Sapporo Agricultural School in Hokkaido in 1875. The curriculum at the new agricultural colleges was based on the "technology-transfer" perspective that had led to the importation of British and American technology.

Impressed by the performance of large-scale agricultural machinery in the USA, a demonstration farm, the Western Farm Machinery Exhibition Yard, was opened in 1871. Machine operations were also demonstrated at the Naito Shinjaku Agricultural Station, established in 1878. In 1879, the Mita Farm-Machinery-Manufacturing Plant was established to produce machines modelled after the imported machines.

[1] *Report of the National Commission on Agriculture*, 1976, Part I

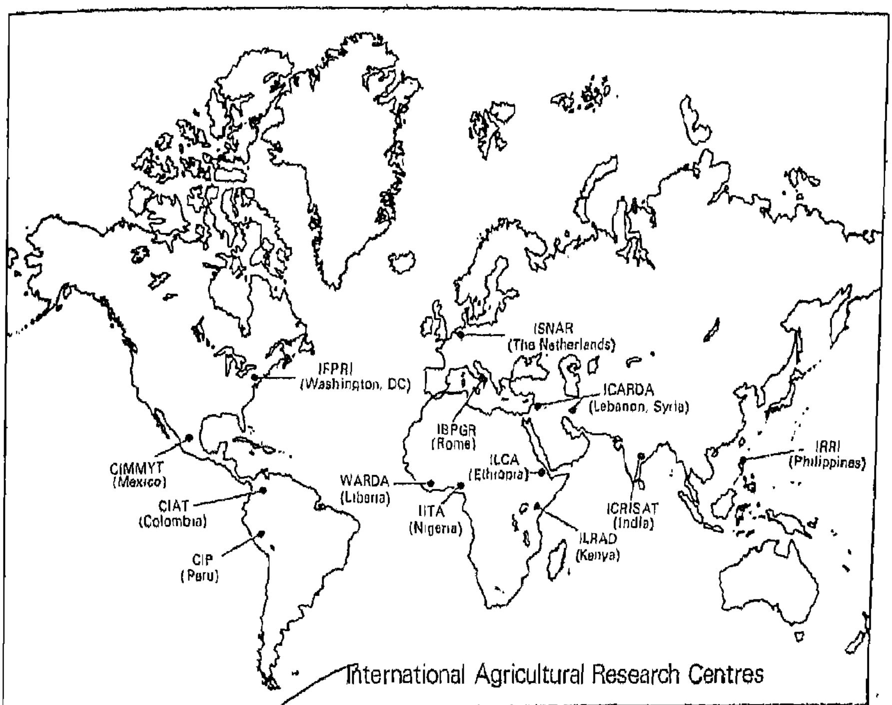


FIG. 114. A map of the world showing location of International Centres of Agricultural Research.

DEVELOPMENT OF AGRICULTURE IN HOKKAIDO ON THE AMERICAN PATTERN

For the northern island of Hokkaido, the Japanese chose American agriculture as their model. This was a natural choice inasmuch as it was an unsettled, frontier area, with a climate similar to that of northern United States. They borrowed the services of Horace Capron, who was serving as the second United States Commissioner of Agriculture, to serve as the head of a technical assistance mission. Capron spent four years in Japan, from 1871 to 1875. His party broke the virgin soil of Hokkaido with American ploughs, planted American crops and vegetables, introduced American fruit-trees, and stocked the frontier farms with American cattle, horses, pigs, and sheep. He started an agricultural school, which in 1876 was raised to collegiate rank and became the Sapporo Agricultural College, now Hokkaido University. In a successful effort to pattern it after the new land-grant colleges in the United States, the Japanese invited President William Smith Clark, of the Massachusetts Agricultural College, to organize its staff and curriculum. Clark brought with him instructors who played a continuing role in transforming the island into an outpost of American agriculture.

'The Japanese had less success with their efforts to westernize agriculture on the islands of Honshu, Kyushu, and Shikoku. Capron established three demonstration farms in the vicinity of Tokyo, where he displayed American crops, animals, and machinery. The government tested Western ploughs, reapers, and other horse-drawn implements; it experimented with Western varieties of wheat, barley and cotton; the prefectural governments established "agricultural encouragement farms" to demonstrate Western farming methods, but with little success. The imported ploughs were built for use in large fields, the late-maturing wheats did not fit in with the Japanese cropping cycle, and the horse-drawn implements were not adapted to hoe-culture. By the mid-1880s, under the influence of Oskar Kellner at the Komba Agricultural School, the Government was shifting its emphasis on imported agriculture for increasing the efficiency of its native small-scale, intensive paddy culture.

EXTENSION

'The Japanese also realized that research without extension provided slow agricultural progress. As early as 1877, the Government urged the formation of agricultural-discussion societies and seed-exchange societies with the object of exchanging knowledge and seeds through meeting and correspondence. Ten years later, it employed many of the more experienced members of these societies to visit farmers and, in this manner, to serve as itinerant instructors.

'This form of extension lasted until the creation of the prefectural experiment stations, which were to provide instruction as well as research. At the turn of the century, the Government organized in each village, county, and prefecture an agricultural association, with an agricultural adviser, employed jointly by the local governments and the associations to provide extension instruction for the farm people. These efforts were supplemented by the establishment of agricultural continuation schools for the younger farmers.

'With these institutions, the Japanese have increased the productivity of their indigenous agriculture. Since about 55 per cent of the cultivated land is devoted to rice, they have devoted considerable effort to augment the productivity of this crop. To achieve this object, they have improved their varieties, have used more fertilizer, and perfected their farm machinery.

VARIETY IMPROVEMENT BY PROGRESSIVE FARMERS

'As in the United States, variety improvement has been an achievement of both farmers and Government experiment stations. In 1877, a farmer in Hyogo Prefecture, named Jujiro Maruo, selected a rice variety, named 'Shinriki', which by 1920 had become the most widely cultivated variety in south-western Japan. Its popularity owed much to seed-growers' co-operatives which encouraged the members to devote their fields to seed production. Another farmer, named Kameji Abe in Yamagata Prefecture, selected 'Kameno-o', which became the favourite of the growers in northern Honshu. However, in the 1920s, these varieties became susceptible to riceblast and other diseases. Then 'Asahi' replaced 'Shinriki, and 'Riku-u 132' developed by a branch experiment station replaced 'Kameno-o.'

FARM MACHINERY

Changes in farm machinery also contributed to the increase in productivity. Indigenous horse-drawn plough supplanted hoes in the late nineteenth century, facilitating double-cropping. The foot-pedal rotary thresher replaced the comb-tooth thresher, which had been invented in the Tokugawa Era. The use of gasoline-powered implements began in the 1930s and it increased, following World War II, with the invention of small, two-to three-horsepower tractors, adapted to the needs of rice farming.

'In this manner, an agricultural revolution occurred in Japan, and it doubled the productivity of the country's agriculture, provided food for an expanding population and capital for its industrial revolution.'[2]

A NEW TYPE OF PLOUGH

Max Fesca, a German expert, who was in Japan from 1882 to 1895, pointed out clearly for the first time the mistake of using the S-type plough in the humid Japan. Fesca recommended the use of a no-sole plough (a W-type plough) which was employed in a part of Japan (Fukuoka Prefecture) at that time. Its use spread rapidly all over Japan in the Meiji Era. This plough drained the inundated paddy fields and thus permitted an increase in the use of fertilizers which encouraged the breeding of new varieties of rice.[3]

'NORIN' VARIETIES OF RICE

By the late 1930s, 'Norin' varieties largely replaced the older selections throughout Japan. These varieties became important genetic sources of dwarfing for the new fertilizer-responsive varieties that were developed by the International Rice Research Institute, Philippines, and earlier by a number of national research stations in the tropics in the 1950s and 1960s. The varieties developed were called 'Norin' varieties (the abbreviation of the name of the Ministry of Agriculture and Forestry of Japan). In 1931,

[2]Dunbar, R.G. 'The Role of Agricultural History in Economic Development', *Agricultural History*, Vol. XLI, 1967

[3]Iinuma J. The Meiji System: the revolution of rice cultivation technology in Japan, *Agricultural History*, Vol. XLIII, 2, 1969

'Norin 1' was released. It was a short-statured, early-maturing, fertilizer-responsive, high-yielding variety. Within a few years, it was the dominant rice variety in western Japan.

THE JAPANESE METHOD OF RICE CULTIVATION

The package of rice-production practices, such as the use of salt water in seed selection, improved preparation and management of nursery beds, planting in rows for weed control, and the selection of new varieties, was developed by farming landlords (*gono*) and veteran farmers (*rono*) during the Meiji Era. This system is known as the Meiji system in Japan, and the 'Japanese method of rice cultivation' in India. Dr Panjabrao Deshmukh, then Minister of Agriculture, Government of India, promoted with great zeal this method throughout India in 1955-59.

INTERNATIONAL RICE RESEARCH INSTITUTE, LAGUNA, PHILIPPINES, 1960

India is much indebted to the International Rice Research Institute, Philippines, for providing it with semi-dwarf, high-yielding varieties of rice. How and when did this Institute develop? The success of the co-operative wheat and maize programme in Mexico encouraged the Rockefeller Foundation to launch a similar research programme with respect to rice. It received enthusiastic support from J. George Harrar, President of the Rockefeller Foundation, himself a distinguished plant pathologist.

The concrete proposal to establish the institute was approved on 18 August 1958 in New York between officials of the Rockefeller Foundation and the Ford Foundation. It was the first co-operative project to be undertaken by the two foundations. The arrangements for establishing the institute in the Philippines were discussed by Dr R.F. Chandler, Assistant Director of the Rockefeller Foundation, with the Philippine Government officials during his visit to that country in November-December 1958. As a result of the deliberations between the two Foundations and the Government of the Phillippines, an agreement was reached to establish the International Rice Research Institute at Los Baños, which is located next to the College of Agriculture of the University of the Philippines, 60 km south of Manila. In 1959, the Rockefeller Foundation assigned Dr Chandler to the Philippines, where since 1960 he has served as Director of the International Rice Research Institute. He could rightly be called the "father" of this Institute because he has played a major role in founding the Institute and guiding it to its present position of eminence.

Dr Chandler was born on 22 June 1907 at Columbus, Ohio, USA. He was raised on a farm in New Gloucester, Maine. He graduated from the University of Maine, from which he received his degree of Bachelor of Science, with honours, in 1929. From 1929 to 1931, he served as the

State Horticulturist in the Department of Agriculture of the State of Maine. He obtained his Ph.D. in soils from the University of Maryland in 1934. In 1935, he was appointed to the position of Assistant Professor of Forest Soils at the University of Cornell. He later became a full professor and continued to serve on the faculty of that University until 1947. In 1946-47, he was on leave from Cornell and spent a year as a soil scientist with the Rockefeller Foundation agricultural programme in Mexico. In 1947, he was appointed Dean of the College of Agriculture and Director of the Agricultural Experiment Station of the University of New Hampshire. He served in that capacity until 1950, when he was elected President of the University of New Hampshire. In 1954, he resigned his post to accept an appointment as Assistant Director of Agriculture with the Rockefeller Foundation.

The funds for the construction of the Institute were provided by the Ford Foundation, and the operating expenses were shared equally by the Ford and the Rockefeller Foundations until 1969, when the USAID became the third major donor. The Philippine Government has provided the Institute with a home. It now receives support from the UNDP, the World Bank and seven national-aid organizations. The last-mentioned are among a group of donors known collectively as the Consultative Group for International Agricultural Research (CGIAR). The CGIAR is co-sponsored by the FAO, the UNDP and the World Bank. The CGIAR now supports 8 international agricultural research institutes besides the IRRI, and all of them are located in the developing parts of the world (Fig. 114).

'Taichung Native 1' Developed in Taiwan, 1958

'The basis for IRRI's advances in changing the architecture of the tropical rice plant originated in Taiwan', states Chandler. 'As early as 1949, plant breeders at the Taichung District Agricultural Improvement Station had crossed a semi-dwarf indica variety, 'Dee-geo-woo-gen', with another indica variety, called 'Tsai-Yuan-Chung', which was tall but drought resistant. A selection from this cross was named 'Taichung Native 1' in 1956. This was the first semi-dwarf indica variety deveolped for the tropics through plant breeding.

Without question the fast progress that the institute made in developing a series of short-statured, fertilizer-responsive varieties would not have been possible without the availability of the dwarfing gene from 'Dee-geo-woo-gen', which was simply inherited and could readily be introduced into the varied and extensive germplasm of the tall tropical varieties of South and Southeast Asia.

Although the creation of 'Taichung Native 1' in Taiwan was a signal advance, it required an organization such as the International Rice Research Institute to implement a massive crossing programme resulting in an extensive series of semi-dwarf genetic lines that could be distributed to rice breeding units throughout tropical and subtropical Asia and to many other parts of the world as well.

The rice breeders at the IRRI made 37 crosses in 1962, 11 of which involved either 'Dee-geo-woo-gen' or 'I-geo-tse' (another semi-dwarf variety from Taiwan, very similar to 'Dee-geo-woo-gen'). Our scientists soon discovered that the dwarfness in these Taiwanese varieties was controlled by a single recessive gene. Thus, in accordance with Mendelian laws of heredity, in the second generation of a cross between a tall and short variety one-fourth of the plants were short and three-fourths were tall. The IRRI scientists discarded the tall ones and made careful selections from thousands of the short ones.'[4]

Engineering an Efficient Rice Plant

The main goal of the IRRI from the beginning was to help increase rice production in the developing countries. One of the main causes for the low yield of rice in the tropics has been the absence of suitable varieties. The typical tropical rice plant in 1960 was tall, with long, drooping leaves and weak stems. Before harvesting, these varieties lodge, with the result that there occurs a heavy reduction in yield. Also, many of these traditional varieties took 5-6 months to mature.

Scientists at the IRRI engineered a new rice plant, which is semi-dwarf, is heavy-tillering and has moderately upright leaves. Its stem has been strengthened, so that the plant does not get toppled when fertilizer is converted into heavy heads of grain. The short, upright leaves utilize solar energy better and allow denser stands. The new rices tiller profusely; where-ever they find room, they send up extra shoots, each topped with a head of grain. Genes for disease and insect resistance have been bred in, and sensitivity to day length has been bred out. The growing season has been reduced from about 160 days to just over 100 days, enabling the farmer with assured water-supply to grow two or even three crops a year, or to grow another food crop after rice.

As these plants are resistant to lodging, they respond positively to added nitrogen. Their upright leaves minimize mutual shading and encourage photosynthetic efficiency. 'IR 8', the first of the new varieties produced at the IRRI, yielded 6-9 tonnes/ha, 2-3 times the yield of conventional varieties. Consequently, 'IR 8' was received with great enthusiasm by both the farmers and the officials charged with the increasing of national production. Released in 1966, 'IR 8' was followed by 'IR 5' in 1967, by 'IR 20' and 'IR 22' in 1969, and by 'IR 24' in 1971. In addition to these varieties, breeding lines with the new plant type and high-yielding ability were

[4]Chandler, R.F. IRRI—the first decade, *Rice, Science and Man*, IRRI, 1972

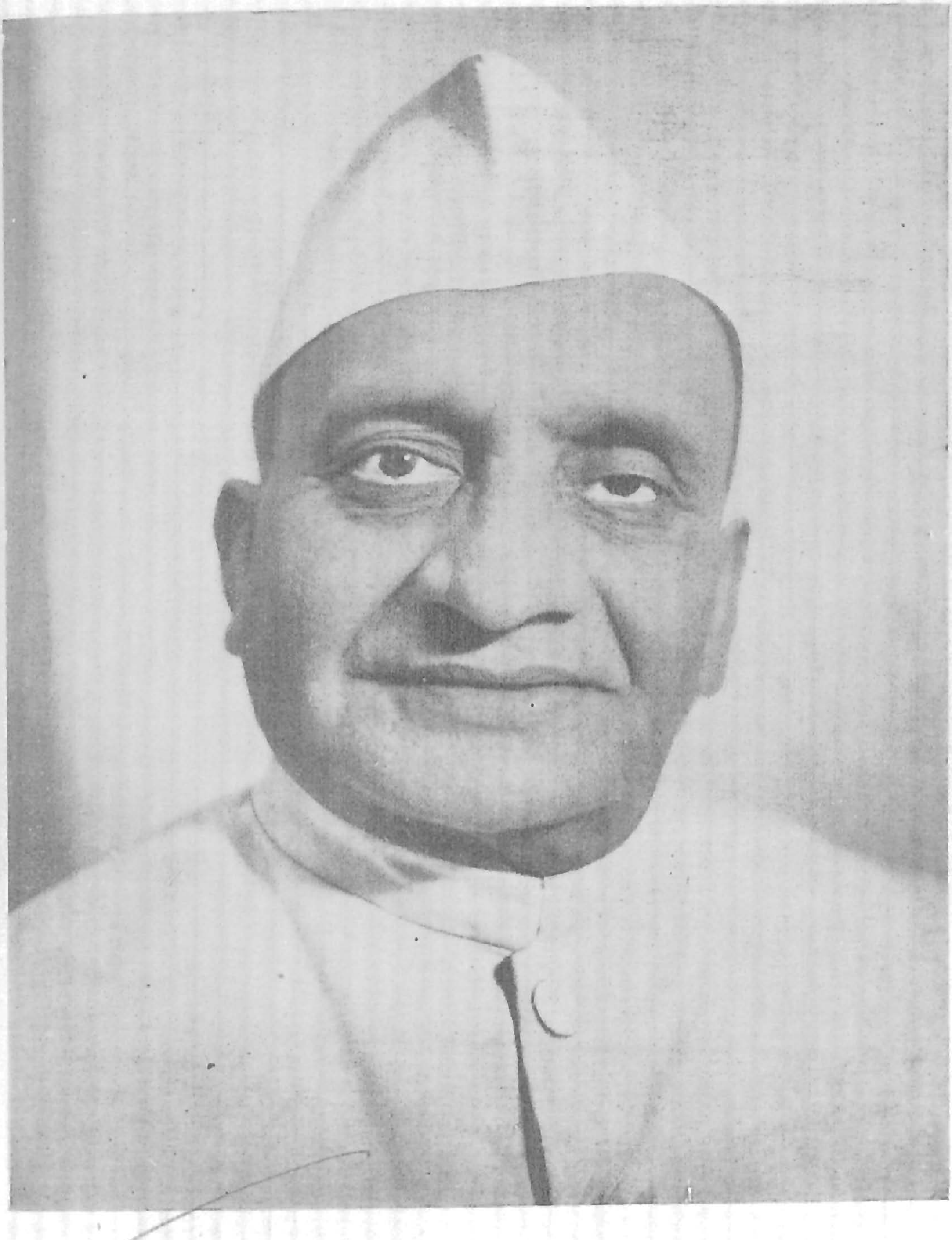


FIG. 115. Dr Punjabrao Deshmukh (b. 1898-d. 1968). An outstanding farm-leader. He founded the Bharat Krishak Samaj (Farmers' Forum of India) in April 1954. He was Minister of Agriculture, Government of India, 1954-1960, and promoted the Japanese method of rice cultivation.

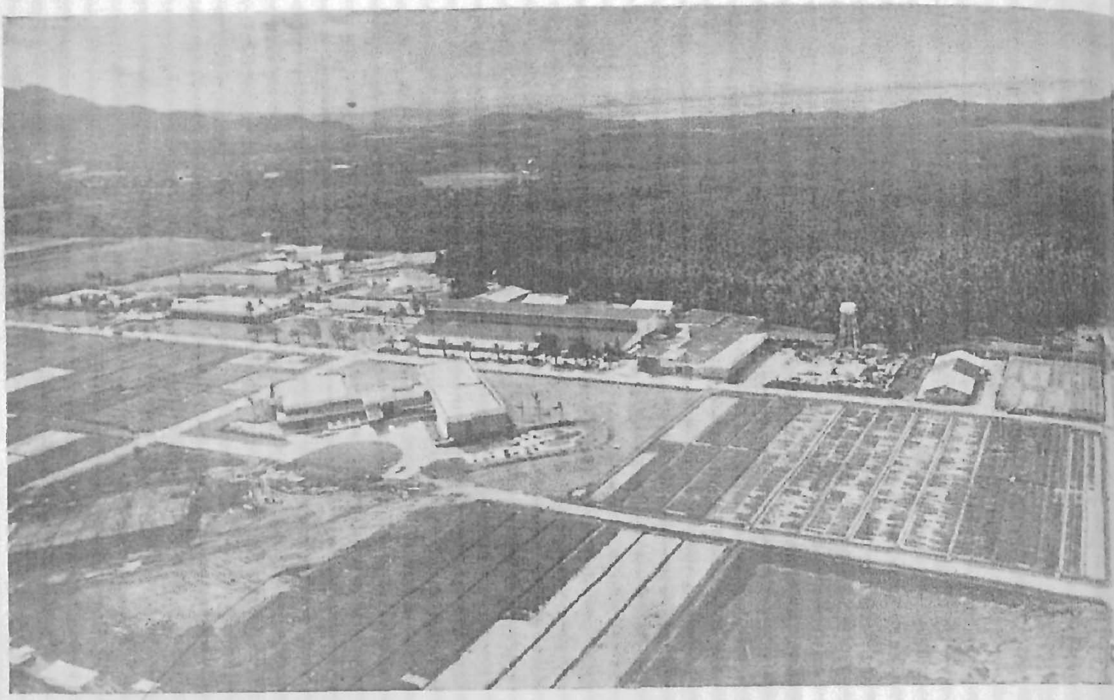


FIG. 116. The International Rice Research Institute, Los Banos, Philippines, has played a great role in the development of the high-yielding varieties of rice. Some of these varieties are grown in India on an extensive scale.

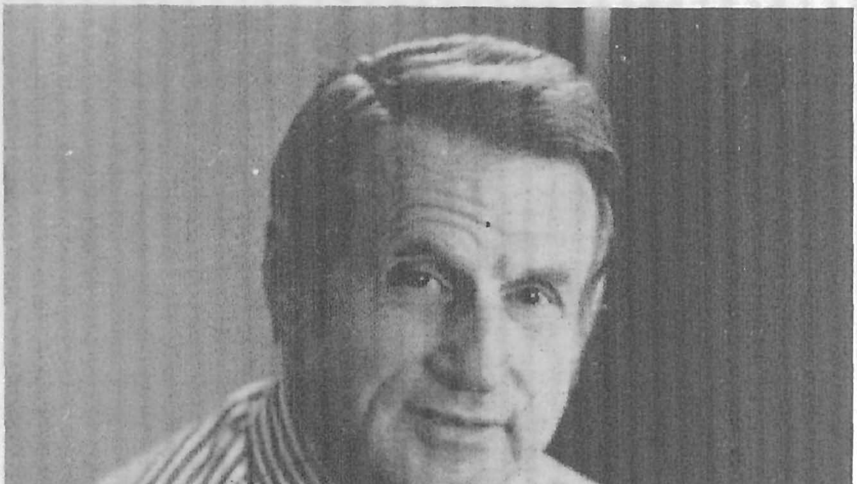


FIG. 117. Dr Robert F. Chandler, Jr, Director, International Rice Research Institute, Philippines. He gave great help to India by providing high-yielding varieties of paddy.

FIG. 118. 'Jaya', a variety of rice, released by Dr S.V.S. Shastry, from Hyderabad in 1969.

Fig. 119. 'PR 106', a fine-grained *rice variety*, released by the Punjab Agricultural University in 1977. Its average yield is 75 quintals per hectare.

promptly supplied to the co-operating scientists working under national programmes. Thus, in addition to the significant accomplishments of redesigning the rice plant for the tropics, the new genetic materials were distributed in a massive way all over the world. Many lines from crosses made at the IRRI were selected and evaluated under diverse ecological conditions throughout the world and were released as varieties by the co-operating scientists. Thus, in addition to the IRRI-named varieties, which were widely accepted by the national programmes, nearly 50 varieties have been named by the co-operating countries from the genetic lines made available to them by the IRRI. Many of these lines were used as parents in the national breeding programmes and numerous high-yielding varieties were developed by the co-operating scientists from these crosses. Improved plant types similar to 'IR 8' are now planted over 30 per cent of the area under rice in the world.

Major emphasis was laid on the increasing of the yield potential and on the improvement of the grain quality of the rices in the earlier years. Later on, the incorporation of insect and disease resistance into high-yielding lines received high priority. The entomologists and plant pathologists of the Institute screened thousands of varieties of rice in the greenhouse and in the field. They have identified sources of resistance to most of the serious diseases affecting rice. The co-operating plant breeders have incorporated this resistance into the IRRI breeding lines and, in turn, into the breeding materials of national research programmes.

The planned programmes of incorporating greater insect and disease resistance into high-yielding varieties have borne fruit. In 1973, the IRRI released 'IR 26' which has moderate resistance to seven of the major rice insects and diseases. This variety was followed in 1974 by 'IR 28', 'IR 29', and 'IR 30' and in 1975 by 'IR 32' and 'IR 34', which have equally good resistance to the major pests of rice. These varieties are also being widely grown in Indonesia, Vietnam, Bangladesh and India.

The genetic materials developed at the IRRI are regularly shared and exchanged with the scientists working under the national programmes through the International Rice-Testing Programme. Thousands of seed samples of breeding lines are sent to the co-operating scientists each year. For the continued success, a collection of the old rice varieties is a vital part of the rice-improvement programme. The IRRI has collected more than 40,000 varieties, which are being systematically maintained and evaluated for various traits of economic importance. Many of these rices become parents in the breeding programme.

India's Contribution to the IRRI Programmes

India has the world's largest resources of rice germplasm. From the very beginning, India has co-operated in sharing its germplasm resources with the IRRI. Thousands of varieties and breeding lines from various research institutes and experiment stations were made available to the IRRI. Many of these varieties, such as 'Tkm 6', 'Pankhari 203', 'Mudgo', *O. nivara* and 'Basmati', to mention a few, were utilized extensively in the breeding programme at the IRRI.

Training Programmes

Besides the research programmes, the Institute has a strong training programme which caters for the needs of training rice scientists at various levels from extension agents to those desiring to obtain M.S. and Ph.D. degrees. By the end of 1976, more than 1,150 persons had undergone training at the IRRI.

As many as 130 Indian scientists have received training for varying periods at the Institute and many of them are holding key positions in rice research in India. In 1967, the IRRI entered into an agreement with the ICAR and the USAID to participate in the development of rice research in India. Under this agreement, several scientists were based at headquarters of the All-India Co-ordinated Rice-Improvement Project at Hyderabad, and they worked closely with the Indian scientists for a number of years to strengthen the rice research in the country.

The IRRI's first and foremost goal has been research on the ways and means of increasing the yield of rice. Towards that end, well-trained scientists are selected, irrespective of national origin. Today, about 50 scientists from 8 different nationalities provide leadership for various research programmes. Four Indian scientists on the staff of the Institute have made significant contributions to the IRRI research programmes. Dr D.S. Athwal was a Deputy Director-General of the IRRI for 5 years. Dr M.D. Pathak, formerly head of the IRRI Entomology Department, is now the Director of Research Co-ordination. Dr G.S. Khush is the head of Plant Breeding and Dr S.K. De Datta is that of Agronomy. In 1982 Dr M.S. Swaminathan took over as the Director-General of the Institute. The Institute has 1,200 members on the staff and 95 per cent of them are Filipinos.

High-yielding Rice Varieties in India

India was one of the first countries to take up the cultivation of 'IR 8' on a massive scale. This variety is still grown in most of the rice-growing areas of the country. Several other IRRI varieties and breeding lines have since been recommended for cultivation in different parts of the country. 'IR 20' is widely grown in Tamil Nadu and Karnataka, 'IR 24' in Uttar Pradesh, 'Pankaj' ('IR 5-114') in West Bengal and Orissa, 'Palman 579' ('IR 579-48') and 'PR 106' ('IR 665-79-2') in Punjab.

'IR 8' and other improved breeding lines were used as parents in the breeding programmes not only at the Central Rice Research Institute, Cuttack, and at the AICRIP, Hyderabad, but also in various States. Numerous dwarf varieties have resulted from these crosses. Most of the high-yielding varieties released in various parts of India are the descendants of crosses involving 'IR 8' or other breeding lines with improved plant types introduced from the IRRI.

A cross involving 'Taichung Native 1' and 'T 141' did remarkably well and was released by the Central Variety Release Committee in December 1968 under the name 'Jaya' (Fig. 118). This variety yields more than 'IR 8'. Another variety developed from the same cross ('Taichung Native 1'×'T 141') and released for general cultivation, along with 'Jaya', is 'Padma'. It is recommended for growing as a summer crop in parts of Bihar and Orissa. 'Padma' has finer grains and has a short duration of 105 days, permitting the farmers to grow it in rotation with potato and jute. 'PR 106', a fine-grained variety released by the Punjab Agricultural University, Ludhiana, in 1977 gives an average yield of 75 quintals of paddy per hectare (Fig. 119).

More recently, to meet the requirements of the various regions for varieties adapted to the season (rice being grown in three seasons in a year in some areas), tolerant to several diseases and pests and possessing better grain quality, a number of new strains have been released under the All-India Co-ordinated Rice-Improvement Project in the names of 'Bala', 'Cauvery', Jamuna', Kanchi', 'Karuna', 'Krishna', 'Pennai', 'Ratna', 'Sabarmati' and 'Vijaya'. These varieties have been recommended for specific areas, taking into consideration the desired duration of the crop, the disease problems and the grain quality liked by the farmers.

Weedicides

For getting the best out of the improved varieties the use of chemical fertilizers is necessary. Weeds in rice are a serious problem and, unless they are controlled, most of the fertilizer is consumed by them. As the result of large scale screening of herbicides, it was found that Butachlor (Machete) could control many of the weeds present in the rice crop. Butachlor is applied as a pre-emergence weedicide. It controls the weeds right from the very beginning, thereby avoiding any crop-weed competition. Weedicides have, thus, materially helped to increase rice production.

Impact of High-yielding Varieties on Rice Production

The production of rice in 1962-63 was 33,551 thousand tonnes. On account of drought in 1966-67, it came down to 30,438 thousand tonnes. From 1968-69, the impact of the high-yielding varieties of rice was felt and the production rose steadily. In 1977-78, the production was 52,680 thousand tonnes. The production of rice from 1964-65 to 1977-78 is given in the Table 1. The increase is largely attributable to the semi-dwarf high-yielding varieties of rice.

TABLE 1. PRODUCTION OF RICE

	Year (agricultural)	*Rice (in thousand tonnes)*
Before the Green Revolution	1964-65	39,324
	1965-66	30,589
	1966-67	30,438
Green Revolution Era	1967-68	37,612
	1968-69	39,761
	1969-70	40,430
	1970-71	42,225
	1971-72	43,068
	1972-73	39,245
	1973-74	44,051
	1974-75	39,579
	1975-76	48,740
	1976-77	42,788
	1977-78	52,680

NOTE: Production is in terms of cleaned rice, which is two-thirds of paddy (rough rice). The fall in production in 1972-73 is owing to the oil crisis and the consequent rise in the price of fertilizers and other inputs.

GREEN REVOLUTION IN PUNJAB, HARYANA AND UTTAR PRADESH

The high-yielding varieties of rice gave remarkable increase in production in Punjab and Haryana. From 1966-67 to 1976-77, there was a five-fold increase in Punjab and a four-fold increase in Haryana. In Uttar Pradesh, the increase was two-fold. In Punjab and Haryana, which are not rice-eating areas, the bulk of the production was contributed to the Central Pool (Table 2).

TABLE 2. THE PRODUCTION AND PROCUREMENT OF RICE IN PUNJAB, HARYANA AND UTTAR PRADESH (ACCORDING TO THE CROP YEAR) DURING 1966-67 to 1976-77 (IN THOUSAND TONNES)

Crop year	*Rice*								
	Punjab			*Haryana*			*Uttar Pradesh*		
	Production	*Procurement*	%	*Production*	*Procurement*	%	*Production*	*Procurement*	%
1966-67	338	129	38	223	90	40	2013	70	3
1967-68	415	238	57	287	167	58	3262	148	4
1968-69	460	270	59	285	163	61	2922	200	7
1969-70	573	376	56	371	238	64	3533	213	6
1970-71	688	525	78	460	252	55	3701	259	7
1971-72	920	771	84	536	316	59	3777	296	8
1972-73	955	754	79	462	277	60	3273	227	7
1973-74	1189	943	79	540	417	77	3859	429	11
1974-75	1179	970	82	393	271	71	3523	283	8
1875-76	1477	1201	83	625	480	77	4294	762	15
1976-77	1741	1504	86	817	632	77	4308	891	16

SOURCE: Food Ministry, Government of India, New Delhi, November 1977

CHAPTER 32

GREEN REVOLUTION IN INDIA-III

MILLETS AND MAIZE

THE term, 'coarse grain' includes millets, e.g. sorghum *(jowar)*, pearlmillet *(bajra)*, finger millet *(ragi)* and maize. From among the pioneers in genetics and breeding of millets, most distinguished work was done by G. N. Ramaswami Ayyangar (1887-1968). He contributed more to the world's knowledge of genetics and morphology of the sorghum plant than any other person. He established the Millets Breeding Station at Coimbatore in 1921. Over the years he made comprehensive studies on the inheritance of several characters in millets, particularly in *jowar*. He standardized the morphological descriptions, evolved genetic symbols and identified linkage groups. He placed sorghum breeding on a highly scientific basis.

SORGHUM

Sorghum originated in the region covered by Ethiopia and Sudan, it is the most important millet grown in India. It is both a dry and irrigated crop and is grown for fodder as well as for grain. It is grown both as a *rabi* crop and a *kharif* crop. The main growing areas lie in Maharashtra, Karnataka, Andhra Pradesh and Madhya Pradesh (Fig. 120).

The average area, production and yield of sorghum, based on the data for 1969-70 to 1971-72, are 17.59 million hectares, 8.52 million tonnes and 0.48 tonne per hectare respectively. The State-wise position is as below:

TABLE 1. AREA AND PRODUCTION OF SORGHUM

State	*Area* (*million hectares*)	*Production* (*million tonnes*)	*Yield* (*tonnes per hectare*)
Maharashtra	34.2	26.4	77
Karnataka	15.5	22.2	143
Andhra Pradesh	14.7	13.4	91
Madhya Pradesh	12.6	16.0	127
Gujarat	7.3	5.4	73
Rajasthan	6.2	4.9	78
Tamil Nadu	4.1	6.4	158
Uttar Pradesh	3.9	4.5	115

SOURCE : National Commission on Agriculture

SORGHUM HYBRIDS

The Commercial hybrids made a significant impact on sorghum production in the USA. The ICAR appointed an *ad-hoc* committee in 1961

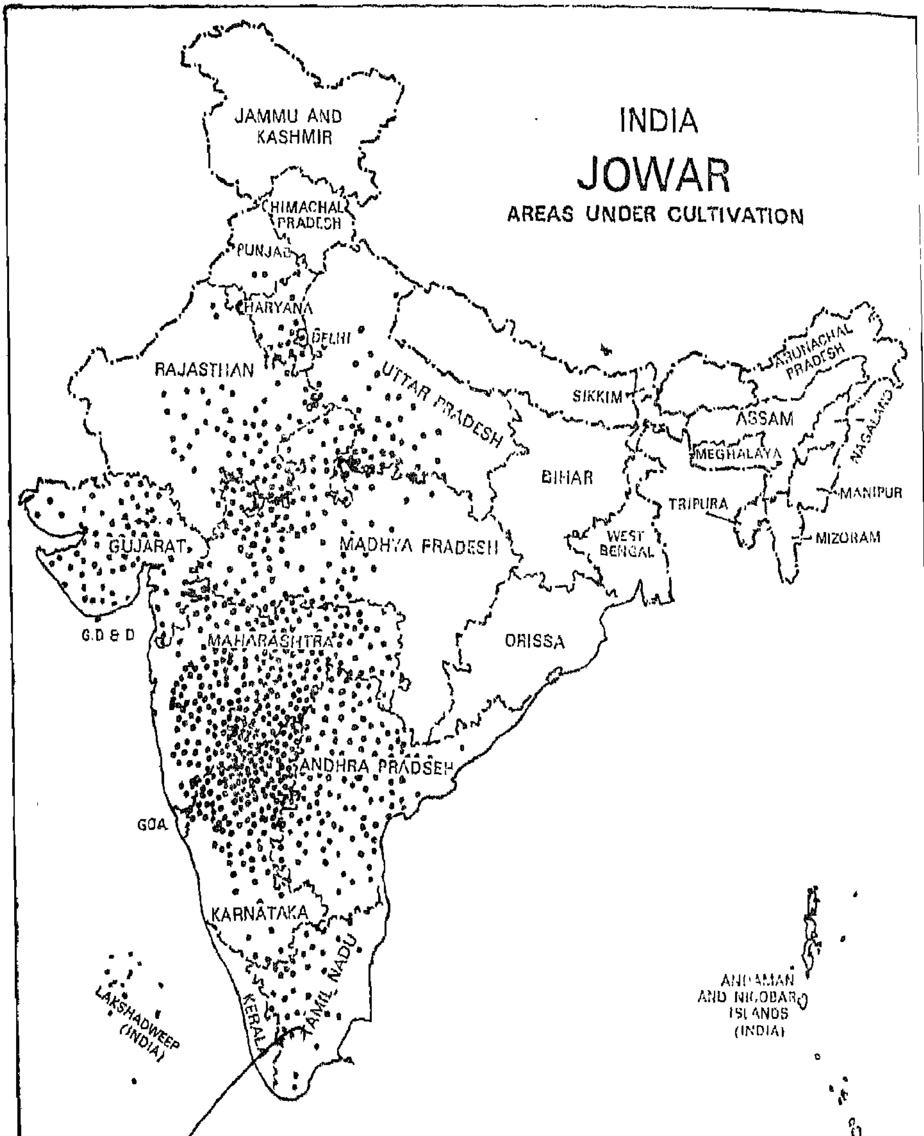


FIG. 120. A map of India, showing the area under sorghum (*jowar*), 1964-65. Each dot represents 20,000 hectares. (ESA)

to explore the possibilities of developing commercial sorghum hybrids in India. This committee recommended that the first commercial sorghum hybrids in India might be developed, using the male-sterile combine 'Kafir 60' as the female parent. As a result of the recommendations, the ICAR, in collaboration with the Rockefeller Foundation, formulated the Accelerated Hybrid Sorghum-Improvement Project in 1962 within the framework of the Project for the Intensification of Regional Research in Cotton, Oilseeds and Millets (PIRRCOM). The first commercial hybrids, 'CSH 1' and 'CSH 2', were released in 1964-65. These hybrids have given grain yields of 4,000 to 6,000 kg per hectare, representing increases ranging from 60 to 80 per cent over those of the local varieties. In 1968, a sorghum variety, 'Swarna', was developed and released. It gives as high a yield as 'CSH 1', and has the advantage that the farmer can easily keep his own seed for growing successive crops (Figs. 121, 122).

PEARL MILLET

Pearl millet, or *bajra (Pennisetum typhoides* (Burm.f.) Staff & C. E. Hubb.), is an important millet crop of India and is cultivated on about 12.38 million hectares. The production is 6.24 million tonnes, and the yield is 0.5 tonne per hectare (1969-70 to 1971-72). The crop is used both for grain and fodder. It tillers profusely and can produce two to three ratoon crops in succession. State-wise, the position is as follows (Table 2):

TABLE 2. AREA, PRODUCTION AND YIELD OF PEARL MILLET

State	*Area*	*Production*	*Yield*
Rajasthan	39.4	25.9	66
Gujarat	14.4	23.1	161
Maharashtra	14.3	9.6	67
Punjab and Haryana	8.7	13.9	159
Uttar Pradesh	8.3	11.6	139
Andhra Pradesh	4.5	4.4	99
Karnataka	4.3	3.5	83
Tamil Nadu	3.8	5.2	134

SOURCE : National Commission on Agriculture

Pearl millet is an arid-zone crop. Rajasthan and Gujarat account for half of the country's area under pearl millet and its production. The yield levels are low in Rajasthan and Maharashtra.

Pearl millet is a highly cross-pollinated crop, the extent of outcrossing being nearly 80 per cent. Before the development of hybrids, improvement in the local populations was made by selecting plants on the basis of well-filled compact and long panicles, high grain weight and uniformity in ripening. As a result of this mode of selection, two varieties, 'T 55' and 'A 1/3', were developed. These varieties gave, on an average, a yield of about 10 quintals per hectare. 'T 55' was recommended for rainfed lands and 'A 1/3' for irrigated areas. Another variety, 'S 530', developed from African material, was released in Punjab in 1965. This was the first bristled variety released for cultivation in the State and yielded about 12 quintals per hectare.

Hybrids of Pearl millet

A male-sterile line, 'Tift 23A', which was developed by Dr G. W. Burton at Tifton, Georgia, USA, in 1958 and was made available to the Indian breeders in 1962, was extensively used to develop hybrids. The attempts made in 1963 resulted in the development of a number of hybrids, some of which had recorded more than double the yield of the local varieties of that time. The best hybrid, produced by Dr D.S. Athwal, and arising from the cross of 'Tift 23A' with 'BIL 3 B', an inbred developed at Ludhiana, was named 'HB 1' ('Hybrid Bajra 1') and was released on all-India basis in 1965. This hybrid had the capacity to give a high yield of 2,500 and 3,000 kg/ha under rainfed and irrigated conditions respectively.

Unfortunately, all the hybrids, based on 'Tift 23 A', including 'HB 1' became susceptible to downy mildew *(Sclerospora graminicola)*, resulting in a setback to the production of pearl millet.

Hybrids Resistant to Downy Mildew

To meet this challenge, strenuous efforts were made at the Punjab Agricultural University, Ludhiana, to locate sources of resistance in the male-sterile as well as in the restorers. The male-sterile line 'L 111A' developed at Ludhiana showed a high degree of resistance to downy mildew at various locations in the country. Dr K.S. Gill developed two hybrids involving this male-sterile line, viz. 'PHB 10' and 'PHB 14', which were found to be highly resistant to downy mildew and also gave an outstanding performance in Punjab as well as in the co-ordinated trials conducted under the All-India Millets-Improvement Project (Fig. 123).

These hybrids also did exceedingly well in the minikit trials in the farmers' fields. Taking into account their superiority to the existing hybrids at that time, the Central Variety Release Committee of the Government of India released 'PHB 10' and 'PHB 14' in 1975 for general cultivation throughout the country. These hybrids have the potential to give a grain yield of 50 quintals per hectare. 'PHB 10' is a non-bristled hybrid, with long ears. 'PHB 14' bears bristled ears, which make it less susceptible to damage by birds. The hybrids mature in about three months and remain green till maturity. Therefore, their stalks can be easily fed to cattle after harvesting the grains. 'PHB 10' and 'PHB 14' have been designated as 'HB 6' and 'HB 7' respectively, under the All-India Millets Improvement Programme. 'PHB 14' was the top-yielding hybrid.

FIG. 121. 'CSA 6'—an early-maturing sorghum hybrid, with a yield potential of 4.5 q/ha, released from Hyderabad under the All-India Sorghum Improvement Project.

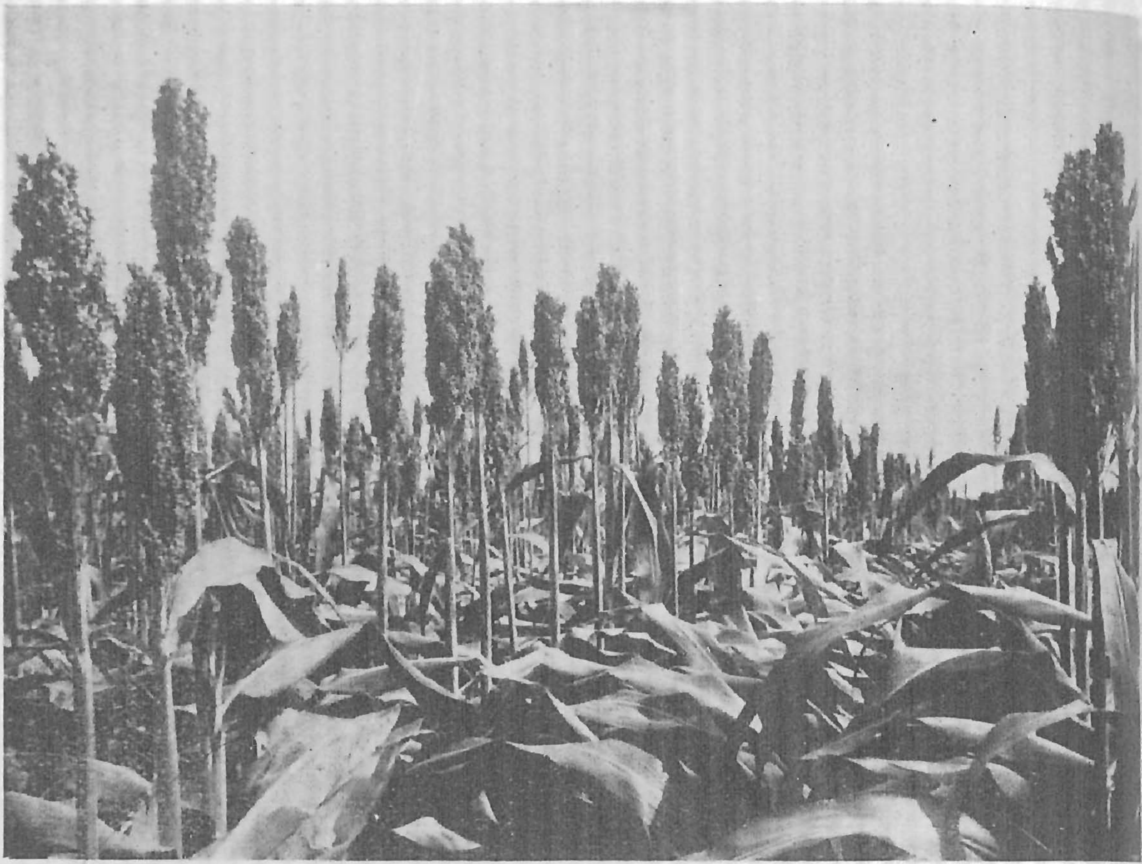


FIG. 122. Hybrid sorghum is very popular in southern India, particularly in Karnataka and Maharashtra.

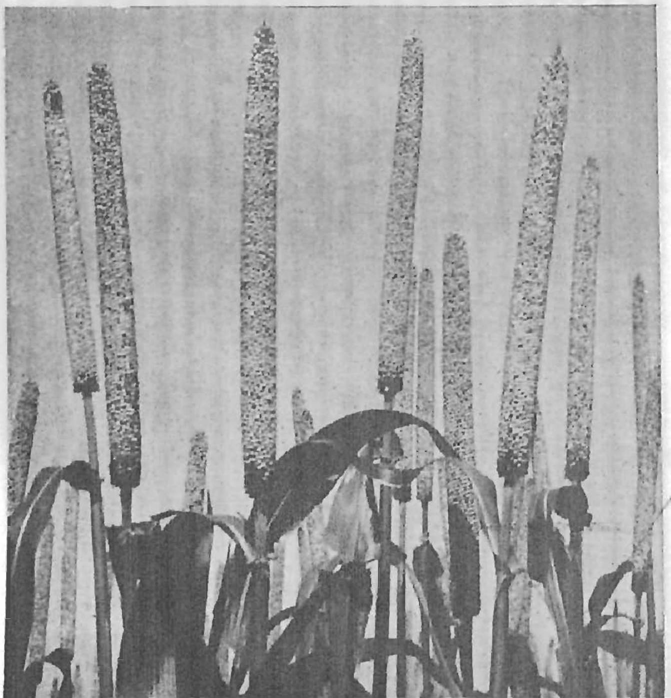
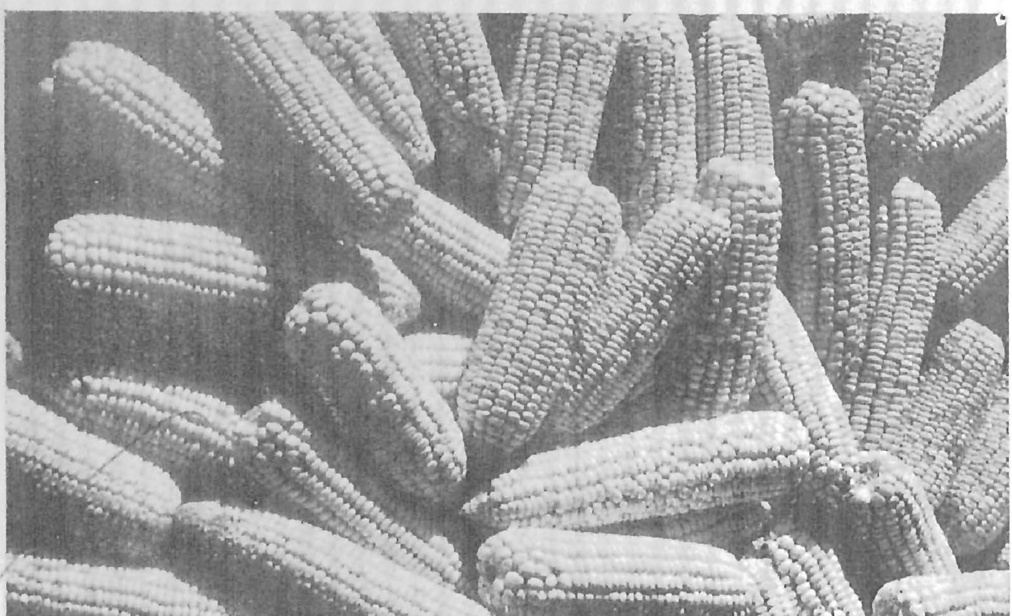


FIG. 123. Hybrid pearl millet (*bajra*) 'PHB 10', released by Dr Khem Singh Gill, from the Punjab Agricultural University, Ludhiana, is resistant to downy-mildew and yields about 30 quintals per hectare.

FIG. 124. Hybrid pearl millet (*bajra*) at the ICRISAT, Hyderabad.

FIG. 125. The composite maize evolved at the Indian Agricultural Research Institute, New Delhi, and the Punjab Agricultural University, Ludhiana, has great appeal for the farmers. *Below*, a heap of the cobs of 'Opaque Composite' maize.



These two hybrids have also been tested in the International Pearl millet-Adaptation Trials (IPMAT), conducted by the ICRISAT. They maintained effective resistance to downy mildew in Africa as well as in India under various agro-climatic conditions.

Composite Varieties

Composite varieties have a good scope in this crop, because it may not be possible to saturate the pearl millet growing areas with hybrids on account of the limitations in seed production. The farmer can himself produce the seed from the varieties once supplied to him.

A composite variety, 'PSB 8', was released in Punjab in January 1980. On the basis of trials conducted on the research stations in different parts of the country and in the minikit trials during 1978 and 1979, this composite was recommended for release on all-India basis by the All-India Millets Workshop held at Hissar in April 1980. 'PSB 8' has, on an average, given a grain yield of 2,535 kg per hectare as compared with 3,014 kg/ha given by 'PHB 14', which works out at 84 per cent of the yield of 'PHB 14'. In the all-India and in international trials, it has even given about 90 per cent yield of the best hybrids. Thus the composites give yields which are quite close to those of the hybrids. The potential of the composite 'PSB 8' is nearly 30 quintals per hectare.

Maize

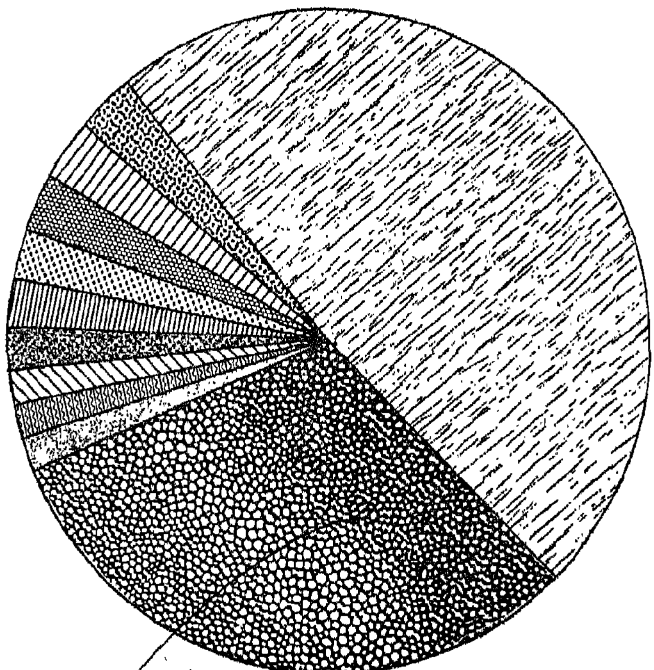
Maize is grown on 4.6 million hectares in India, which is the seventh largest maize-growing country in the world (Fig. 126). Maize is largely rain-fed and is grown in the submontane areas of Bihar and Uttar Pradesh (Fig. 127). The State-wise position is given in Table 3.

Table 3. State-wise area, production and yield of maize, 1969-70—1971-72

State	*Percentage on all-India basis*		
	Area (million hectares)	*Production (million tonnes)*	*Yield (tonnes per hectare)*
Uttar Pradesh	25.9	21.1	81.4
Bihar	16.0	11.6	72.8
Rajasthan	13.3	12.1	90.6
Madhya Pradesh	10.4	8.3	80.0
Punjab and Haryana	11.5	16.2	137.1
Gujarat	4.8	6.4	133.4
Jammu and Kashmir	4.7	6.0	129.0
Himachal Pradesh	4.4	6.9	157.3
Andhra Pradesh	4.2	4.9	117.5
	95.2	93.5	999.1

Source: National Commission on Agriculture

MAJOR MAIZE PRODUCING
COUNTRIES OF THE WORLD
BASED ON THE AVERAGE 1976 TO 1978



REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%	REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%
	USA	167.4	48.0		FRANCE	7.9	2.3
	ROMANIA	10.6	3.0		INDIA	6.2	1.8
	USSR	10.0	2.9		HUNGARY	5.9	1.7
	MEXICO	9.2	2.6		ITALY	5.9	1.7
	YUGOSLAVIA	8.8	2.5		OTHER COUNTRIES	108.8	31.2
	ARGENTINA	8.0	2.3				

TOTAL MAIZE PRODUCTION IN THE WORLD; 348.7 MILLION TONNES (3 YEARS' AVERAGE)
(F) F.A.O. ESTIMATE

FIG. 126. The major maize-producing countries of the world, based on the average 1976 to 1978. (ESA)

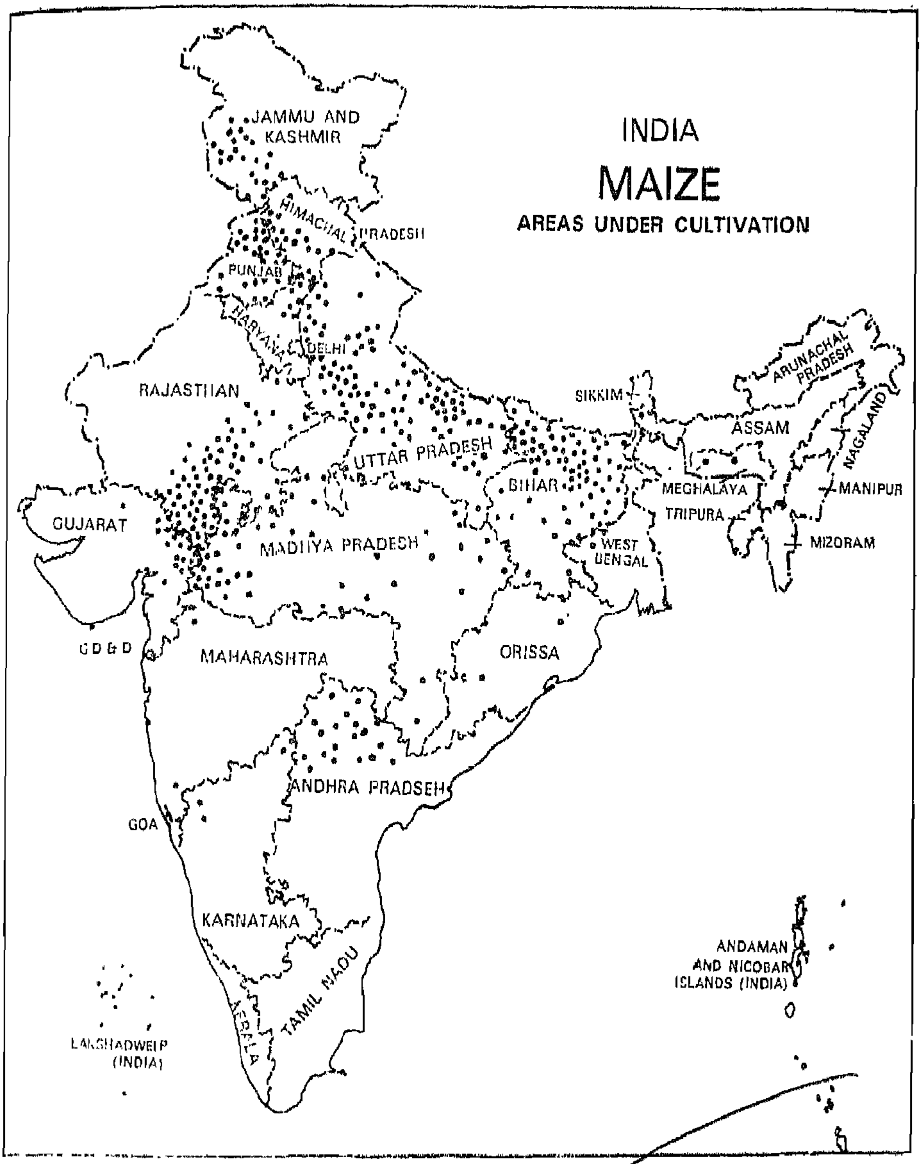


FIG. 127. A map of India, showing the area under maize, 1964-65. Each dot represents 20,000 hectares. (ESA)

Although the work on the improvement of this crop was started at the IARI as early as 1930, and in several States, there was no substantial improvement. The ICAR sanctioned a number of schemes to step up maize production. In 1945, the ICAR sanctioned a project on maize breeding in Punjab, and a year later another project was started at the IARI. As hybrid vigour in maize is capable of boosting yields substantially, emphasis shifted to this aspect of maize production.

The ICAR invited Dr E.J. Wellhausen and Dr U. J. Grant, well-known maize breeders of the Rockefeller Foundation, who had been working in Mexico, to come to India to study the problems facing the maize breeders of the country, and to evaluate the possibilities of developing hybrid maize suitable for growing on a commercial scale in India. In pursuance of the suggestions contained in the report, a Subcommittee of the Botany Committee of the ICAR drew up the first fully co-ordinated crop-breeding project on a regional basis. With some modifications, the All-India Maize-Breeding Project came into operation and was so successful that it served as a model for formulating subsequent projects on other crops.

A large quantity of breeding material was introduced into the country from the USA, Columbia, Mexico and other countries. This material gave an impetus to the maize programmes. In the next few years, a number of very successful maize hybrids were released, including 'Ganga 1', 'Ganga 101', 'Ranjit' and 'Deccan'. 'Hi-Starch', a hybrid, especially suitable for manufacturing starch, was also released. As the next step in the programme, six composite varieties, including 'Vijay', 'Jawahar', 'Kisan' and 'Vikram', were released in 1967 for general cultivation. The development of these composites is a significant advance, as the farmers can produce their own seed and need not go back every year to a commercial organization for getting the seeds of hybrids. The composites have given as high yields as the double-cross hybrids so far released in the country. More recent work on maize has led to the development of hybrids 'Ganga Safed 2', 'Ganga 3', 'Ganga 5' and 'Him 123'. The high-lysine content, associated with the opaque 2 gene, has also been incorporated into the new hybrids (Fig. 125).

Maize is a sensitive crop, which suffers when there is too much rain or drought. Most of the hybrids are late-maturing and occupy the land too long. Besides, there are serious problems arising from the attack of diseases and insect pests. When there is a competition between rice and maize, the farmers prefer to grow rice. Hybrid maize has not fulfilled the expectations entertained originally.

High-yielding Short-stature Maize

A major breakthrough in maize has been reported from the CIMMYT in breeding short-statured, high-yielding maize. According to a report by the Consultative Group on International Agricultural Research (CGIAR), 'Research aimed at breeding short-statured plants with wide adaptation, multiple disease and pest resistance and high protein quality has begun to show results. This is a radical departure from past objectives: it aims at developing varieties for use over a wide area instead of breeding a distinct maize type for each narrowly delimited growing environment.'[1]

The research techniques used in this effort are as innovative as their concept. Populations of as few as 200 or as many as 5,000 plants of similar aspect, but of different genetic make-up, are planted together to allow natural mixing; then the mix is tested under different conditions. The plants that show desirable traits are retained, and the poorly performing ones are eliminated. In this way, a superior population is developed, with wide adaptation and a broad genetic background.

Structural change in the maize plant has been achieved analogous to the restructuring of the rice and wheat plants in the 1960s. By continual selection of short-statured plants and by crossing tall tropical plants with short types, dwarf varieties have been developed with a low ear placement and fewer leaves. The plant's new features make it possible to increase the population density from a traditional 20,000-30,000 to more than 70,000 plants per hectare: the shorter plants show less tendency to topple over as the grain ripens, and they can absorb more fertilizer and use it to manufacture grain; furthermore, the thicker stands make a more efficient use of solar energy and soil nutrients, and they compete successfully against weeds. Moreover, the higher yields create empolyment, since more hands are needed for sowing the crop, and for harvesting, shelling, hauling and handling the increased output from it. The yields of such experimental varieties in the highland tropical experiment station have risen from 5-6 tonnes per hectare to 9-10 tonnes, and those in the lowland humid tropics from 2-3 tonnes to 5-6 tonnes.

Another important achievement is the incorporation of day-length insensitivity into the short-statured lines. Wide adaptation to altitude is being sought in much the same manner.

The introduction of this character of maize may revolutionize maize-growing in northern India.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

The international centres are in a unique position to assist the national programmes. They are independent, non-political international organizations, which, although originally funded by private foundations, now receive support from many diverse sources. Their scientific staff are outstanding international scientists representing various scientific disciplines affecting

[1]*Consultative Group on International Agricultural Research* (CGIAR), New York, 1976, p. 19

crop production. Included on their staff are a number of crop production experts who have the scientific competence and broad experience to assist national agencies in organizing and launching crop-production programmes. The ICRISAT, established in July 1972, at Begumpet, near Hyderabad, for research on millets and allied crops is one such centre. Its first Director was Dr Ralph W. Cummings. Research in plant breeding is being carried on sorghum, pearl millet, pigeonpea, chickpea and groundnut at this Centre. It also concentrates on the objective of the funding system of farming that will result in a higher output. Comprehensive research is being carried on soil and water management, and crop alternatives.

The ICRISAT has built up a world collection of sorghum germplasm, with over 17,000 successions. From this collection, superior lines for given environments are being identified as well as specific genes for desirable traits, which the breeders want to incorporate into their best geno types. Characteristics sought to be included are genetic resistance to striga, downy mildew and resistance to harmful insects, e.g. shoot-fly, stem-borer and midge.

In the pearl millet breeding programme, stress is on early-maturing and bird-resistant varieties. Useful work has been done on building reservoirs for the storage of water at higher sites, so that water may flow to most of the fields by gravity, and thus may be used during dry spells.

Production of Coarse Grains

From 1964-65 to 1977-78, production of coarse grains has been fluctuating from 21 million tonnes to 30 million tonnes, as is evident from Table 4.

Table 4. Production of coarse grains from 1964-65 to 1977-78

Year	*Production of coarse grains (million tonnes)*
1964-65	25,378
1965-66	21,420
1966-67	24,053
1967-68	28,798
1968-69	25,183
1969-70	27,287
1970-71	30,547
1971-72	24,596
1972-73	23,139
1973-74	28,828
1974-75	26,129
1975-76	30,409
1976-77	28,491
1977-78	29,800

Source: Annual Economic Surveys, Government of India

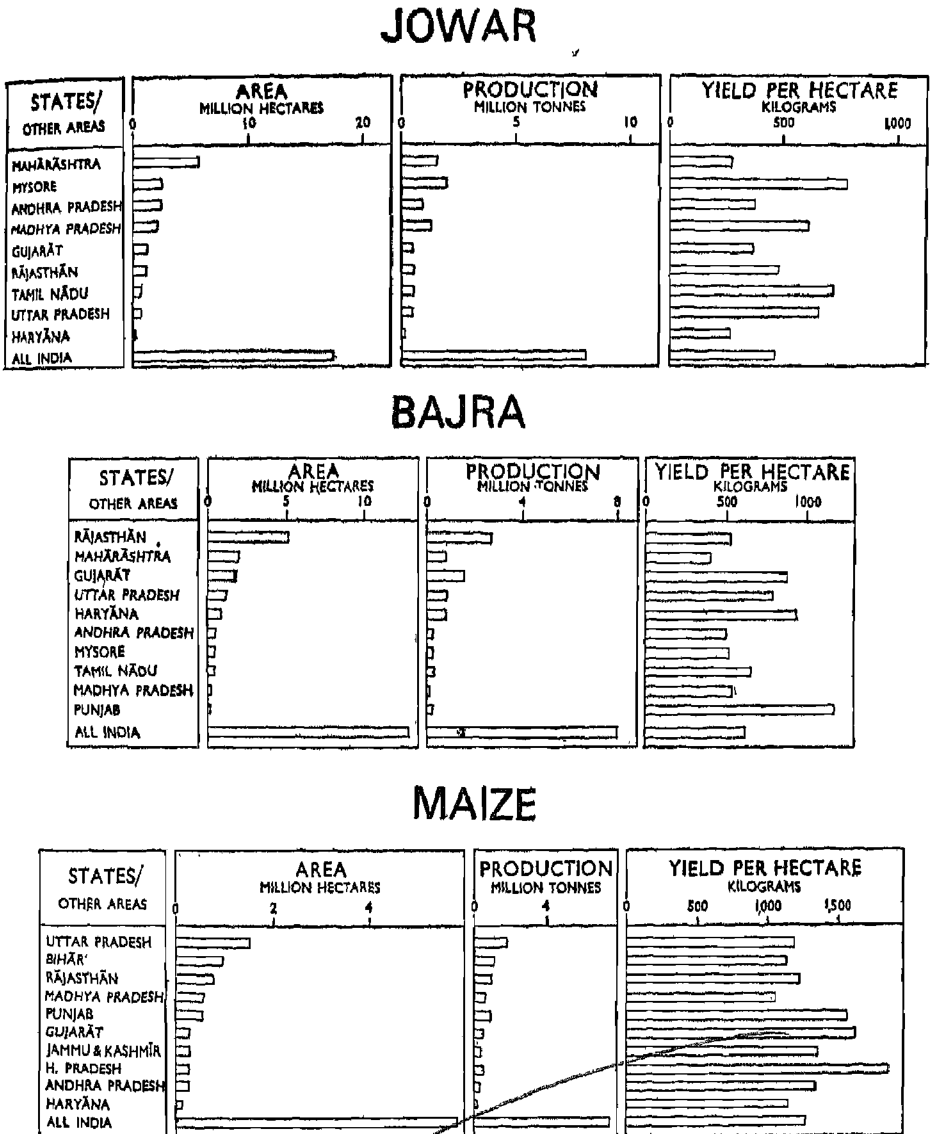


FIG. 128. Area, production, yield per hectare of sorghum, pearl-millet and maize in the major growing States in India. The figures relate to 1970-71. (ESA)

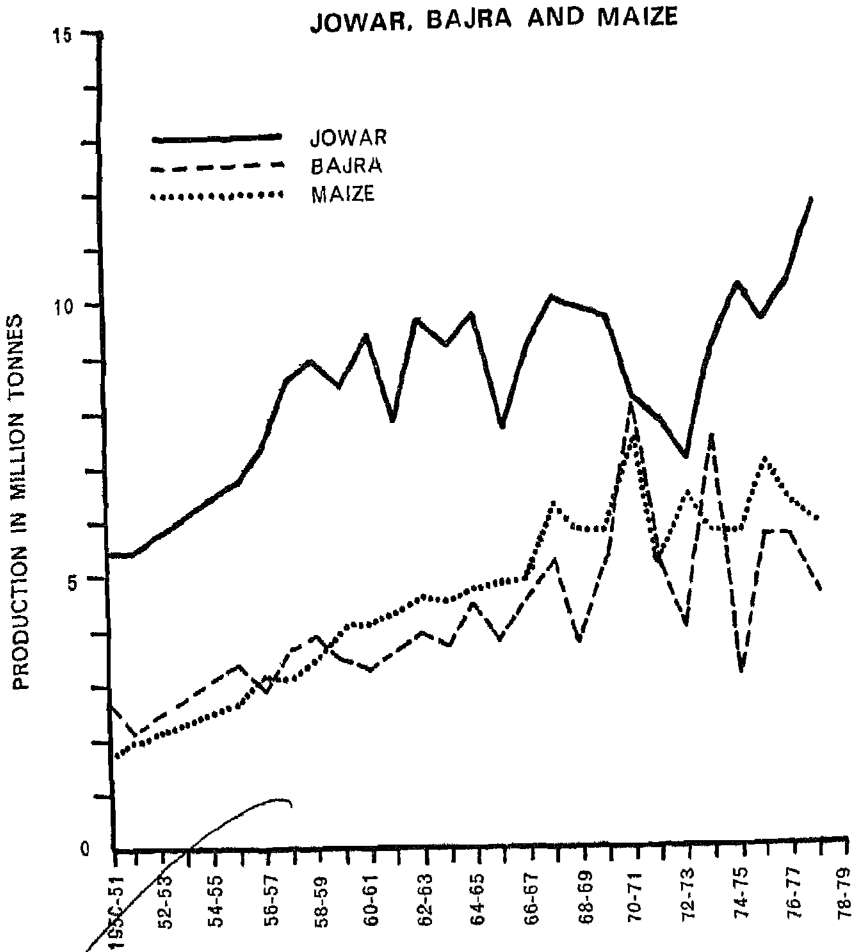


Fig. 129. Trends in the production of sorghum, pearl millet and maize in India from 1950-51 to 1978-79.

As the coarse-grained crops are mostly rainfed, their production dips seriously in the drought years. A graph showing the production of sorghum, pearl millet and maize from 1950-51 to 1978-79 shows many troughs and crests, but the trend is upwards (Fig. 129).

CHAPTER 33

COTTON

THE INTRODUCTION OF AMERICAN COTTONS
LABH SINGH AND 'LSS' COTTON
DR C. T. PATEL AND 'HYBRID 4' COTTON
DR V. SANTHANAM AND 'MCU 5' AND OTHER VARIETIES

COTTON is the most important cash crop of India. With respect to production, India occupies the fourth place in the world, with a production of 1.2 million tonnes of lint. The first three countries are the USSR, the USA and China (Fig. 130).

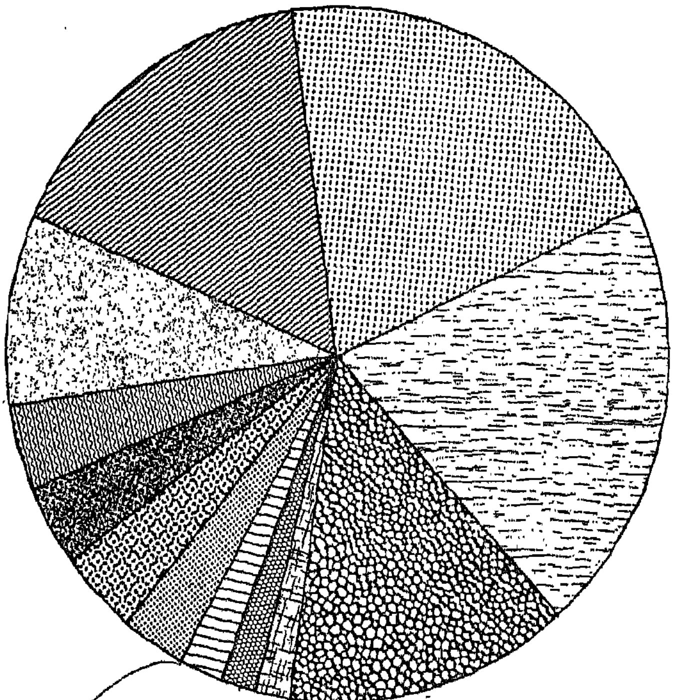
Cotton is grown in India from the sub-Himalayan region in the north to Kanyakumari in the south, its cultivation being confined mainly to areas lying between longitudes 70° and 80°. This enormous cotton tract has been divided into six regions on the basis of species and tracts: (i) the nothern *hirsutum* region, comprising Punjab, Haryana, western Uttar Pradesh, Delhi and north-western Rajasthan; (ii) the central *arboreum* region, comprising Madhya Pradesh, southern Rajasthan, Gujarat and Vidarbha, Marathwada and the Khandesh tracts of Maharashtra; (iii) the western *herbaceum* region, comprising Gujarat, Kutch and northern Saurashtra and the Belgaum, Dharwar and Bijapur districts of Karnataka; (iv) the central *herbaceum-arboreum-hirsutum* region, comprising Andhra Pradesh and Karnataka; (v) the southern *hirsutum-arboreum* region, comprising Tamil Nadu and Kerala, and (vi) the eastern region, comprising Assam, Tripura, Bengal, Orissa and Bihar States (Fig 131).

Western Punjab and Sind are important cotton-growing areas, which, on the partition of India, were included in Pakistan. In 1947-48, India produced only 2.1 million bales of cotton, and in 1978-79 the production increased to 7.2 million bales (Fig. 132). Thus an increase of more than 300 per cent was achieved—a remarkable achievement, indeed. The increase was owing to more area having been brought under cultivation, varietal improvement and agro-techniques. The cotton crop supports a gigantic textile industry, comprising more than 700 textile mills, located mainly in Maharashtra and Gujarat.

Maharashtra has the largest area under cotton, but it is mostly rainfed. Punjab gives the highest yield per hectare. Haryana follows Punjab in this respect. Gujarat gives the largest production of cotton, despite small area under this crop. Next comes Punjab (Fig. 133).

MAJOR COTTON (LINT) PRODUCING COUNTRIES OF THE WORLD

BASED ON THE AVERAGE 1976 TO 1978



REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%	REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%
	USSR	2.6	20.2		BRAZIL	0.5	3.9
	USA	2.6	20.2		EGYPT	0.4	3.1
	CHINA (F)	2.1	16.2		MEXICO	0.3	2.3
	INDIA	1.2	9.3		ARGENTINA	0.2	1.5
	TURKEY	0.5	3.9		SUDAN	0.2	1.5
	PAKISTAN	0.5	3.9		OTHER COUNTRIES	1.8	14.0

TOTAL COTTON PRODUCTION IN THE WORLD: 12.9 MILLION TONNES (3 YEARS' AVERAGE)

(F) F.A.O. ESTIMATE

FIG. 130. The major cotton (lint)-producing countries of the world. India is the fourth producer of cotton (ESA).

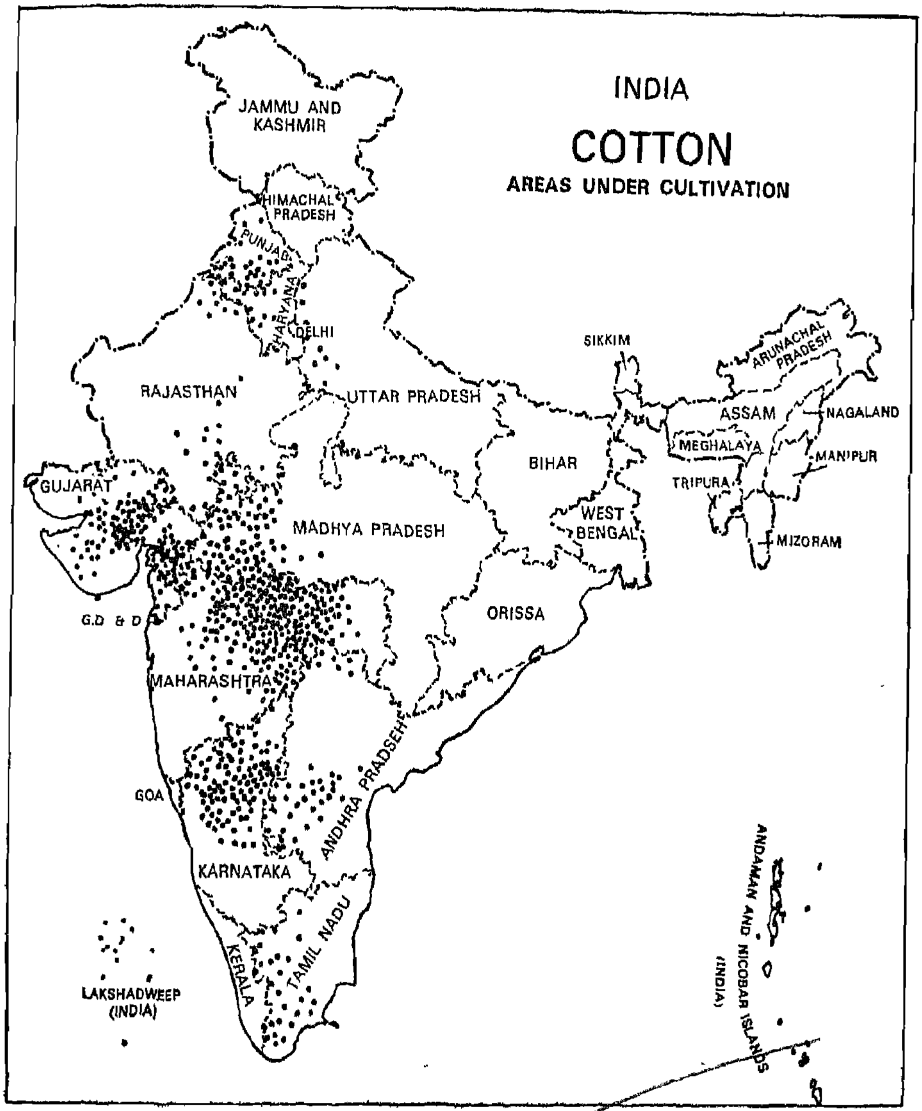


FIG. 131. A map of India, showing the area under cotton, 1964-65. Each dot represents 10,000 hectares. (ESA)

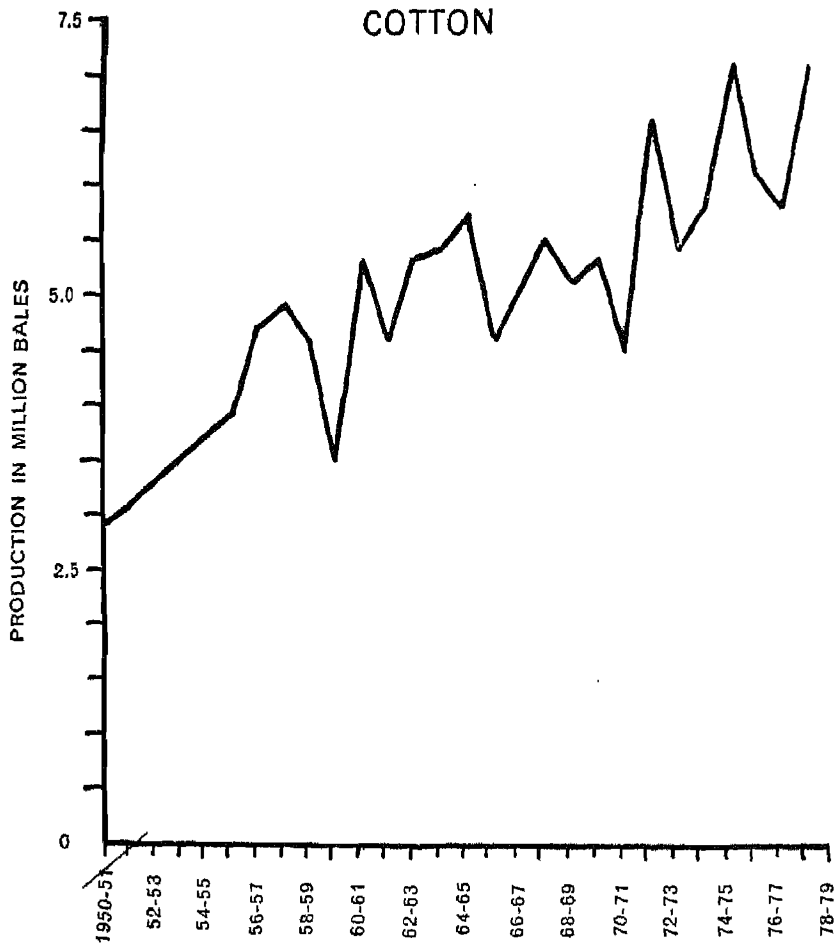


FIG. 132. Trend in the production of cotton in India from 1950-51 to 1978-79.

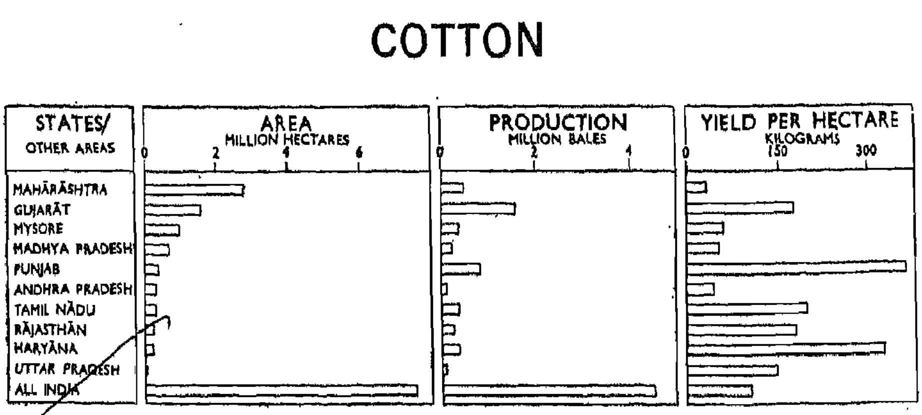


FIG. 133. Area, production and yield per hectare of cotton in India, 1970-71. (ESA)

Introduction of American Cottons in the Bombay Presidency (now Maharashtra and Gujarat)

American cottons were first introduced in Bombay Presidency (now Maharashtra and Gujarat) in the second half of the eighteenth century. The seed of Bourbon cotton was obtained from Malta and Mauritius and distributed in 1790. The strains of this cotton are still found in certain parts of the cotton tracts of the Deccan as well as in Konkan. A fresh supply of seed was obtained from Mauritius in 1812 and distributed to the collectors of Surat and Broach, but the trials proved a failure. The experiments continued thereafter in Kaira by Dr Gilders also failed. Of the 12 American cotton-planters who were brought to India in 1840, three were allotted to Bombay, where they started work at Broach. Trials with exotic American cotton were carried out in Gujarat, the Deccan and Konkan. It was only in the Dharwar area that some tangible results were obtained. The New Orleans seed was grown there in 1842 in the Hubli *taluka*, and the area under it registered a peak of 1,78,682 acres (72,310 hectares) by 1861-62.

American Cotton in Madras (now Tamil Nadu and Kerala)

The Bourbon cotton seeds obtained from Malta and Mauritius were first distributed among the cultivators in Madras in 1790. The surviving relic of this introduction is the Bourbon cotton which has become naturalized and is found only in the districts of Salem and Coimbatore. Three American planters, invited by the East India Company, were allotted to Madras. They commenced work in the Tinnevelly District, where the *ryots* refused either to adopt the American method of cultivation or to sow the American seed unless Government guaranteed the purchase of the produce. Trials with New Orleans, Sea Island and Bourbon cottons were thereafter undertaken on the four farms established in the Coimbatore District, but the results proved unsatisfactory. For some years after the reorganization of the Madras Agricultural Department in 1905, American, Peruvian, Egyptian, Sea Island and Caravonica cottons were tried on the farms at Bellary, Attur, Taliparamba and Hagari, but without success. Susequently, the Cambodia cotton, an exotic American variety, acclimatized originally in Cambodia (Indochina), was introduced into the Madras Presidency in 1907. Its performance under irrigated conditions was encouraging, and, subsequently, it became popular with the cultivators.

Hilson and Ramanatha Iyer were the earliest workers in Madras. 'Co 1' from Cambodia, 'No. 14' from Northerns, 'H 25' and 'H 1' from Westerns and several other strains stand to the credit of Hilson whose foresight has stood the test of time. It may be stated that 'N 14', which he had isolated, stands supreme to this day in the field, not having been replaced by any strain superior to it in quality. 'Co 2', which was a more robust and cosmopolitan strain than 'Co 1', was isolated by Ramanatha Iyer.[1]

AMERICAN COTTON IN PUNJAB

The first attempts at growing American cottons in Punjab were made in 1853, when some quantity of seed was distributed by the Deputy Commissioner of Shahpur. In 1876-77, the seed obtained from Dharwar was distributed in parts of the Province. In 1884, some Upland Georgian seed was distributed by the office of the Director of Land Records. Apparently, the crop grew fairly well and became common in the form of stray plants among *desi* cotton for many years afterwards. In 1902, the question of American cotton came into prominence again owing to the tests made by Mr Mollison, Inspector-General of Agriculture, in Hissar. In his note on the improvement of Indian cotton, 1902-03, he remarks: "27 newly introduced and 5 acclimatized American Uplands did surprisingly well at Hissar on deep rich alluvial soil helped by irrigation. All exotics there came to maturity, on an average, as soon as the early ripening indigenous varieties. They did not therefore suffer from frost."

In 1903, the matter was taken up and trials were made at the Lyallpur Farm with the Cawnpore-acclimatized American and the 'Punjab Narma'. The seed of the latter was obtained with difficulty through the courtesy of Messrs Mela Ram & Sons of Lahore, who managed to collect sufficient seed for half an acre from stray plants growing among the plants of *desi* cotton. This 'Punjab Narma' was a relict of the Upland Georgian, first grown here 20 years previously. It was unknown as a separate crop, though in favour with the housewife on account of its softness; hence named *Narma*. Curiously enough, some seed of *khaki* American cotton appears to have been given out at the time of the Boer War and the *khaki*-coloured American was grown in the Canal Colonies in minute quantities or as stray plants in *desi* cotton—it was exclusively used for home consumption by the farmers.[2]

Both in 1902 at Hissar and in 1903 at Lyallpur, the sowings were late and the late pickings in December were affected by frost. In 1904, Mr Mollison supplied trained men and bullocks together with drills for the proper sowing and trial of a few American and some good Bombay *desi* types, to the *zamindars* in Lyallpur. The early-drilled seed did not germinate and had to be resown. Some of the *desi* types failed, but in spite of poor germination, the American cotton, especially 'Punjab Narma', the 'Dharwar-acclimatized' and the 'Cawnpore-acclimatized', gave encouraging results. The 'Dharwar-acclimatized' had better staple and matured earlier than 'Punjab Narma', and it yielded better than the 'Cawnpore-acclimatized'. In 1905, the trials were extended to Sargodha on the Lower Jhelum Canal.

[1]Sethi, B. L. *et al. Cotton in India, a Monograph*, Vol. I, Bombay, 1960, pp. 7-9
[2]Roberts, W. 'American Cotton in the Punjab', *Agric. J. India*, Vol. 10, 1915, P.8

Altogether, about 300 acres (121 hectares), more or less, was grown from the Dharwar seed in 1905.

Up to this time, the growers of American cotton secured in many cases extra water and compensation in the case of the failure of the crop. The extra water was demanded, as it was asserted that American cotton required much more water than the *desi* cotton.

It was after 1905 that it became possible to work systematically. The Agricultural Department here may be said to have properly started in that year. The sales of American cotton were started in Sargodha in 1905-06 and in Lyallpur in 1907, and a premium of over Re 1 a maund (Rs 27 a tonne) over the *desi* cotton was generally obtained at these sales. The importance of the botanical aspect of the question was soon recognized. The Dharwar-American cotton is apparently very much mixed. It was noticed that the smooth-leaved types suffered from jassid which attacked the leaves and caused them to crumple and become reddish. These attacks were, however, not regular and were almost completely absent in some years. The botanical work, including a large number of selections and crosses, was transferred to the Botanical Section in 1908.

In 1909, two varieties were given out by the Botanical Section. They were 'Punjab Narma' and 'Dharwar-American', which did not appear to be any improvement upon the ordinary crop. In 1910, '4 F', a heavy yielder, was isolated from the acclimatized Punjab-Americans by D. Milne.

Till 1911, with the exception of the Jhang District, where cultivators kept their own seed, the success achieved was insignificant. The practice of importing seed from Dharwar was abandoned in 1912, as it became evident that American cotton grown in Punjab was superior to that grown in Dharwar. Selection was started at Lyallpur by Dobbs, the Principal of the Agricultural College, and was continued by Milne, the Economic Botanist, and it resulted in the isolation of cotton varieties '3 F' and '4 F' in 1912. The former a smooth-leaved type, failed because of its susceptibility to jassid, whereas '4 F', a rough-leaved upland type and a selection from the 'Punjab Narma', proved to be immune to jassid. The total area under American cotton in the Punjab in 1913 was some 30,000 acres (12,140 hectares). Subsequently, '4 F' variety spread rapidly, and in 1917 out of the total area of 276,000 acres (111,693 hectares) was covered by it.[3] Almost the entire area was in the Canal Colonies of Jhang, Lyallpur, Sargodha and Montgomery.

LABH SINGH (B.1889-D.1962) AND 'LSS' COTTON, *1933*

For almost a quarter of a century, cotton variety 'LSS' figured prominently in the agriculture and trade of the Punjab. Even today, this variety

[3]Sethi, B.L. *et al. Cotton in India, a Monograph*, Vol. I, Bombay, 1960

sells at a premium over other varieties grown in this region. The variety was named after Labh Singh, the man who evolved it.

Labh Singh was born on 7 November 1889 in the Village of Singhpura, known for progressive farming, in the Gurdaspur District of the Punjab. He received his early education in the neighbouring towns of Dhariwal and Gurdaspur. He joined the Punjab Agricultural College, Lyallpur, in 1909, and obained in 1912 his L.Ag. diploma among the first batch of eight students. He stood first in Agriculture and was bracketed with Ram Dhan Singh and also obtained Honours in Botany.

He joined the Department of Agriculture on 24 July 1912 as an Agricultural Assistant. In 1920 he was promoted Assistant Professor of Agriculture, and in 1927 as Associate Professor of Agriculture.

The story of the evolution of the 'LSS' cotton reflects the qualities of this man whose life was devoted wholly to agriculture. A malady called *tirak,* which resulted in the premature shedding of leaves, in the premature opening of bolls and in the consequent reduction in yield, threatened the very existence of the established variety '4 F' American cotton in Punjab. This problem baffled the scientists. During one such cotton failure in 1928, Labh Singh, who had the habit of roaming about in the fields and who was endowed with keen observation, noticed in a sick field of '4 F' cotton one healthy plant, with well-opened fluffy bolls. He immediately marked this plant and collected its seed. Since the Cotton Breeder at Lyallpur did not agree to take up this new strain, Labh Singh, confident of its merit, grew it in the compound of his house and continued the trials on the Lyallpur Agricultural Farm. Luckily, this plant bred true to type. Later, the trials in the Cotton Section established this variety to be superior not only in yield but also in the quality of lint to other strains of American cotton.

Being a modest man, Labh Singh named this variety '4 F Selection'. It was D. Milne, then Director of Agriculture, Punjab, who recognized the importance of his work and named this variety 'Labh Singh Selection' ('LSS') in 1933, when it was released. The cotton variety '320 F', which became very popular in Punjab after partition, is a daughter strain of 'LSS' (Fig. 135).

In 1938, Labh Singh was appointed Professor and Deputy Director of Agriculture at Lyallpur. He continued in this position till his retirement from the Department of Agriculture, Punjab, in November 1944.

The British Government conferred upon him the title of Sardar Sahib in 1937 in recognition of his services to agriculture. He was also awarded Sir Ganga Ram-Maynard prize for outstanding work in the field of agricultural research.

After retirement as Professor of Agriculture and Deputy Director of Agriculture, he worked as the Director of Agriculture in the Jaipur State.

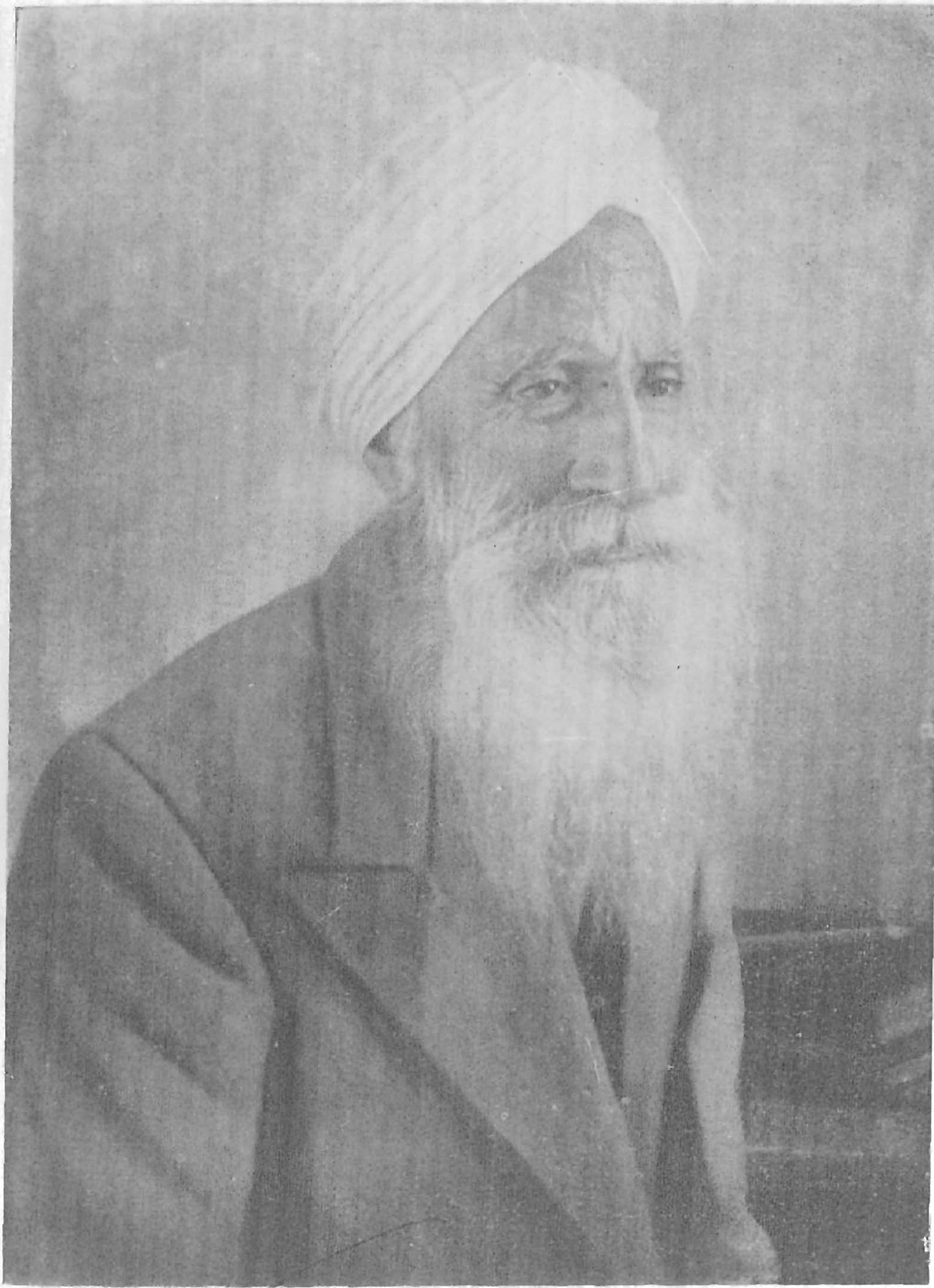


FIG. 134. Labh Singh (b. 1889, d. 1962), famous plant breeder. He evolved the 'LSS' ('Labh Singh Selection') variety of cotton, released in 1933 from Lyallpur. The cotton variety '320 F', which became popular in the Punjab after Independence is a daughter strain of 'LSS'.

FIG. 135. Women picking cotton in a field in the Bhatinda District, Punjab. The variety is '320 F'. (PAU)

FIG. 136. Dr C.T. Patel, who has done outstanding work in evolving the high-yielding 'Hybrid 4' cotton.

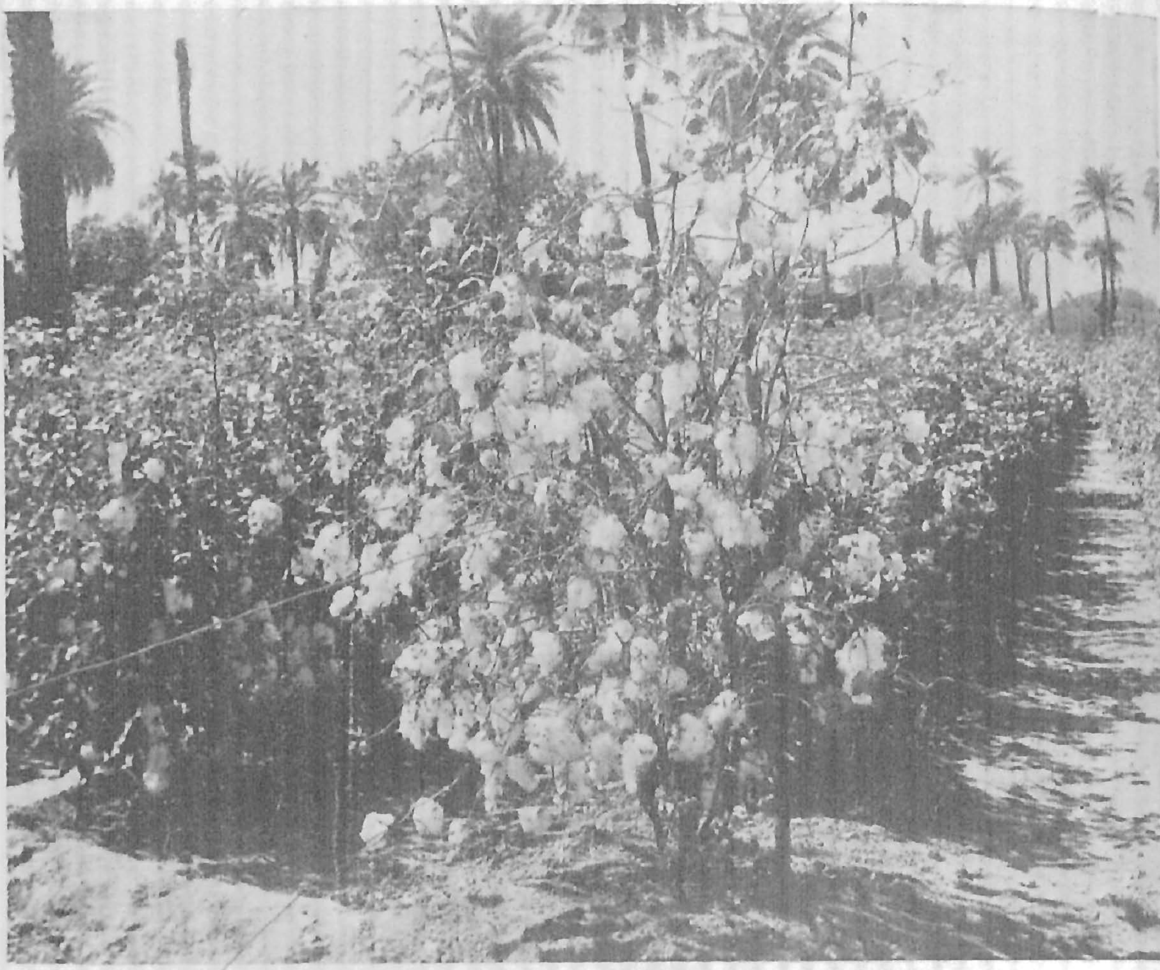


FIG. 137. The telephone system for the cultivation of 'Hybrid 4' cotton at Surat. The plants are kept upright by tying the branches to a horizontal galvanized-iron wire. Thus the plants get maximum light and branches do not break off owing to the heavy load of bolls.

He continued in that capacity for six years. In 1951, he acted as Deputy Adviser for Intensive Cultivation in the ICAR.

The call back to land was too strong to be resisted by Labh Singh, who was a son of the soil in the real sense and whose soul always longed for the village. During his last years, he settled on a land which he had purchased in the village of Khera near Jagadhari in the Ambala District, now in Haryana. At his farm, he built up a large collection of plants of different crops, selected from the surrounding areas. Shortly before his death, when he was brought home from a nearby hospital, his keenest desire was to see the plots in which he had sown some selections of wheat. On 20 January 1962, this lover of crop plants breathed his last. Shortly before his death, he received a gold medal from the Pakistan authorities for his services to agriculture. In 1969, the Punjab Agricultural University, Ludhiana, honoured him by naming the Plant-Breeding Laboratories after him.

As a teacher, Labh Singh always tried to infuse into his students practical approach to agricultural problems. His simplicity and unassuming manners left a deep impression on all his students and those who worked under him. As a researcher, he attached great importance to precision in all experiments. He was a keen observer and appreciated this quality in others. It is a tribute to his scholarship that despite his holding only the B.Sc. (Agric.) degree, the Panjab University appointed him an examiner and guide for postgraduate students. Labh Singh had very candid views on higher education. He believed that only intelligent and dedicated persons could benefit from higher education. He attached much greater importance to basic intelligence, aptitude and devotion to duty than mere academic qualifications. The scientists of the present generation have much to learn from the work and life of this modest and unassuming man, who made such an important contribution to the economy of India.

Dr C. T. Patel (b.1917) and 'Hybrid 4' Cotton, Surat, Gujarat

C. T. Patel was born in a farming family in the Village of Sarsa in the Kheda District of Gujarat in 1917. He graduated from the College of Agriculture, Poona, in 1941. Later on, he obtained his M.Sc. degree in plant Breeding and Genetics from the Bombay University. From 1964 to 1974, he worked as Cotton Specialist, Gujarat, and as the Zonal Co-ordinator Cotton-Improvement Project of the ICAR. On retirement from government service, he became the Research Project Co-ordinator of a private organization, ICMF Cotton Development and Research Association, Bombay.

During his 36 years of service, Patel specialized in cotton research and made a great contribution to the isolation and development of superior and extra-long Indo-American cottons, such as 'Deviraj' ('1070 Co 2') in

1951-52, 'Devitej' ('134 Co 2.2M') in 1952-53, 'Gujarat 67' ('ISC 67') in 1962-63, 'Hybrid 4' ('Sankar 4') in 1967-68 and 'IAN/579-188' ('Vishnu') in 1972-73, 'SRI 1' and 'Hybrid 5' in 1973-74. The evolvement of these cottons, with staple lengths ranging from1-1/16" to 1-3/16" (26. 99 mm to 30.16 mm) and above, and capable of spinning good 40s to 100s is a landmark in cotton improvement in India. These strains are the products of different species, which are not only widely related to one another, but possess a higher number of chromosomes; hence it is difficult to obtain stable forms. Patel was able to stabilize them.

Development of 'Hybrid 4'

'Hybrid 4' ('Gujarat 67' × 'American Nectariless') is not only remarkable for its good quality of 50s counts but it was also outstanding in its productive capacity, viz. a yield of 40 to 50 quintals of *kapas* per hectare. These yield levels were unheard of in the annals of Indian cotton so far.

Incessant efforts to exploit hybrid vigour in cotton for commercial production at Surat since 1948-49 at last had resulted in the evolvement of versatile hybrid, viz. 'Sankar 4' ('Hybrid 4') in 1964-65. This hybrid is an inter-*hirsutum* cross, involving a well-adapted extra-long-staple Indo-American popular variety 'Gujarat 67' as the female parent and an exotic *hirsutum* variety 'American Nectariless' as the male parent. The evolvement of 'Hybrid 4' is a landmark in cotton improvement in the world as it has led to a phenomenal increase in yield. It is capable of spinning good 60s (combed), nep-free yarn. It has combined in itself good yield quality and wide adaptability.

In the maximization plots, 'Hybrid 4' has given as high a yield as 6,918 kg/ha. Some cultivators grew 'Hybrid 4' cotton under maximization condition and obained very encouraging results and broke the world record. One such cultivator in Karnataka produced 87 quintals of seed-cotton per hectare in 1970-71, and another cultivator in Gujarat produced 89.5 quintals of seed-cotton per hectare in 1971-72.

The plant of 'Hybrid 4' cotton has bigger bolls, profuse and continual flushes, overlapping one another, all leading to a bumper harvest. It has big bolls, with excellent opening, which ensures easy and clean picking, and cuts down the harvesting cost. It is less photo, and thermo-sensitive, which quality affords it the scope of its being taken as a pre-monsoon, *kharif* or *rabi* crop. It has wider adaptability to different soils and climates. It gives a high response to fertilizers and possesses a high degree of tolerance to the black arm disease caused by *Xanthomonas malvacearum.*

Telephone System of Cultivation

Under this system, the plants are kept in an upright natural position by tying branches to horizontal galvanized-iron wire, running over the entire crop from end to end (Fig. 137). This device helps the plants to get the maximum advantage of sunlight, aeration, etc., so essential for the maximum photosynthetic activity and other processes. The branches do not tear off owing to the heavy bearing of bolls.

The plant population is limited and, hence, it is most convenient to follow intensive agro-care practices. The system also facilitates the spot application of fertilizers, ensuring proper placement and affording more efficient absorption. As the plants are upright and there is no crowding of branches and leaves, spraying and dusting can be more efficient.

Under normal practices there is lodging of plants on the heavy bearing, and 25 to 30 per cent of the lower-set bolls rot or are attacked heavily by insects and fungi. The adoption of the telephone system greatly reduces these losses. Under this system, on account of intensive care, crop production is more assured even under aberrant weather. This new cotton-growing technology is at variance with the high-population concept, followed in countries such as America, Russia and Israel. For 'Hybrid, 4' cotton, a population of 7, 415 plants is sufficient to obtain a yield of 8,895 kg of seed-cotton per hectare as against 135, 900 to 296,525 plants per hectare under the high-planting-density technique, recommended in these countries for the maximization of cotton yields. By adopting this new management technique, the farmers in Gujarat have obtained as high yields as 87 to 100 quintals of seed-cotton per hectare and the technology is now spreading in Gujarat, Maharashtra and Andhra Prasesh, where this variety is cultivated.[4]

Large-scale Seed Production

The production of hybrid cotton seed is complicated and expensive. Each individual flower-bud is to be emasculated and pollinated by hand by a large labour-force. The seed-production programme is, therefore, undertaken through co-operative bodies, such as Cotton-Sale or Ginning and Pressing Societies. Such societies undertake the responsibility for purchasing and selling hybrid seed at reasonable rates. Hence the seed-producer has no problem in the disposal of seed. The price of seed varies from Rs 80 to 100 per kg. Now State seed corporations have also taken up the seed-production programmes.

Seed-Production Technique

The seed-production technique consists in the growing the female and male parents in separate plots in the proportion of 5 : 1. The sowing periods are so adjusted that there is a synchronization of the flowering phases in both the parents and an adequate supply of male flowers is maintained.

[4]Patel, C.T. *Major achievements through research in cash crops*, ICAR, New Delhi, 1981.

Doak's method of emasculation of the flower-bud is used. This method consists in the removal of bracts first by hand, and then the petals, along with the entire anther-sac whorl, with the nail of the thumb, without damaging the stigma, style or ovary.

Success in crossing is about 40 to 50 per cent. However, this success depends upon the care taken while crossing, the treatment given to the crop and the atmosphere. Trained and experienced labourers are engaged. One such labourer attends to about 200 to 250 flower-buds in a day, when the crop is in the full flowering phase.

In order to maintain the purity standards of the hybrid seed, produced on a commercial scale, seed certification was introduced, both for germination and genetic purity, before release. The processing and bagging in standard packages are done under strict departmental supervision and each bag is sealed and tagged with a certification label.

COVERAGE

The coverage under 'Hybrid 4' cotton in various States is as follows: Gujarat 2,96,200 ha, Maharashtra 2,52,700 ha and Madhya Pradesh 26,900 ha. The crop is also being cultivated in Andhra Pradesh, Rajasthan and Orissa.

TABLE 1. SEED PRODUCTION AND AREA COVERED UNDER 'HYBRID 4' COTTON IN VARIOUS STATES, 1978-79

Year	*State*	*Quantity of hybrid seed produced (in quintals)*	*Area covered under commercial crop (in thousand hectares)*
1978-1979	Gujarat	4,962	296.2
	Maharashtra	5,562	252.7
	Karnataka	—	2.2
	Madhya Pradesh	1,200	26.9
	Andhra Pradesh	177	4.4
	Rajasthan	—	5.5
	Total:	11,901	587.9

DR V. SANTHANAM AND THE RELEASE OF HIGH-YIELDING COTTONS 'VARALAXMI', 'SUJATA' AND 'SUVIN' IN SOUTHERN INDIA

The year 1968 signifies a high watermark in the development of long-staple and high-yielding cottons in India. During that year, cotton breeders, headed by Dr V. Santhanam, achieved a remarkable success in the shape of an outstanding cotton,'MCU 5' which revolutionized cotton production in southern India. 'MCU 5', stapling 30.16 mm (1-3/16") and spinning 60s counts, spread fast to the states of Tamil Nadu, Andhra Pradesh and Maharashtra. In 1972, 'Varalaxmi', a superior long-staple variety, was released, followed by 'Sujata' and 'Suvin.' These varieties are also resistant to wilt. They are extremely popular on account of their potential of very high yield. To cut down the cost of producing hybrid seed, the male-sterile 'Gregg' line was used in hybridization. The hybrids have made a significant contribution to the quantitative improvement and qualitative change in the Indian cotton crop. Santhanam was given the ICAR award for team research in 1975-76 for his contribution to cotton research by evolving these high-yielding varieties.

CHAPTER 34

GROUNDNUT, SUGARCANE AND JUTE

THERE are three other crops in which India has a pre-eminent position. These are groundnut, sugarcane and jute.

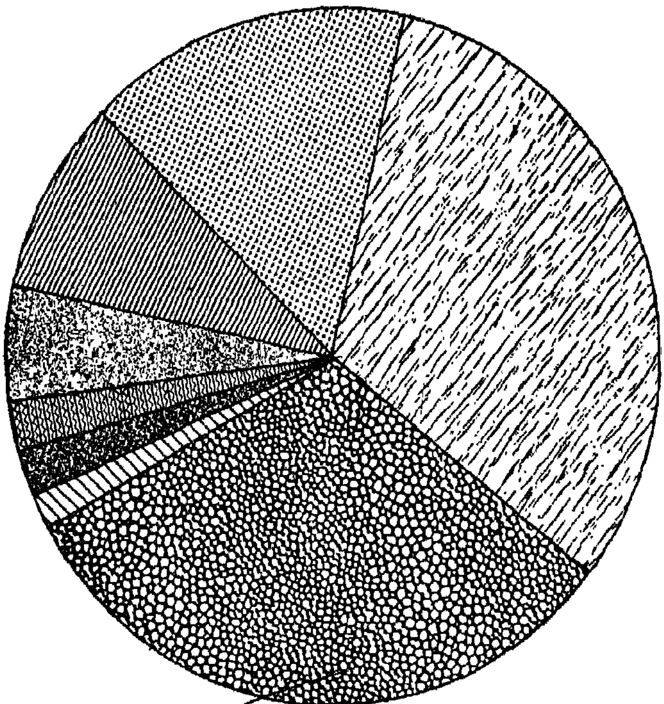
A little over half a century ago, groundnut (*Arachis hypogaea)*, also known as peanut, was a food crop of minor importance, grown over small areas in India and abroad. Now, however, it is extensively cultivated all over the world. Its original home is believed to be Brazil in south America, but the chief centre from which its world-wide expansion commenced is West Africa, from where the French colonialists introduced it into their possessions. Thereafter, it spread to other parts of the world.

Groundnut is cultivated principally as an oilseed, but considerable quantities are consumed directly as food. It is also a good rotation crop. It has soil-recuperating value, is an efficient soil cover against erosion, and provides forage for the cattle. It is as a source of oil that it finds its largest use. In Europe and America, groundnut oil largely finds its use in the manufacture of margarine. In India, it is used as a direct cooking medium or after conversion into vegetable fat known as vanaspati. India has the largest area under groundnut, and is also the largest producer (5.9 million tonnes) (Fig. 138), accounting for the one-third of the world groundnut production. After India comes China, the USA and Senegal (Fig. 138). The area under groundnut in India is about 7.2 million hectares. Gujarat, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka are the important groundnut-growing States, covering about 90 per cent of the area under it (Fig. 139). Gujarat produces about 22 per cent of the country's groundnut, and has the highest yield per hectare (Fig. 140).

Both bunch and spreading types of groundnut are grown in India. As a result of organized breeding, started in the first decade of the current century, a number of varieties have been evolved. Apart from a higher yield of pods, some of them have better shelling percentage and oil content. Gujarat has released a number of varieties —'Junagadh 11', 'AH 32', 'GAUG 1' among the erect types, 'and GAUG 10' among the spreading types.

'J 11', the bunch variety of groundnut extensively cultivated in Gujarat, Maharashtra and Orissa, has a low level of aflatoxin and, hence, its cake can be safely exported. Further efforts to improve upon 'J 11' have yielded promising results. The centre at Junagadh has evolved 'J 113' (out of a cross 'AK 19' × 'AK 12-24'). In 1972-73, with a dry monsoon this variety yielded 14.4 per cent more than 'J 11'. Some of the 'AH' series in Tamil Nadu and the 'Kopergaon' types in Maharashtra are

MAJOR GROUNDNUT PRODUCING
COUNTRIES OF THE WORLD
BASED ON THE AVERAGE 1976 TO 1978



REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%	REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%
	INDIA	5.9	32.2		BURMA	0.4	2.2
	CHINA (F)	2.9	15.8		ARGENTINA	0.4	2.2
	USA	1.7	9.3		ZAIRE	0.3	1.6
	SENEGAL	1.0	5.5		OTHER COUNTRIES	5.7	31.2

TOTAL GROUNDNUT PRODUCTION IN THE WORLD: 18.3 MILLION TONNES (3 YEARS' AVERAGE)

(F) F.A.O. ESTIMATE

FIG. 138. The major groundnut-producing countries of the world. India is the biggest producer of groundnut. (ESA)

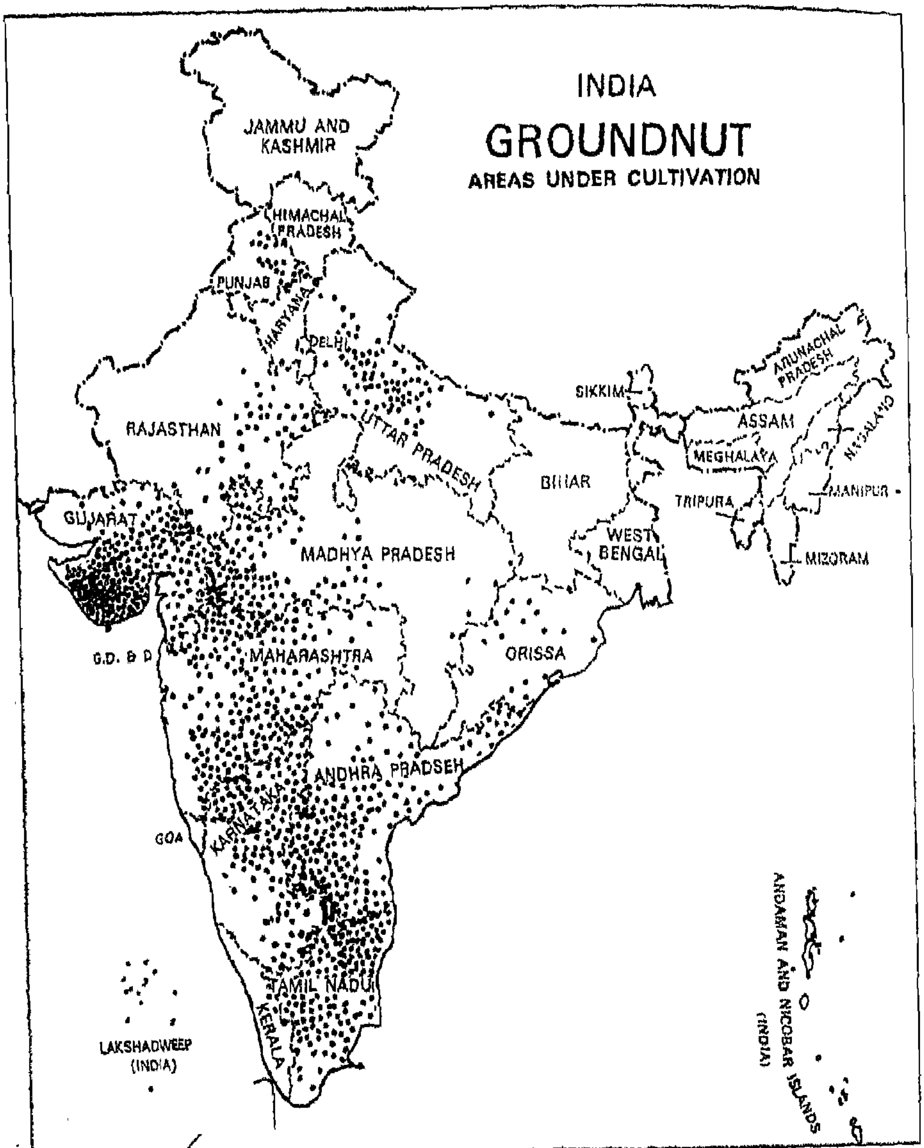


Fig. 139. A map of India, showing the area under groundnut, 1964-65. Each dot represents 4,000 hectares. (ESA)

GROUNDNUT

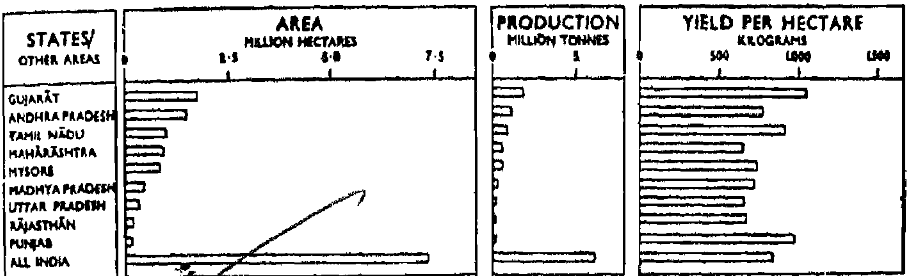


FIG. 140. Area, production and yield per hectare of groundnut in India, 1970-71. Gujarat produces 22 per cent of the country's groundnut, and has the highest yield per hectare. (ESA)

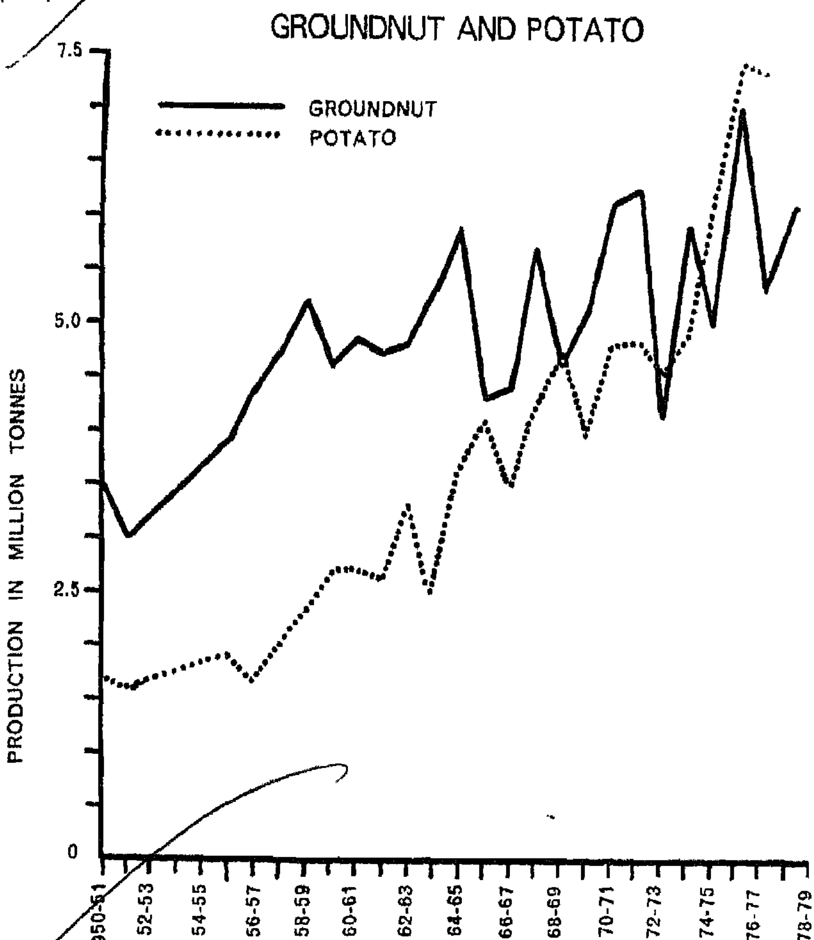


FIG. 141. Trends in the production of groundnut and potato in India from 1950-51 to 1978-79.

important varieties. New bold-kernelled table-purpose varieties such as 'M 13' and 'TG 3' are also gaining ground because of their excellent export market.

Though new varieties have spread and improved agro-techniques have been worked out, the yield level is more or less at a plateau. The lack of genetic variability seems to be one of the most important hurdles in the development of high-yielding types. With the establishment of advanced centres for groundnut research, efforts are being made to develop variability, from which the requisite breeding material can be built up.

The main hurdle in the spread of the improved strains of groundnut was the absence of an appropriate seed-production programme. Hence a project was initiated by the ICAR at six centres, which produced 13 tonnes of the nucleus seed of 10 varieties in 1978. It is for the first time in the country that such a large-scale nucleus seed production was achieved.

The productivity of groundnut has also started increasing. In Tamil Nadu and Punjab, the productivity has crossed the 1-tonne mark against the national figure of 7 q/ha. An outstanding research achievement in groundnut is the release of 'TMV 10' with oil content as high as 55 per cent. No less important is the release of 'M 13' in Punjab. It was selected by Ranbir Singh Sandhu and Satvir Jaswal from an American variety in 1972, and was released by the Punjab Agricultural University, Ludhiana, in 1975. This variety is also well suited to the dry regions of Andhra Pradesh. In field tests, it has yielded over 3 tonnes/ha in a dry year without any irrigation (Fig. 144).

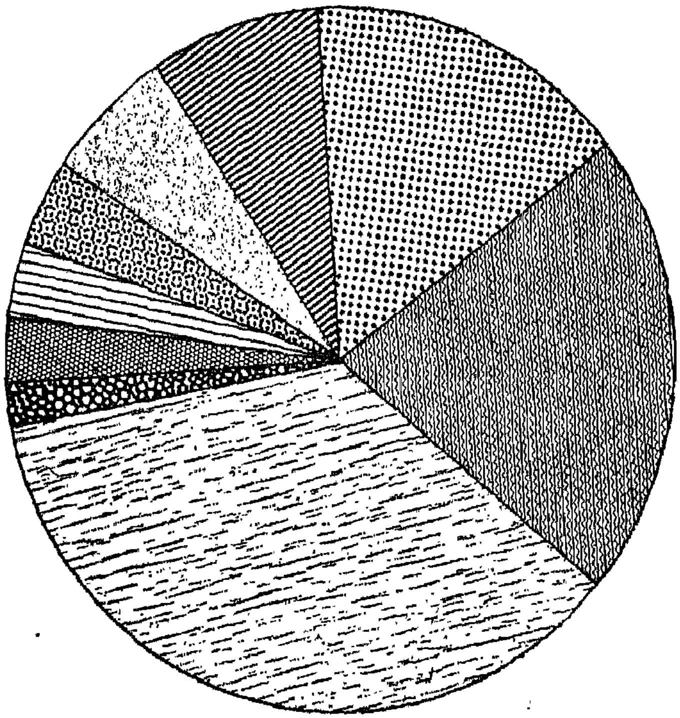
The production of groundnut has a close correlation with weather. Production goes up in years of good rainfall, and declines in years of drought (Fig. 141). The application of chemical fertilizers from 1959 onwards has materially increased production.

SUGARCANE

India is the largest producer of sugarcane in the world, accounting for 156.9 million tonnes of sugarcane, which is 21.3 per cent of the world production. The next three countries are Brazil, Cuba and China (Fig. 142).

Sugarcane is grown in every part of India, except in the extreme north or in the high mountains. Ninety per cent of the area and a similar percentage of production, however, are contributed by eight States—four in the north, viz. Bihar, Uttar Pradesh, Haryana and Punjab, and four in the Peninsula, viz. Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu (Fig. 143). The all-India averages of area and yield for the period 1965-66 to 1971-72 are 2.50 million hectares and 46 tonnes/ha respectively. The State-wise averages of area and production, based on seven years' data, i.e. 1965-66 to 1971-72, are given in Table 1. Uttar Pradesh alone accounts for 51 per cent of the area and 43 per cent of the production (Fig. 143).

MAJOR SUGARCANE (IN TERMS OF CANE)
PRODUCING COUNTRIES OF THE WORLD
BASED ON THE AVERAGE 1976 TO 1978



REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%	REFERENCE	COUNTRY	PRODUCTION (Million Tonnes)	%
	INDIA	156.9	21.3		USA	24.8	3.4
	BRAZIL	117.6	16.0		AUSTRALIA	22.8	3.1
	CUBA	59.1	8.0		INDONESIA	14.5	2.0
	CHINA (F)	46.4	6.3		OTHER COUNTRIES	265.7	36.1
	PAKISTAN	28.4	3.8				

TOTAL SUGARCANE PRODUCTION IN WORLD: 736.2 MILLION TONNES (3 YEARS, AVERAGE)
(F) F.A.O. ESTIMATE

FIG. 142. Major sugarcane-producing countries of the world (in terms of cane). India is the largest producer. (ESA)

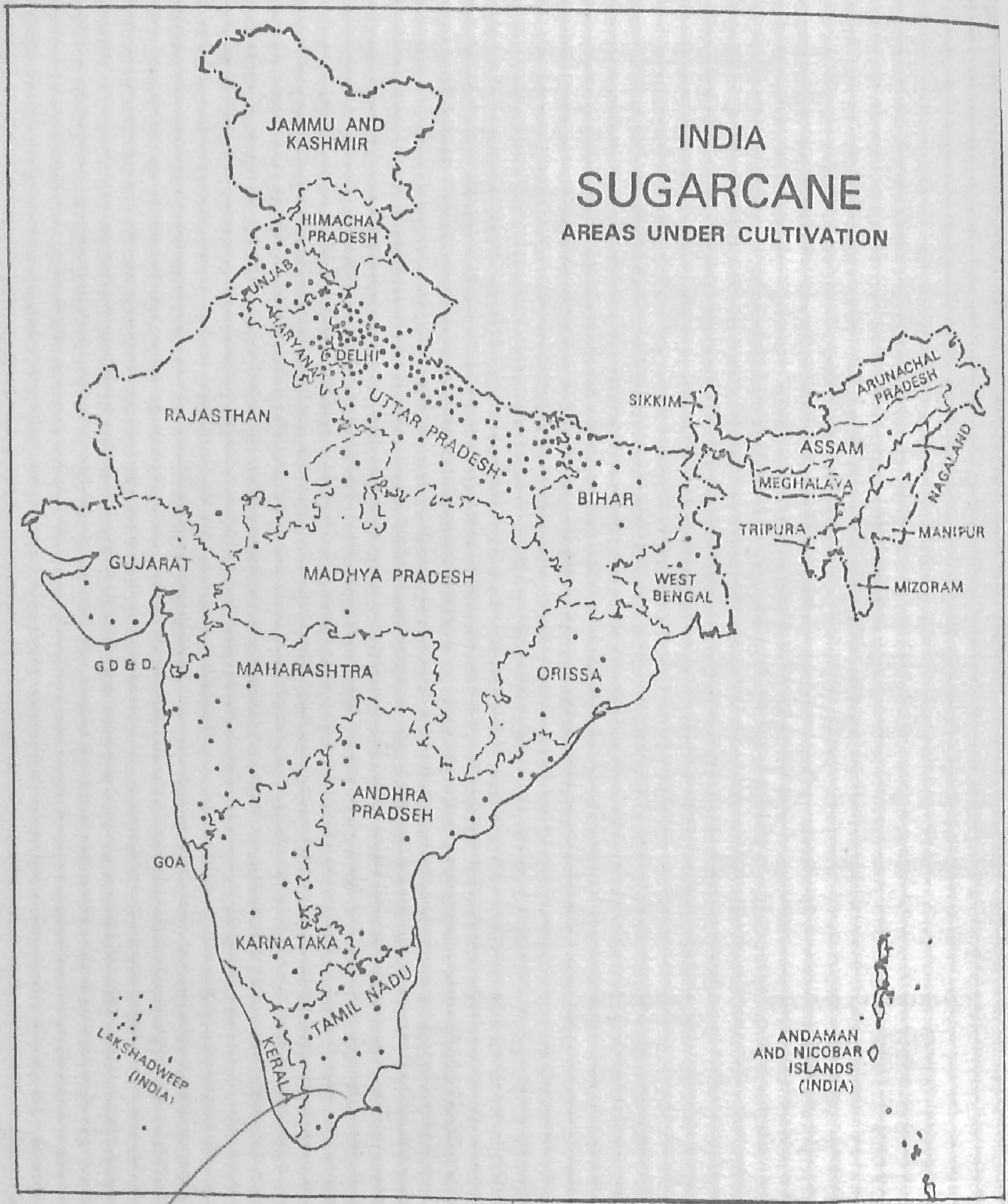


FIG. 143. A map of India, showing the area under sugarcane, 1964-65. Each dot represents 20,000 hectares. (ESA)

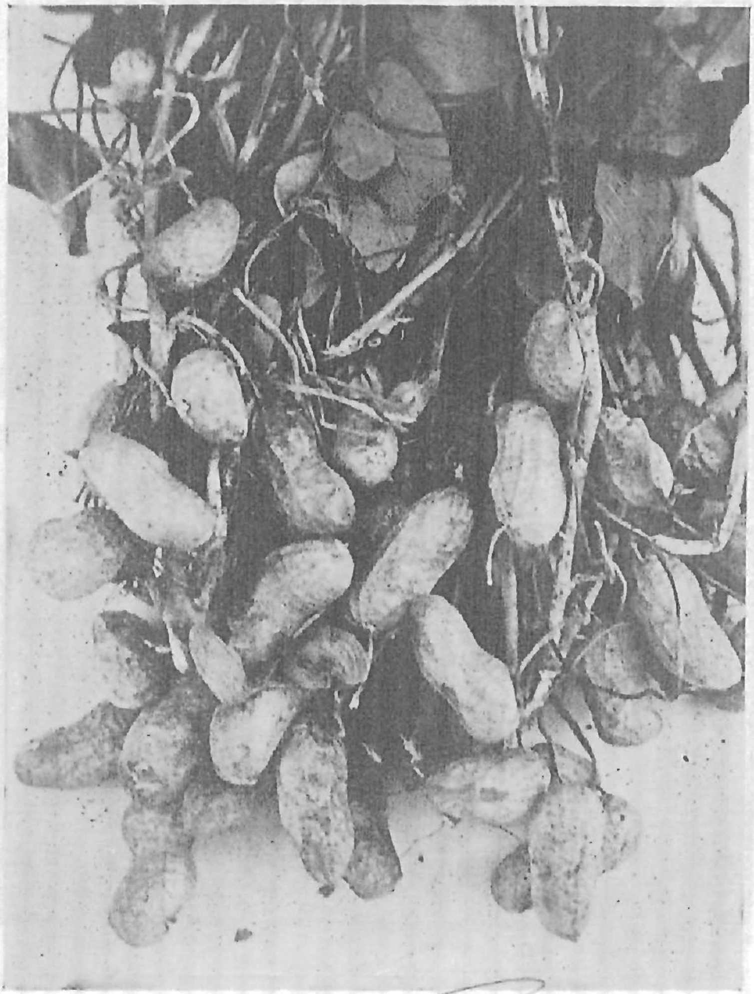


FIG. 144. 'M 13' variety of groundnut, bold-seeded and high-yielding, producing up to 30 quintals per hectare. It was selected by Ranbir Singh Sandhu and Satvir Jaswal in 1972, and was released by the Punjab Agricultural University, Ludhiana, in 1975.

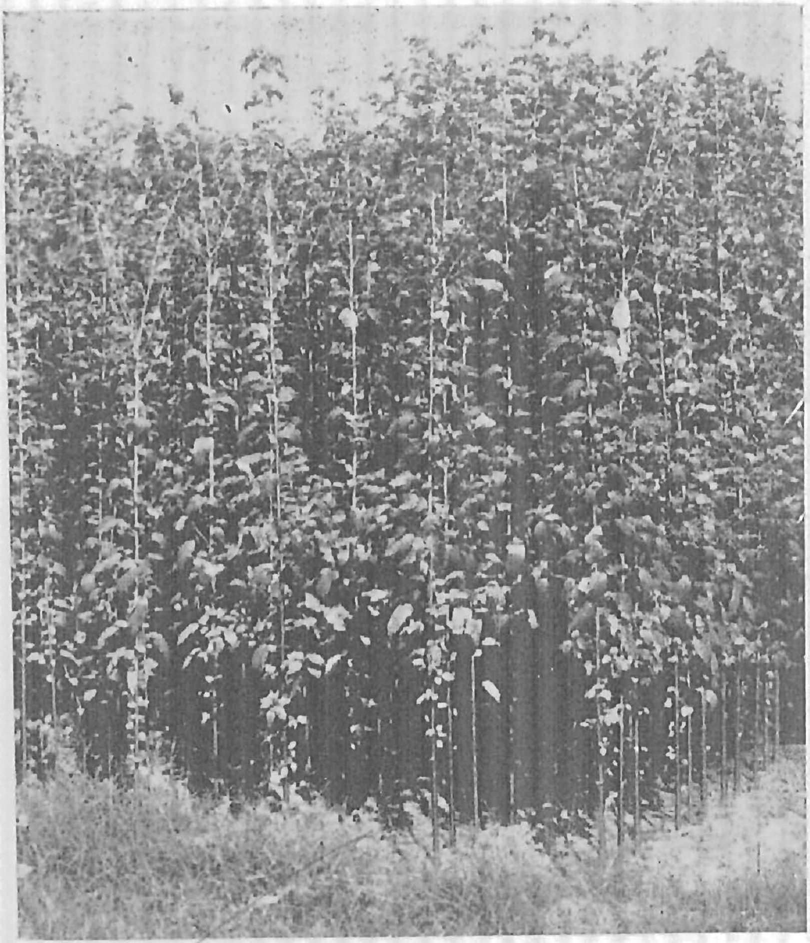


FIG. 145. A stand of 'JRC 212' jute (*Corchorus capsularis*). It yields 11 per cent higher than other strains. It is a full-green type and the quality of its fibre is very good.

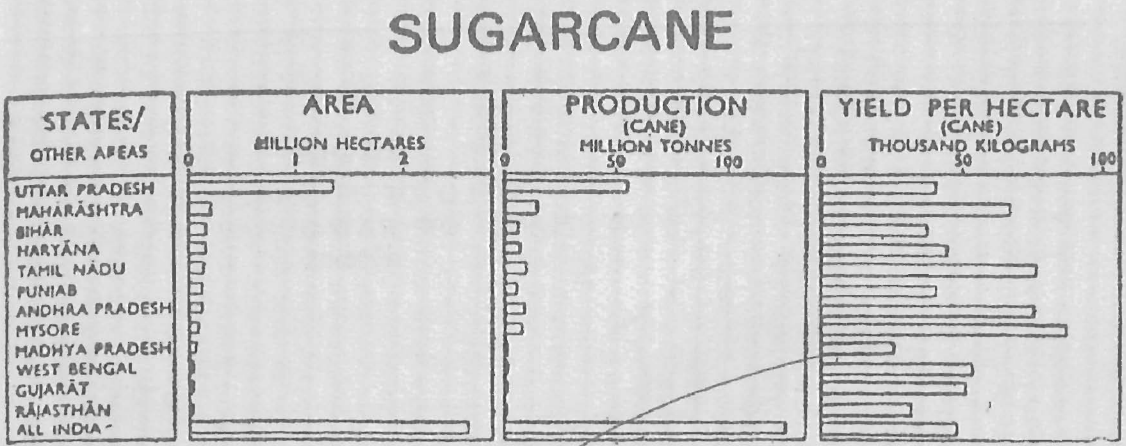


FIG. 146. The area and the yield per hectare of sugarcane, 1970-71. (ESA)

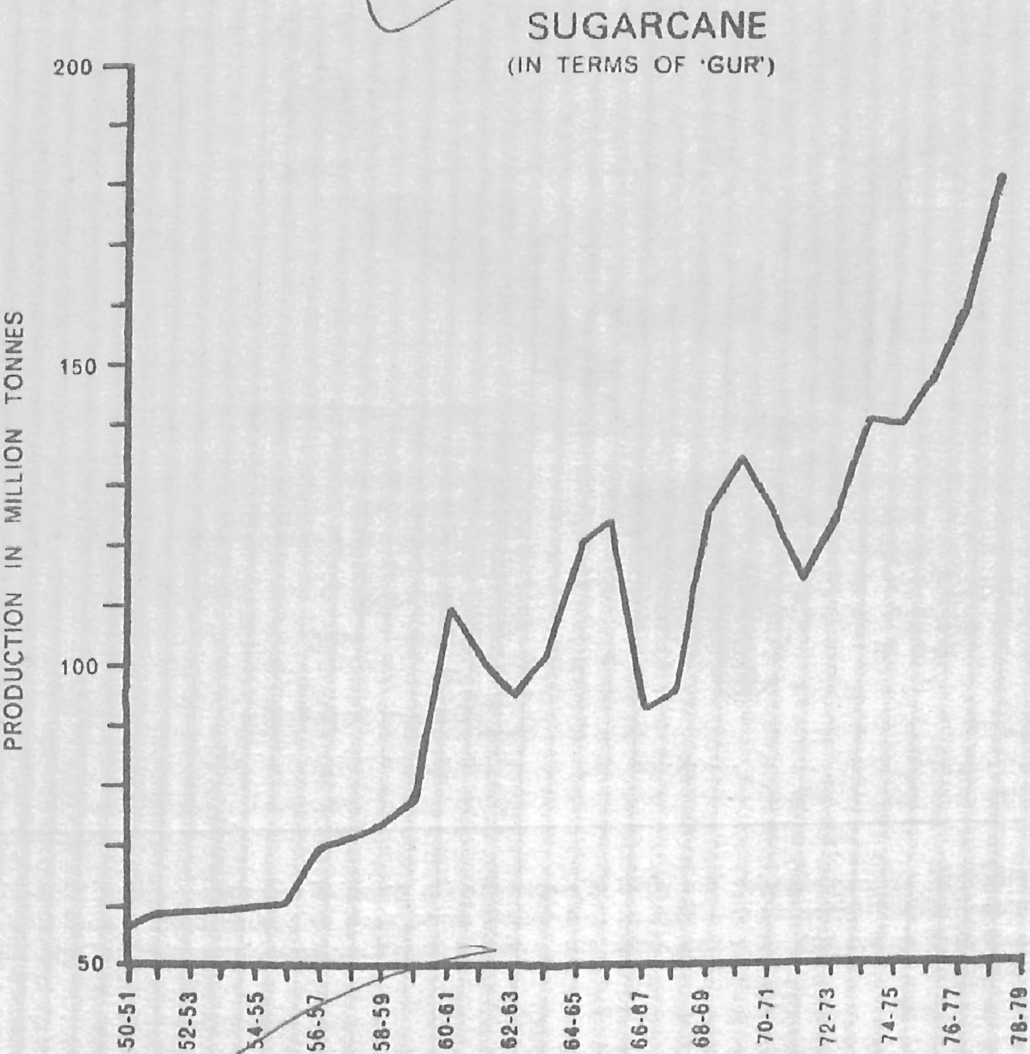


FIG. 147. Trend in the production of sugar (in terms of *gur*) in India from 1950-51 to 1978-79. Production fell when the price paid for cane was unremunerative. Drought also affects the production of sugarcane.

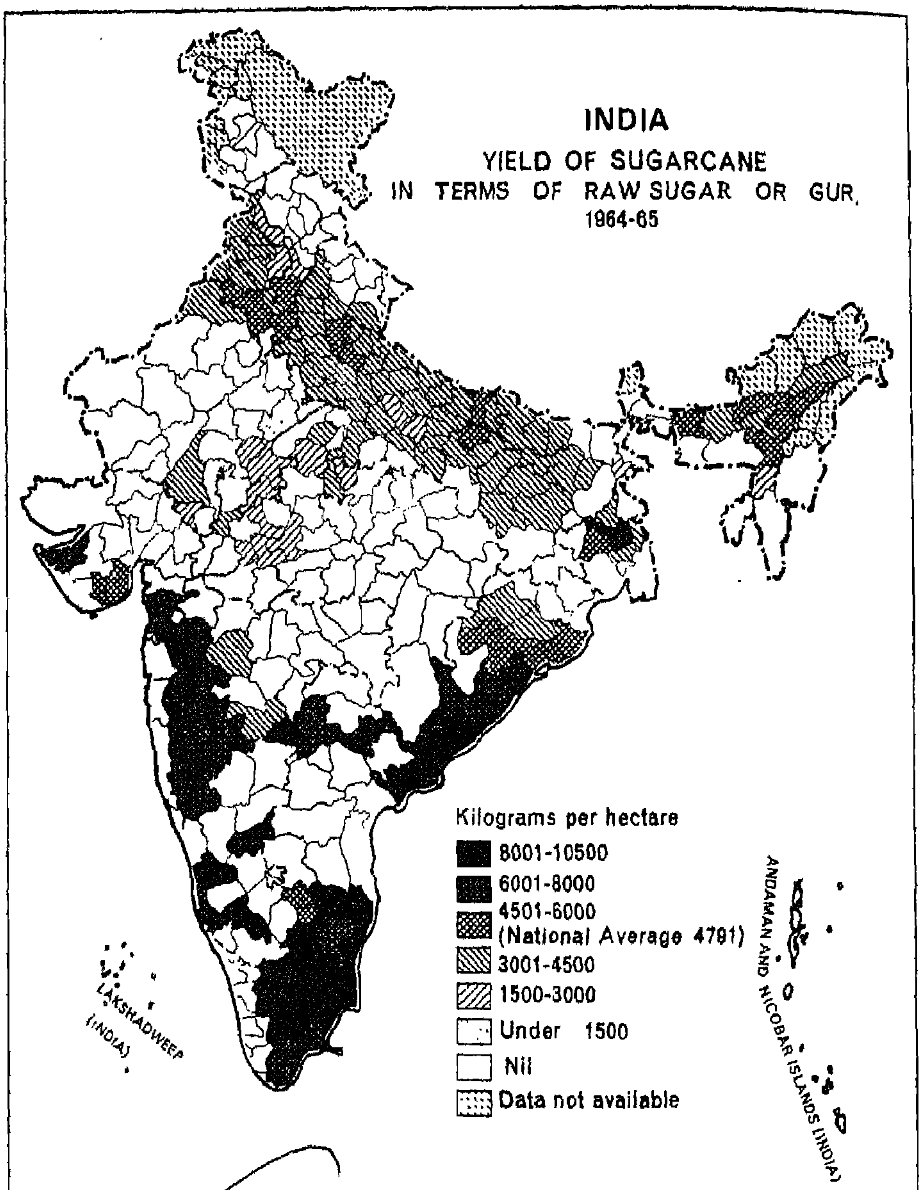


FIG. 148. A map showing the yield of sugarcane (in terms of raw sugar or *gur*), 1964-65. The yield of sugarcane was highest in tropical areas, such as Maharashtra, Tamil Nadu and Andhra Pradesh. In these areas, the growing period is almost a year. (After Dr Jasbir Singh)

The yields are much higher in the Peninsula than in northern India (Fig. 148). Higher yields are obtained in the peninsular States because of the much longer growing period, ranging from twelve to eighteen months. Besides, improved agronomic practices are followed and there is a more liberal application of chemical fertilizers. The average yield is 60 tonnes/ha in Maharashtra, 80 tonnes/ha in Andhra Pradesh and Tamil Nadu, and 90 tonnes/ha in Karnataka. The yield in Uttar Pradesh approximates to 40 tonnes/ha.

TABLE 1. AREA AND PRODUCTION OF SUGARCANE (1965-66 TO 1971-72)

State	*Area (million hectares)*		*Production (million tonnes)*		*Yield*
	Actual	*% of all India*	*Actual*	*% of all India*	*(tonnes/ha)*
Uttar Pradesh	1.27	51	50	43	39
Haryana	0.15	6	6	5	40
Bihar	0.15	6	5	4	33
Punjab	0.14	6	5	4	36
Maharashtra	0.19	8	12	10	63
Andhra Pradesh	0.13	5	10	9	77
Tamil Nadu	0.12	5	10	9	83
Karnataka	0.09	3	8	7	89
Other States	0.26	10	10	9	38
Total all-India	2.50		116		46

SOURCE: *Report of the National Commission on Agriculture*, Part I, 1976, p.147

The popular improved varieties of sugarcane are 'Co 419', 'Co 775' and 'BO 17'. Recently, 'Co 41', 'C 13' selection 'Co J', 'Co 1' canes, 'BO 13' 'Co 62175' and 'Co 1148' were released. 'Co 368', 'Co 997', 'Co 1336' and 'CoJ 58' are the varieties with high recovery. 'Co 62399' in Punjab, 'Co 6304', 'Co 62174', 'Co 6404' and 'Co 6412' in Tamil Nadu are the promising varieties. Similarly, the early-maturing type 'Co 6414' and the late-maturing type 'Co 6411' have given good yields in Orissa.

Sugarcane requires high doses of fertilizer. As high doses as 250 kg of N, 150 kg of P_2O_5 and 150 kg of K_2O per hectare have been found to be economical. Frequent light irrigations have given higher yield per unit of water use.

A visual idea of the trend in the production of sugar since Independence can be had from Fig. 147. Whereas, on the whole, there is an upward trend in the production of sugar since 1952, there are also serious dips in 1962-63 and 1966-67 due to drought, and in 1972-73 due to a sharp rise in the price of oil, chemical fertilizers, and plant-protection chemicals. These data highlight the necessity of giving an incentive price to the growers, so that they do not hesitate to invest in the cultivation of this labour and capital-intensive crop, which is so sensitive to price offered by the factories to the growers.

JUTE

Jute is one of the most important commercial fibre crops of the world. It is extensively used in the manufacture of packing-cloth, hessian and bags. The fibre is obtained from two distinct species, *Corchorus capsularis* and *C. olitorius*, the former producing the white fibre, and the latter the tossa fibre of commerce. The cultivation of jute is confined mostly to India and Bangladesh. India contributes 1.4 million tonnes or 31.8 per cent to the world production of jute. Bangladesh follows with 1 million tonnes of jute, which is 22.7 per cent of the world production. Then comes Thailand, with a production of 0.2 million tonnes only (Fig. 149). Bangladesh is a heavy exporter of raw jute, whereas India leads in the export of the manufactured materials. The history of the cultivation of jute in India and of the development of its manufacture is remarkable in that the crop has risen within less than a century from a humble position to one of leading importance among the industrial crops of the world.

When Bengal was partitioned in August 1947, the main jute-growing area went to East Pakistan (now Bangladesh), whereas the jute-mills were in the Indian Bengal. Dr B.C. Kundu, a distinguished botanist, was the Director of the Jute Agricultural Research Institute, Dacca. On the partition of Bengal, Kundu and his team brought valuable strains of jute from Dacca, and reached Chinsurah in West Bengal, where they continued their work from 1948 to 1953. Kundu's special task was to organize jute development by extending the area in the post-partition India. This was a task of great national significance, since jute remained the mainstay of Indian economy, and owing to partition the country had lost its jute belt. Extensive surveys were made and suitable areas were identified in West Bengal. Sir Datar Singh, Vice-President of the ICAR and President of the Indian Central Jute Committee, took great interest in these schemes. The area under jute increased three times that of 1947. As a result of this effort, India has become the largest producer of jute (and substitutes) in the world.

In India, jute is sown between March and May, and is harvested between July and September. It is grown mainly in West Bengal, Assam and Bihar, which together account for about 90 per cent of the total area under jute. Orissa, Uttar Pradesh and Tripura are the other States which contribute the remaining 10 per cent to the area under it (Fig. 150).

A brief account of some of the improved strains of jute developed by the Jute Agricultural Research Institute, Barrackpore, Calcutta, is given below.

'*JRC 212*': This strain matures at about the same time as 'D 154', the standard *capsularis* strain, and yields about 11 per cent higher. The quality

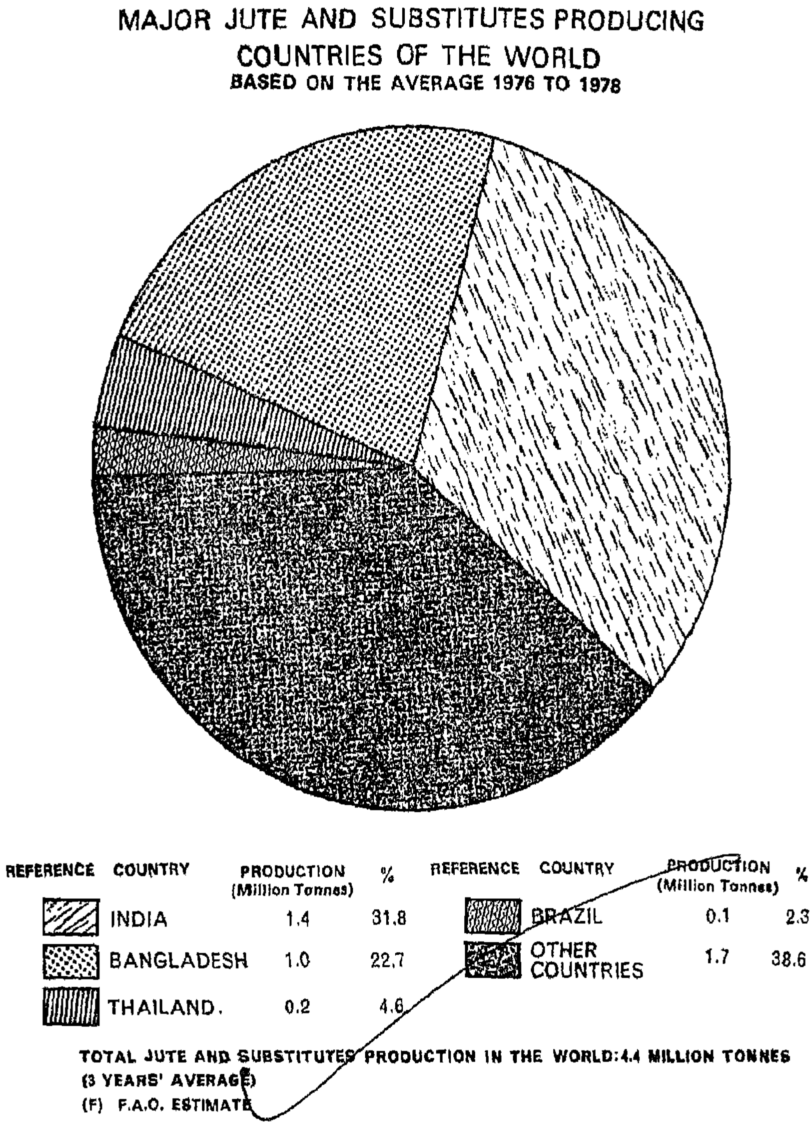


FIG. 149. The major countries producing jute and substitutes. India is the biggest producer. (ESA)

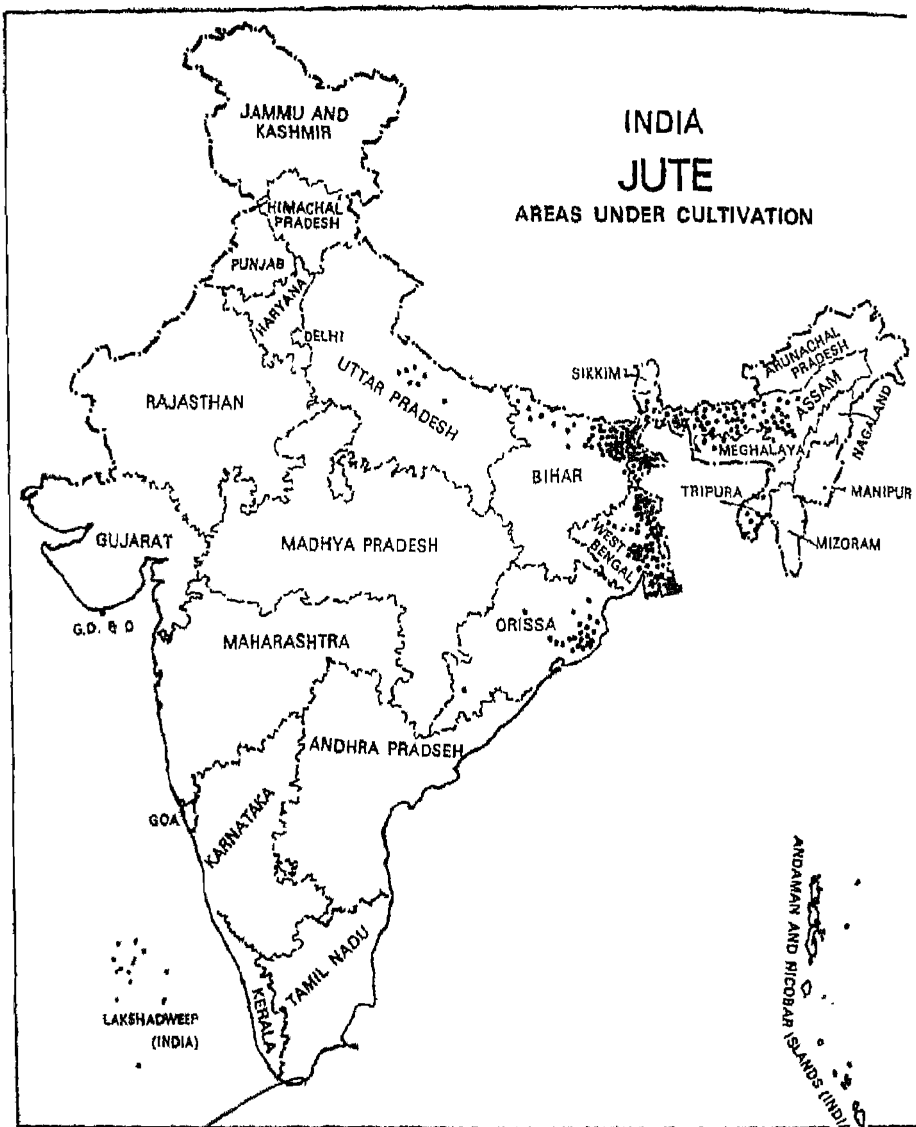


Fig. 150. A map of India, showing the area of jute, 1964-65. Each dot represents 2,000 hectares. (ESA)

of its fibre is very good. Among the *capsularis* strains, it is the highest yielder (Fig. 145).

'JRO 632': This high-yielding, sparsely branched, full-green type takes about 10 days longer than the standard *olitorius* strain to mature. It yields about 30 per cent higher and has fibre of good quality.

'JRO 620': This is a light-red type, matures at about the same time as *'CG'* does, but yields about 20 per cent higher, giving the fibre of the best quality among the cultivated *olitorius* types.

HIGH-YIELDING VARIETIES OF POTATO

THE SEED-PLOT TECHNIQUE FOR THE PLAINS

GREEN REVOLUTION IN POTATO PRODUCTION

SOUTH AMERICA is the ancestral home of potato, where it has been under cultivation for over a thousand years. It has been the staple diet of the people since the early Inca Civilization. It freely grows in a wild state in the Andes in Chile. The genus *Solanum* comprises well over 2,000 species. These constitute a long polyploid series—diploids ($2n=24$), triploids ($2n=36$), tetraploids ($2n=48$), pentaploids ($2n=60$), and hexaploids ($2n=72$). The cultivated potato, *Solanum tuberosum*, is a tetraploid.

The first mention of potato in India occurs in Terry's account of a banquet at Ajmer, given in 1615 by Asaf Khan to Sir Thomas Roe, the British Ambassador (Watt, 1908). Potato established itself quickly in the gardens of Surat and Karnataka. In the subsequent two centuries and a half, following its first introduction into the country, agri-horticultural societies and the botanical gardens took a keen interest in promoting its cultivation. How keen was the interest taken by these organizations in promoting this crop would be appparent from one of the early recorded accounts (Johnson, 1874):

"At a horticultural show at Calcutta during 1842, I saw potatoes exhibited which would not have shamed the potato growers of Lancashire if mistaken for their produce. These were grown in the immediate vicinity of the city, but in the hills of Cherapunji, though not far distant, the potatoes are grown still finer."

The entry of potato into this country was through the sea route. It was first cultivated in the plateau regions of the south. Through the northern Indian plains, it travelled to the Himalayan hill ranges. In the hills, it found a hospitable environment; a temperate climate for a temperate plant. In the plains of India, potato could be cultivated only through the cool winter months. But in the hills it was a summer crop, and spread rapidly owing to the following reasons: the preservation of the seed-tubers presented no problems through the cold winter months, and there was no need for annual imports of seed. In the plains, however, a restrictive virulent malady was the 'degeneration' of the seed-tubers. The cause was a plethora of virus diseases, with their large family of strains. They reduced the productive potential of the crop to uneconomic levels. The permanency of a variety could never be achieved. Indiscriminate and annual imports of new varieties, from all over the world, created problems of adaptation of anything good. It also helped to build up a hostile environment of

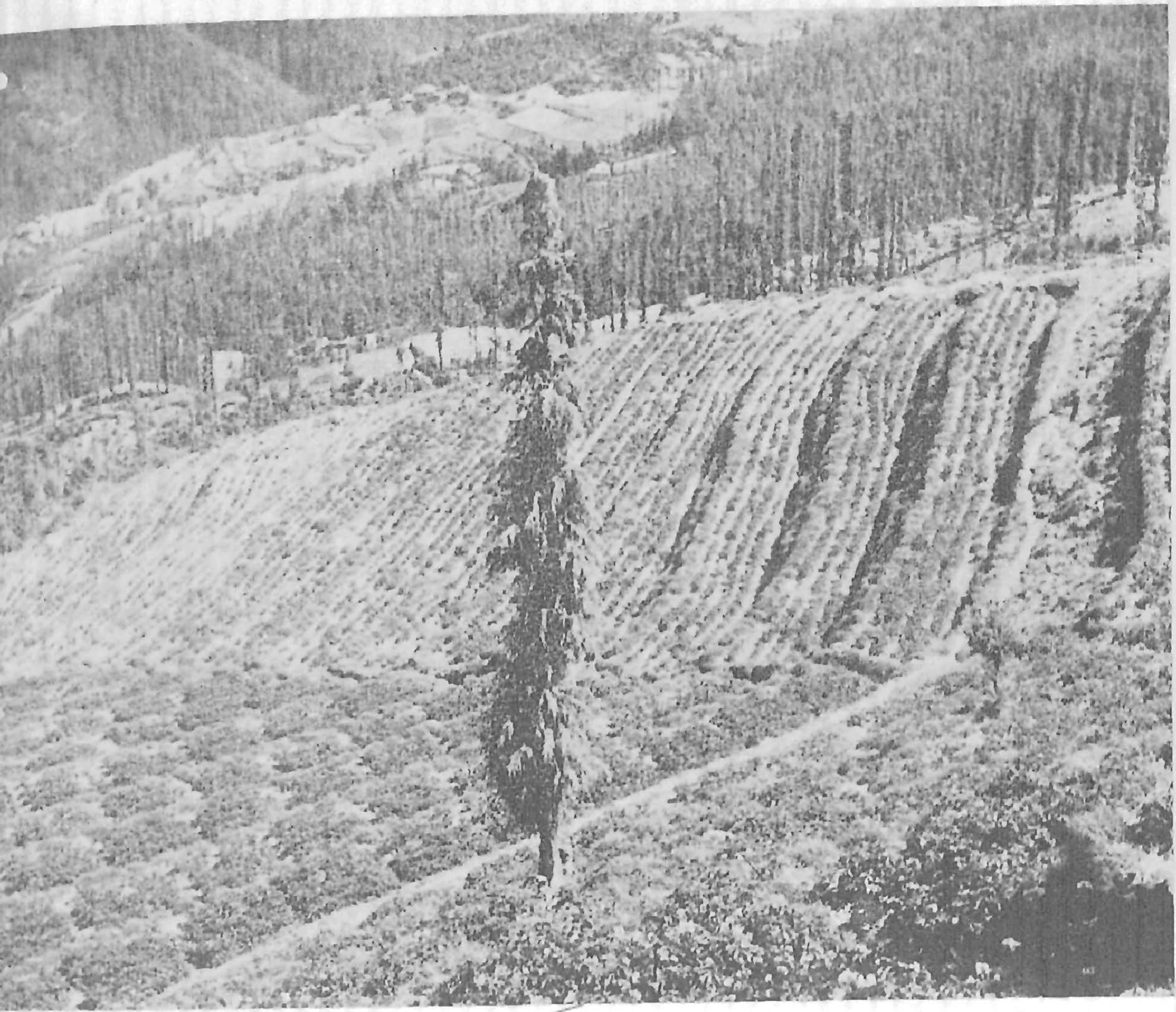


FIG. 151a. Terraced fields of the Fagu Station of the Central Potato Research Institute, Simla, in Himachal Pradesh. Nucleus and foundation seed of potatoes is raised at Fagu.

FIG. 151b. A seed plot of the 'Chandramukhi' variety of potato, raised by Rana Moti Singh, a progressive farmer in the Village of Jadla, District Jullundur. This district is now well known for growing potatoes.

several destructive diseases, viral, soil- and tuber-borne, often imported from all over the world along with the seed tubers. These diseases got firmly established in the country.

In course of time,the hills became a major source of seed-potatoes for the plains. With this meaningful hill-plain culture, the dependence on foreign sources for seed was considerably reduced.

British Army Officers Introduce Potatoes into Hill Stations

Army officers took keen interest in extending and stabilizing potato culture in the hills. Major Young introduced potatoes into the hills of Dehra Dun. Captain Townsend took special interest in improving the quality of potato in the Kumaon Hills. Yet another enthusiastic military officer, Captain Mundi, took keen interest in extending the potato into the Simla Hills as early as 1828. By 1835, the potato became a new and profitable source of income to the hill people.

Research on Potato before the Establishment of the ICAR

Improvement in the quality of potato before the establishment of the ICAR was directed, almost entirely, to the importation and acclimatization of potato varieties, mostly from European countries. In Assam, the work began some time in 1830 when the well-known 'Khasi' variety was introduced by one David Scot. Its origin or source is not available. Subsequent introductions were extensive, persistent and continued up to 1947. In West Bengal, an old resident of Darjeeling, William Lloyd, offered land to the Bengal Government to establish a botanical garden, and work on the introduction and testing of potato varieties began almost immediately. In 1880, a large collection, secured from England and Australia, was tested and this work continued for over several decades, but nothing significant emerged from it. Large stocks of potatoes of different varieties were imported into the Bombay Presidency in the early nineteenth century. No variety of potato lasted for long on the soils of Maharashtra, but several diseases and pests did. Two outstanding examples are the ring-rot and the tuber moth. In the Madras Presidency, systematic work on potato improvement began in 1822. In the Nilgiri Hills, one Mr Sullivan procured about 2,000 acres (810 hectares) from the Government and started the large-scale cultivation of potato with the assistance of a foreign trained gardener, Johnson. Later, in 1930, S.R. Lushington, then Governor of Madras, established an experimental farm at Ootacamund. Immediately following these efforts, government botanical gardens were established in 1848 at Ootacamund to stabilize and extend potato culture into the Nilgiri Hills. Jamieson, the Superintendent of the Botanical Gardens, made careful studies on 'degeneration', which repeatedly prevented all the imported varieties from establishing themselves in the local environment. He attributed the cause to the "continued use of the same seed". Extensive trials with varieties imported from Europe and Australia failed to produce lasting results. In 1917, an experimental potato station was established at Najinand in the Madras Presidency. It succeeded in selecting a variety from among the plants of 'Great Scot' imported from Edinburgh. It established itself in the local climate and has since been the dominant potato variety in the region till the present times. The United Provinces of Agra and Oudh is yet another State where work on the varietal improvement of potato started in 1882 at the Botanical Gardens at Saharanpur and Mussoorie. Dr J. F. Duthie, a noted botanist, was closely associated with this work. Repeated attempts to acclimatize potatoes received from Europe failed. Later, the potato station established by the State Government in 1924 had to be closed down after some years of resultless activity. In this largest potato-growing State, the old *desi* varieties, 'Phulwa' and 'Darjeeling Red Round', dominated till recently.

RESEARCH UNDER THE ICAR

With the establishment of the Imperial Council of Agricultural Research in 1929, a scheme was sanctioned for operation in the Nilgiri Hills at Nanjinand Potato Research Station of the Madras Government. This scheme, from the very start, encountered a major problem inasmuch as hybridization could not be successfully carried out at that site. The products of cross-breeding, the seed berries, failed to develop to maturity and most of them dropped off under heavy rainfall and high windy monsoon conditions. Consequently, the scheme had to be closed down. Again in 1935, the ICAR gave some funds to the Indian Institute of Agricultural Research, New Delhi, for operating a project in potato-breeding in northern India. After a preliminary survey directed towards the establishment of a suitable station in the Himalayan hill region, the Potato Breeding Station was established at Simla, with Dr Pushkarnath in charge, and Dr B.P. Pal, then Second Botanist at the Imperial Agricultural Research Institute, New Delhi, as the administrative and technical head of the scheme (Fig. 151). This was the beginning of a systematic scientific study of the problems of potato production in India. The work continues and can be divided into four phases.

1. PHASE I (1935 to 1949)

During this period of 14 years, potato research was carried out at Simla. In 1943, a substation in the mid-hill region at Bhowali in the Almora Hills was added to the project with the main aim of overcoming the problem of dormancy of the seed-tubers. Later, under the control of the Head of the Division of Mycology of the Imperial Agricultural Research Institute, New Delhi, another "Potato Certification Scheme" was added and established at Kufri, in the high hills, not very far from Simla.

This period of 14 years was a period of probe and search and in the process much basic groundwork was done. The main gains to our knowledge of potato during this period were as follows:

An extensive collection of genetic resources, comprising over 500 commercial varieties of potato from all parts of the world, was built up and studied. Simultaneously, a wide range of wild and cultivated tuber-bearing *Solanum* spp., collected mostly from the Andean mountains in South America, the home of potato, by the Imperial Bureau of Plant Breeding and Genetics, was secured. Much of this material was personally selected and brought into this country by Pushkarnath, who worked with the Imperial Bureau at Cambridge during 1945-46.

Extensive studies made on Indian potato varieties, of which over 500 clones were collected for study from all parts of the country, not only cleared the confusion that had prevailed in the country over the centuries, but also helped to reveal, in clear terms, the problems of varietal adaptation in the subtropical India. B.P. Pal and Pushkarnath, thus, laid a sound foundation for future studies on the crop in the country.

A survey of the diseases revealed the main problems of disease control and the main virus diseases responsible for the degeneration of seed-potatoes in the plains of India.

A quick method of multiplication of the seed stock, through sprouts and the sprout cuttings, was evolved and standardized.

2. Phase II (1949 to 1956): Dr S. Ramanujam

Realizing the great potential of potato in augmenting the food resources of the country and the complexities involved in the purposeful operational research, it was recommended to the Government of India that a Central Research Institute be established. Accordingly, in 1949, the Central Potato Research Institute was established with its headquarters at Patna in Bihar. The research stations at Simla, Kufri and Bhowali were merged with it and operated as the substations of the Institute. To begin with, the Institute had four sections, viz. Botany, Agronomy, Pathology and Entomology. The Director, Dr S. Ramanujam, operated as the Research Co-ordinator and Administrative Head of the Institute from 1949 to 1956. He created the basic infrastructure of the Institute and the base for the variety-evolvement programme and the seed-production system.

During this period, useful information on the agronomic aspects and potato diseases and pests was built up. A number of varieties—'Kufri Red', 'Kufri Safed', 'Kufri Kuber', 'Kufri Kundan' and others—were released for growing in the plains. All these varieties passed into oblivion, as the degenerative diseases reduced their yield to subeconomic levels.

3. Phase III (1957 onwards): Dr Pushkarnath, New Varieties and the Seed-plot Technique for the Plains

A major shift in the breeding policy was effected in 1957 as a consequence of the recommendations of a committee headed by Dr B.N. Uppal, appointed by the Government of India to examine the working of the Institute. These recommendations had a far-reaching effect on the future of the operative research in the country. The committee recommended the establishment of six stations for the trial of potato varieties, bred at the Institute, in the principal potato-growing regions of the country.

Following this recommendation, Regional Experimental and Trial Centres were established at Jullundur (Punjab), Babugarh (Uttar Pradesh), Patna (Bihar), Shillong (Assam), Poona (Maharashtra) and Ootacamund (the Nilgiri Hills, Madras). With their establishment, it became possible to undertake a co-ordinated programme of research on potato on an all-India basis.

In spite of these expanded activities of the Institute, research on potato made no impact on the country and the average yields remained static at 62 ± 5 maunds per acre (5.26-6.18 tonnes per hectare) in the country. Again, while a number of varieties growing in the plains were released by the Institute, they were destroyed by degenerative diseases. The country had, of necessity, to depend on the production of the healthy seed in the hill areas of northern India. The "Hill-Plain" system of seed potato problem in the country was a poor substitute for the real problem of potato production in the plains.

Seed-plot Technique. It was only in 1959, after Pushkarnath took over as the permanent Director of the Institute, that new dimensions were introduced into the research programme of the Institute. The priority of breeding was subordinated to the problem of tackling the degenerative diseases in the plains of India. A new approach to the problem of maintaining seed-potatoes in a healthy state in the plains of India was suggested, in 1959, through what is now widely known as the "Seed-plot Technique". It did not attract much attention, but with the first pilot experiment to commercialize the technique undertaken at Jullundur at the farm of Iqbal Singh Dhillon, a progressive farmer, the entire situation changed. Hundreds of hectares of uniform, healthy and vigorous crops of potato completely changed the old conceptions, and the plains of India emerged as the most favourable place for the production and propagation of healthy seed-potatoes (Fig. 152).

These stocks proved to be healthier than the best produced in Europe. This development marked the beginning of the placing of potato on the agricultural map of the country.

The credit for the discovery in 1963 of the seed-plot technique, which opened up a new avenue of producing healthy seed-potatoes in the plains, goes to Dr Pushkarnath and his colleagues. It revolutionized the production of potato seed for which dependence was on the hills, and also changed the cropping pattern in Punjab and Haryana. It also shows how a simple observation can lead to impressive results in crop production. This technique is based on the observation of aphid population. The principal vector for the infection of potatoes with viruses is the aphid, *Myzus persicae*. Aphids spread viruses effectively when their population exceeds 20 per 100 leaves. The peak population is reached in February-March. The aphid population in Punjab is negligible from October to December, and potatoes are planted in the first week of October. The haulm, the portion of the plant above-ground, is cut at the ground level in the last week of December. For his contribution to the development of new varieties of potato and for the production of disease-free seed potatoes in the plains, Pushkarnath received the Rafi Ahmed Kidwai Prize in 1968.

However, growing the crop in low-aphid periods could only take care of aphid-transmitted viruses and not of contagious viruses, such as PVX and PVS, which cause yield losses of 10-20% and the incidence of which was higher than that of the aphid-transmitted viruses. The method was, therefore, further improved upon by Dr Nagaich and his co-workers in 1969 by growing glasshouse-produced virus-tested tubers in autumn as the main crop in the plains.

The production of seed-potatoes in the plains has a number of advantages: the suitable area in the plains is large; soil-borne diseases and pests, which are common in the hills are absent or rare in the plains; late blight is less frequent and less serious in the plains; and the yields per unit area per unit time are also higher in the plains. With the use of the newly evolved varieties of shorter duration, the potato crop has not only started yielding more per unit area per unit time but could also suitably fit in with the relay-cropping pattern. Early lifting, essential in the 'seed-plot technique', eliminates the chances of the charcoal-rot of tubers. Apart from a 37 per cent increase in the yield in the plains over that obtained in the hills, the seed can be produced at a cost of Rs 500 a tonne against Rs 1,200 to 1,600 a tonne for the seed imported from the high hills. The production cost of disease-free seed in the plains is only about one-third of the cost of the hill seed.[1]

4. Phase IV: Agronomical Work: Dr Mukhtar Singh, 1969-1975

Mention may also be made of the work of Dr Mukhtar Singh who was associated with the Central Potato Research Institute from 1969 to 1975,

[1]Nagaich, B. B. 'Major achievements in potato production through plant-protection research', *ICAR Golden Jubilee Symposium*, September, 1979, New Delhi

as an agronomist right from its inception. Mukhtar Singh has done creditable work in his field of specialization, viz. agronomy and plant physiology. His work on the interrelation between seed size, spacing and fertilizers, water management, the effect of growth-regulators on plant growth, the breaking of dormancy of freshly harvested potatoes, post-harvest treatment and storage management is commendable. He started the programme on the direct, cumulative and residual effect of fertilizers in different crop rotations, both in the hills and the plains, as well as in inter-cropping and multiple-cropping patterns with potatoes. He has also to his credit many innovations, e.g. the smoke-screen method which has helped the growers to protect their potato and other vegetable crops against frost, a crust-breaker for special use on ridges, and a seed-treatment chamber for breaking the dormancy of freshly harvested tubers with a triple (vapour) treatment of thiourea, ethyene chlorohydrine and GA_3. His research on the country storage design at Patna has relevance even today in areas where facilities of refrigerated storage are not available.

Green Revolution in Potato Production

To sum up, the Green Revolution in potato is the result of new high-yielding varieties, the seed-plot technique for the production of potato seed, and the adoption of improved cultural practices. New high-yielding varieties suited to varying agro-climatic situations in the country and trade needs were evolved and released. They have taken firm roots in the country and brought about the stabilization of the varietal pattern. Among the more important varieties released and now in commercial use in the plains of the country are: 'Kufri Sindhuri', 'Kufri Chandramukhi', 'Kufri Chamatkar', 'Kufri Alankar' and 'Kufri Sheetman'.

National Potato Seed Production Committee

U.S. Kang organized seed-multiplication programmes, with emphasis on quality control in the primary and secondary seed-producing areas of the country, which led to stabilization of new varieties and their extension over larger areas. The varieties released before 1963 ran out quickly because small quantities of seed were released to State Departments and progressive farmers, without any linking with the production of disease-free seed stock at the field level. U.S. Kang suggested the formulation of a National Level Potato Seed Production and Development Committee with representatives from State Governments and National Seeds Corporation, who planned the multiplication of seed 'Kufri Sindhuri' and 'Kufri Chandramukhi', now extensively grown. The National Level Committee thereafter allotted breeder-seed to the National Seeds Corporation and the State Potato Development Departments for further multiplication as foundation or certified seed. He also initiated the central scheme for setting up and develpoment of foundation potato seed farms in the states, for which assistance was provided by the Central Government in the mid-sixties. In this way, the potato cultivation has extended to large areas and productivity has increased substantially.

For hill regions, where late blight was a limiting factor, in securing the full potential of yield, varieties with in-built resistance (resistance derived from *Solanum demissum*) were evolved, the most popular of these being 'Kufri Jyoti', 'Kufri Jeevan' and 'Kufri Naveen'.

With the seed-plot technique, it has now become possible to produce disease-free seed of quality comparable with that of the hill seed, in the plains of India, where nearly 90 per cent of the area under potato is situated. Survey, identification and control measures of several serious diseases (such as late blight, charcoal and brown rots, viruses and mycoplasmal diseases, hitherto unknown and unrecorded in India), recommendation of a package of practices for improved potato production for different potato-growing regions in the country, and creating an awareness about the potentialities of this crop as a source of food and as an earner of foreign exchange are achievements of great importance.

These achievements of research on potatoes completely transformed the centuries-old picture of gloom and helplessness into one of hope and promise. The potato for the first time in the country emerged as an important food in the subtropical plains and the temperate hills of India. The yields, which were 62 ± 5 quintals per hectare in 1963-64, have risen to 116 quintals per hectare in 1975-76.

As a result of improvement in varieties, cultural practices and the seed-plot technique, a remarkable increase has been achieved in the production of potatoes. In 1949-50, potato covered 234,000 hectares. In 1964-65,

TABLE 1. AREA, PRODUCTION AND YIELD OF POTATO IN INDIA DURING 1967-68 TO 1977-78

Year	*Area ('000 ha)*	*Yield (kg/ha)*	*Production ('000 tonnes)*
1967-68	501	8,441	4,232
1968-69	524	9,011	4,726
1969-70	511	8,006	4,093
1970-71	514	9,030	4,640
1971-72	496	9,746	4,834
1972-73	528	8,472	4,473
1973-74	533	8,680	4,626
1974-75	594	10,389	6,171
1975-76	587	10,598	6,225
1976-77	634	11,494	7,287
1977-78	664	12,272	8,153

SOURCE: *Fertilizer Statistics*

it covered 429,000 hectares. In 1966-67 potato production was 3,462,000 tonnes, and in 1977-78 it more than doubled. The progress in the area cultivated, the yield per hectare and the production from 1966-67 to 1977-78 is given in Table 1. The linear trend in the improvement of yield is still being maintained.

Prospects for Export

For suppplementing food supplies, potato has a great potential. In terms of yield per unit area and time, potato is an efficient crop, and there is scope for increasing its output.

Potato cultivation in India is unique, as the crop is grown in different geographical zones and the supply of fresh potatoes can be ensured almost all the year round, unlike in Europe. The availability of fresh potatoes for a long duration is of great significance in developing the processing industries.

Nearly 70 per cent of the potato crop in India is concentrated in the northern region, where the crop is cultivated from autumn till early spring. The harvesting period commences from January and extends to March. This is an off-season for potato in Europe. Such a situation has a great potential for developing a thriving export trade.

In the plains of India, the potato is cultivated in sandy-loam soils, which promote a regular shape and a lustrous skin of the tubers. In contrast, in several countries in Europe, the potato is grown in wet and heavy soils, as in the Himalayan hill zone of India. A team of importers from the UK and Holland, which visited Jullundur in 1976, was highly impressed with the uniformity, regular shape and lustrous tuber surface of our potatoes, since these are the basic requirements for mechanized making of chips and Frenchfries.

India is more favourably placed for export trade than European countries, because many of the devastating soil- and tuber-borne diseases and pests, which are deeply entrenched in the temperate climate, are not reported to occur in the subtropical plains of India. The duration of the present-day Indian potato varieties and the high summer temperature for several months act as barriers to the perpetuation of soil pathogens and pests.

FIG. 152a. 'Golden Delicious' apple in an orchard in Himachal Pradesh. This variety was introduced by Mr. S N. Stokes from the USA into Kotgarh.

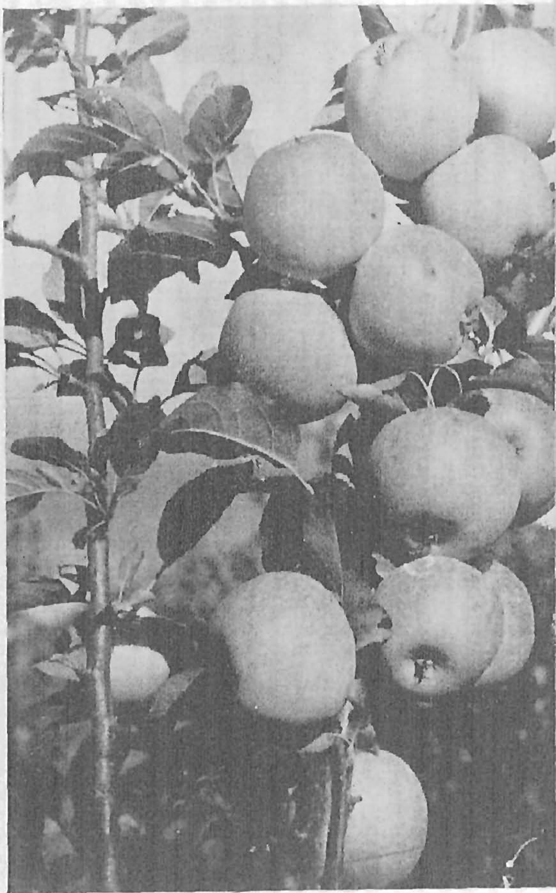


FIG. 152b. 'Red Delicious' apple was introduced by Mr. S.N. Stokes from the USA into the Simla Hills. This introduction changed the economy of the Simla Hills.

FIG. 153. *Above*: 'Red Gold' apple, now popular with orchardists in Himachal Pradesh. *Below*: 'King David' apple variety is popular in the Kumaon Hills, Uttar Pradesh. The area under apples in Kumaon is 33,000 hectares, with an annual production of 60,000 tonnes. Apples in Kumaon ripen earlier than those in Himachal Pradesh and Kashmir and are available in the market from the middle of June.

APPLE REVOLUTION IN HIMACHAL PRADESH

THE earliest record of apple cultivation in the Simla Hills goes back to the last quarter of the nineteenth century. The first orchardist was an Englishman, Alexander Cout, who bought a property known as Hillcock Head, at Mashobra. He grew English varieties of apples, pears, cherries, vegetables and flowers for the Simla market. This property, which was popularly known as Couts Orchard, became a regional research station of the ICAR for temperate fruits.

From 1845 to 1852, attempts were made by some Englishmen to plant tea in the Simla Hills. Of these tea-planters, Warles and Mrs Bates planted apple-trees of the variety 'Yellow Newton', now popularly known as 'Ruspippen', in their tea estates at Bharari. Two hill-men, Patia Ram and Gudru Mall, following the example of the English tea-planters, planted apples.

In the sixties of the nineteenth century, some Englishmen in the Kulu Valley founded the Kulu Tea Company, with gardens at Bajaura, Raison and Naggar. However, tea-growing was not a success and the tea-growers turned their attention to fruit-growing. The pioneer of the Kulu fruit industry was Captain R. C. Lee who, on his retirement from the army in 1870, bought some land at Bundrole. He sent for fruit-plants from his father's estate in the West County in England and planted apples, pears, plums and cherries in his orchard at Bundrole.

A few years later, an Irish friend of Lee, Captain A. T. Banon, settled at Manali. He, too, planted an orchard. In 1880, Colonel Rennick, who settled at Naggar, also planted an orchard.[1]

The varieties of apple introduced were 'King of Pippins', 'Autumn Pippin', 'Hawthorndon', 'Cox's Orange Pippin', 'Golden Pippin', 'Newton Golden Reinet', 'Lord Derby', 'Baldwin' and 'Blenheim Orange Pippin'.

In pears, the varieties introduced were 'Marie Louise', 'Donne of Jersey', 'Bartlett', 'Bergamotte', 'Knight', 'Monarch', 'Easter Beurre', 'White Dayenne', 'Seckle' and 'Duchess de Bordeaux'. The cooking European plums, such as 'Victoria', 'Pond's Seedling', 'Yellow Magnum Bonum', 'Denbigh Seedling' and others, improved so much in flavour and sweetness that they became suitable for dessert.

S. N. STOKES AND INTRODUCTION OF 'GOLDEN' AND 'RED DELICIOUS' APPLES

The pioneer in apple cultivation in the Simla Hills was an American,

[1]Chetwode, P. *Kulu, the End of the Habitable World*, London, 1972, pp. 128, 129

Samuel Nicholas Stokes (b. 1882, d. 1946). He came to Sabathu in the Simla Hills in 1904 and served in a leper colony. In the same year, he happened to visit Kotgarh near Narkanda, which commands a panoramic view of the snow-covered Dhaula Dhar Range and was fascinated by it. At that time, there was only a 52-mile mule-track, connecting Simla with Narkanda. Stokes purchased the property of one Mrs Bates in Kotgarh in 1912 and built a house, which he named Harmony Hall. In the same year, he married Agnes Benjamin, a beautiful Rajput girl. He became interested in India's Freedom Movement, led by Mahatma Gandhi, and was imprisoned by the British in 1919. In 1932, he embraced Hinduism and changed his name to Satya Nand.

In India, Stokes was the first person who imported the famous 'Delicious' varieties of apples from Stark Brothers Nurseries in the USA (Figs 151 and 152). He introduced many varieties, but the most popular among them are 'Stark (Royal) Delicious', 'Rich-a-Red', 'Winter Banana', 'Summer Queen', 'Red Delicious' and 'Golden Delicious'. Because of his initial efforts to introduce 'Delicious' apples into this country, he is called the "Father of Delicious Apples in India". Though Stokes was not a farmer, he studied books on apple-growing, contacted people for the scientific growing of apples and helped them to develop orchard. He found that the climate of Kotgarh approximates that of the apple-growing States in the USA. In a couple of years, he had perfected his knowledge of apple-growing and planted in 1921 an orchard on a commercial scale. Stokes distributed apple plants bought from the USA free among the villagers, so that even the poorest peasants of Kotgarh might have a future. He went to their homes and planted the saplings himself. The villagers were not enthusiastic in the beginning, but the success of the first set of trees ended their doubts. Soon, the entire culturable land of Kotgarh was covered with apple orchards.

As the annual apple harvest grew, Stokes turned his attention to marketing. He taught the villagers modern grading and packing methods and it was largely through his efforts that the bridle-path between Kotgarh and Simla was made into a motorable road in 1943. Instead of headloads or mule packs, now apples could be transported in diesel trucks.

He taught the villagers to plan ahead for their orchards, and today most of the apple-growers have their own nurseries to sell plants and to replace their old trees. It is because of his pioneering efforts that Kotgarh, the home of delicious apples, became the most prosperous village in India.[2]

Dr Yashwant Singh Parmar, Chief Minister, Himachal Pradesh Government, who was an orchardist and took keen interest in promoting apple

[2]Kashyap, C. M. and Post, E. "Yankee in Khadi"—The story of Samuel Evans Stokes, *Span*, January 1961

cultivation, honoured Satya Nand Stokes by naming after him the Horticultural Complex of the Himachal Pradesh Agricultural University at Khaltoo near Solan.

Apple Revolution, 1952-1981

The area under apples in Himachal Pradesh (including Kulu, which was in Punjab) in 1950-51 was only 792 hectares and the production was 1,200 tonnes. In five years, the area increased to 2,030 hectares and the production to 7,000 tonnes. The start of the apple revolution was in the Kulu Valley in 1952. At that time I was the Development Commissioner, Punjab, and paid a visit to the Kulu Valley. I proposed that 1,000 acres (400 hectares) be brought under apple cultivation. There was opposition from the apple-growers of the Valley, who thought that it would create a glut in the apple market. I decided to go ahead. Areas suitable for apple-planting were surveyed and selected for establishing orchards. A large nursery programme was chalked out and plants were supplied on no-profit-no-loss basis to the growers. Pruning-knives, secateurs, and spray pumps were given to the growers as loans in kind. Provision was also made for opening training classes in gardening. Apart from the village-level workers, orchardists were encouraged to go in for this training.[3]

Sardar Partap Singh Kairon, as Chief Minister of Punjab from 1959 to 1964, gave further fillip to apple cultivation in the Kulu Valley. In 1966, as a result of the reorganization of Punjab, the Kangra District, including Kulu, was merged into Himachal Pradesh.

Research Support

Research has also played a major role in the apple revolution of Himachal Pradesh. In 1953, the ICAR sanctioned for Himachal Pradesh the first fruit research scheme, which was located at Cout's Orchard at Mashobra. Amolak Ram Thapar was the first officer in charge, who implemented the research scheme, and he was followed by R.S. Rana. Dr T.R. Chadha and Dr D. R. Thakur also later on participated in this work. Thapar and Rana introduced many new varieties, standardized their propagation techniques and planned the expansion of apple cultivation in Himachal Pradesh. Under the guidance of Dr L.S. Negi, Director of Agriculture, a chain of progeny orchards was established and plants were supplied to the growers.

Bajrang Bahadur Singh, Raja of Bhadri, who was Lieutenant-Governor of Himachal Pradesh from 1955 to 1963, took keen interest in promoting apple-growing. His contribution to the apple revolution in

[3]Randhawa, M.S. *National Extension Service and Community Projects in the Punjab*, Chandigarh, 1955, p.52

Himachal Pradesh is memorable. He gave unstinted encouragement to growers, researchers and the extension staff.

Dr Yashwant Singh Parmar (b. 1906, d. 1981), who was the Chief Minister of Himachal Pradesh for 18 years from 1952 to 1956 and 1963 to 1977, was himself an apple-grower. In 1970, Parmar created a separate Department of Horticulture. He toured the fruit-growing areas in Europe and the USA, along with some officers of the Department of Horticulture. In that tour, he realized the importance of the latest techniques for growing and marketing apples.

Roads

Lack of roads was the main hurdle in the extension of apple cultivation in Himachal Pradesh. The Himachal Pradesh Government was aware of this problem and took steps to remedy it. Hence, the expansion of the road network in Himachal Pradesh has been rapid. In 1948, there were only 288 km of roads in it. The income per head then was Rs 216.80 and the gross national product of the State was only Rs 240 million. As the network of roads expanded to 12,418 km in 1980, the income per head rose to Rs 1,267. The roads promoted apple cultivation by opening up inaccessible areas.

The World Bank Project

While apples can be produced in large quantities, the problems of storage, marketing, transport and processing remained. Harbans Singh, who was the first Director of Horticulture in Himachal Pradesh from 1971 to 1974, formulated a project to be financed by the World Bank. The world Bank Project of Rs 163 million contributed substantially to the solution of these problems. Under this project a chain of packing-and-grading houses, cold stores and processing-plants is being developed. A provision for the construction and improvement of 401 km of road and 20 km of cable-ways was made for improving the transport system. Out of 10 packing-and-grading houses, 2 packing-houses at Pattlikuhal and Bhunter, 3 packing-and-grading houses at Chailchowk, Chindi and Rajgarh have been commissioned.

Also, the Department of Horticulture collected information on prices, arrivals, demand, etc., from 25 main consuming markets of the country and daily rates were broadcast from the All India Radio for the benefit of the orchardists. Over 27,000 boxes of apple and stone-fruits were graded by way of demonstration for helping the orchardists to get optimum returns and about 1,500 farmers were approached for rendering them advice and solving their marketing problems.

To solve the problem of increased demand of wood for manufacturing packing-cases, trials were conducted by the Department of Horticulture on substitute packing-cases. Corrugated cardboard packing-cases were tried on a large scale.

To utilize the inferior or damaged fruit, a processing-plant of 18,000 tonne capacity was commissioned at Parwanoo. Apple-juice made at this plant is sold all over the country and is also exported.

Table 1 shows the progress of the apple revolution in Himachal Pradesh. The area under apples increased from 792 hectares in 1950-51 to 26,735 hectares in 1970-71 and to 43,356 hectares in 1980-81. The production of apples increased from 1,200 tonnes in 1950-51 to 1,35,475 tonnes in 1979-80. In 1981, it is estimated at 2,20,000 tonnes.

TABLE 1. AREA UNDER APPLES AND PRODUCTION IN HIMACHAL PRADESH FROM 1950 TO 1981

Year	*Area (ha)*	*Production (tonnes)*
		All fruits
1950-51	792	1,200
1955-56	2,030	7,000
		Apples
1960-61	3,025	1,2000
1965-66	12,711	24,000
1966-67	15,146	28,900
1967-68	17,588	39,344
1968-69	20,230	50,524
1969-70	23,482	72,250
1970-71	26,735	1,03,120
1971-72	28,308	1,25,060
1972-73	31,003	29,800
1973-74	32,127	1,18,676
1974-75	33,628	43,299
1975-76	35,076	2,00,000
1976-77	36,734	1,19,228
1977-78	38,925	1,31,617
1978-79	40,655	1,21,896
1979-80	41,947	1,35,475
1980-81	43,356	1,18,013*

*Fall in production due to adverse weather

SOURCE : *Directorate of Horticulture, Himachal Pradesh*

The apple revolution in Himachal Pradesh is the result of well-planned efforts of administrators, scientists and fruit-growers. As a result of this spectacular increase in production, apple which was the rich man's fruit has now become every man's fruit. Himachal apples are now sold in all the cities of India and have reached so far south as Kanyakumari. In Punjab and Haryana, apples are sold not only in the towns, but also in the villages.

CHAPTER 37

GRAPE-GROWING SINCE INDEPENDENCE

IN MAHARASHTRA, ANDHRA PRADESH, KARNATAKA AND TAMIL NADU IN SOUTHERN INDIA AND IN PUNJAB, HARYANA, DELHI AND WESTERN UTTAR PRADESH IN NORTHERN INDIA

THE original home of the grape is the ancient Armenia. The most important species under maximum cultivation is *Vitis vinifera.* Its wild form is still found in the north-eastern Afghanistan and is called *Vitis sylvestris.* It seems that the vinifera grape was domesticated around 400 B.C.

The cultivation of grape is largely concentrated in regions with a Mediterranean type of climate, i.e. with a hot and dry summer and a cool and rainy frost-free winter. The vineyards in the world occupy about 11 million hectares. The principal produce is wine. The biggest producers of wine are Italy, Turkey, Bulgaria, USA, Greece and Portugal. Raisins are mainly produced in the USA, Turkey, Greece and Australia.

In India, a mention of the grape has been made in early medical treaties written in the first century: *Charaka Samhita* and *Sushruta Samhita.* The Moorish traveller, Ibn Battuta (1430), saw healthy vineyards in Daultabad (the Aurangabad District in Maharashtra). Grape cultivation flourished during the Mughal period. However, with the decline of the Mughal Empire, viticulture was neglected and was almost wiped out in the eighteenth century.

VARIETIES

All the grape varieties being cultivated in India belong to *Vitis vinifera* except 'Bangalore Blue' and 'Himrod', which are hybrids between *vinifera* and *labrusca.* In Andhra Pradesh, 'Anab-e-Shahi' occupies more than 95 per cent of the area. The other grape varieties getting popular are 'Thompson Seedless', 'Kali Sahebi' and 'Karachi Gulabi'. In Maharashtra, the most popular varieties are 'Thompson Seedless', 'Cheema Sahebi' ('Selection 7') and 'Bhokri'. In Karnataka, most of the area is covered by the disease-tolerant 'Bangalore Blue', but new areas are being planted with 'Anab-e-Shahi', 'Thompson Seedless', 'Gulabi' and 'Cheema Sahebi'. Important varieties in Tamil Nadu are 'Gulabi', 'Bhokri', 'Anab-e-Shahi' and 'Kishmish' (seedless). In northern India, comprising Punjab, Haryana, Rajasthan and western Uttar Pradesh, 'Perlette', 'Beauty Seedless', 'Himrod' and 'Thompson Seedless' are most popular.

Grape Growing in the Tropics

So far, there was a belief that in the tropical areas, successful grape growing was not possible. To the contrary, the vineyards of peninsular India produce grapes of fine quality and are very productive, giving the highest yield in the world. In the tropical belt of this country, the vines stay evergreen throughout the year and do not enter dormancy as in the temperate and subtropical zones. The cropping of vines is regulated by pruning twice a year, once in April and again in October. This practice has been adopted by the growers after attaining experience for decades. With this technique of pruning, even two crops in a year are harvested in the case of some grape varieties such as 'Bangalore Blue'. In some parts of Tamil Nadu, even five crops are harvested in two years by staggering the time of pruning. However, the main harvesting season in peninsular India is from February to March. In the case of 'Bangalore Blue', the growers are able to harvest grapes almost round the year by staggering the pruning.

Grape Growing since Independence

The traditional grape-growing areas, Baluchistan and the North-West Frontier Province, became a part of Pakistan in 1947. The partition of country greatly restricted the import of grapes into India from these areas and also from Afghanistan. Though it was regarded as a hardship by fruit-eaters at that time, it proved to be a boon for the country. Grape-growing was revived first in Maharashtra, Andhra Pradesh and Karnataka. Since 1962, it has been taken up in Punjab, Haryana, Rajasthan and western Uttar Pradesh.

Maharashtra

Grape cultivation was first taken up (1300 A.D.) by the Muslims in Daulatabad, Aurangabad and Golconda. In 1669, its cultivation spread to Ahmednagar, Poona and Jalna. Under the patronage of the Peshwas of Poona, grape-growing flourished in the Maratha Empire from 1717 to 1817. Later on, an impetus was given to it by educated and progressive growers. In Nasik, H.V. Gole established a vinery on a large scale and he educated other growers in the methods of combating pests and diseases. He also wrote a book in Marathi on growing grapes. During the recent years, D.G. Shambekar perfected the technique for the successful cultivation of grapes. He introduced in Maharashtra varieties such as 'Kandhari', 'Gross Colman', 'Selection 94' and 'Thompson Seedless'. He also got prizes for producing new high-yielding varieties such as 'Selection 7' and 'Selection 94'. Another grower who has achieved astonishing results with 'Bhokri' variety is Shanker Rao Date. He produced over 61,775 kg of grapes per hectare in a single season. Yet another grower, Nilakhe, succeeded with the 'Anab-e-Shahi' variety to a remarkable degree and obtained a yield of 37,065 kg per hectare. Rao Bahadur Borake of Poona has the largest area under grapes in Maharashtra.

Nawab Siraj Yar Jung, Director of the Department of Education and Horticultural Adviser to the Nizam, made commendable efforts to revive the growing of grapes by establishing the Horticultural School in the Muqbara Gardens at Aurangabad. At that time, this area was included in the Hyderabad State. He induced the local authorities to help the growers in many ways. The co-operative Department of the Government of Hyderabad launched a scheme for the revival of grape cultivation in Daulatabad. In 1921, Shanker Pillay, the State Horticulturist, helped the departments to implement the scheme. Fortunately, Nawab Siraj Yar Jung, who had formerly done so much for promoting the cause of grape-growing, was again in charge of the scheme and Shanker Pillay had the privilege of starting his career under his guidance. Shanker Pillay obtained grape cuttings from Daulatabad, Nasik and Poona and supplied them to the growers. The industry was once again put on its feet. The most prominent grower of the Aurangabad District was A.B. Mehta, who had an orchard at Parsoda, a railway station on the Aurangabad-Manmad portion of the Nizam's State Railway.

The varieties grown in Maharashtra are 'Bhokri', 'Gulabi', 'Kala Sahebi' and 'Anab-e-Shahi'. The 'Bhokri' grapes are known to be earliest in the grape-growing history of the Deccan. It has a very vigorous growth. The bunches are large, long and conical, and weigh 400-500 g each. The berries are pinkish yellow and spherical. 'Gulabi' variety was once very popular in Maharashtra. Its bunches are medium-sized and loose, weighing 150-250 g each. The berries are purplish red, small and possess a typical flavour in the pulp. This variety is excellent for wine-making. 'Kali Sahebi' grapes are largely grown in Maharashtra. The growth of the vines is vigorous. Its bunches are medium to heavy, weighing 450-475 g each. The fruit is long, conical and juicy. The yielding capacity of the variety is low and it is very susceptible to diseases.

Dr G.S. Cheema, Director of Ganeshkhind Fruit Research Station, Poona, and later on Horticulturist to the Bombay Government, made a distinguished contribution to horticulture. He was endowed with a keen sense of observation. He evolved new varieties of grapes which contributed greatly to the expansion of grape cultivation in Maharashtra, Karnataka and Andhra Pradesh. The varieties developed by him, viz. 'Selection 7' (now known as 'Cheema Sahebi') and 'Selection 94', are high-yielding. Even today 'Cheema Sahebi' stands as a monument to the deep insight that 'Cheema' had into viticulture. Apart from grapes, he also took interest in other fruits. 'Lucknow 49' guava (renamed 'Sardar Guava'), 'GBG 1' pomegranate (renamed 'Ganesh') and 'Poona' fig were selected by him. These not only became popular in western India but are extensively grown

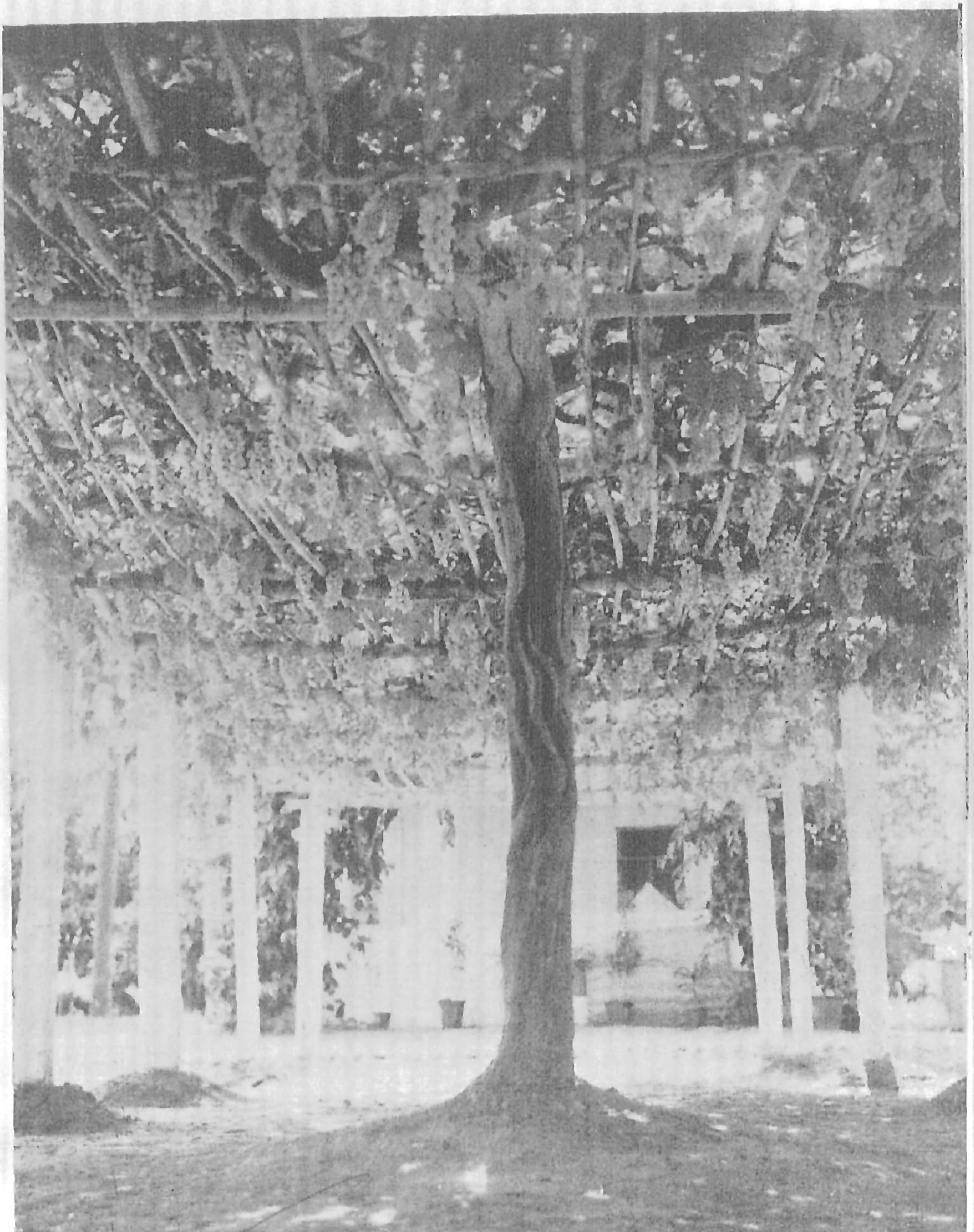


FIG. 154. A Biological Wonder—a single vine of 'Anab-e-Shahi' grown on an overhead bower, covering 55.7 square metres at Coimbatore. It had over 600 bunches of grapes.

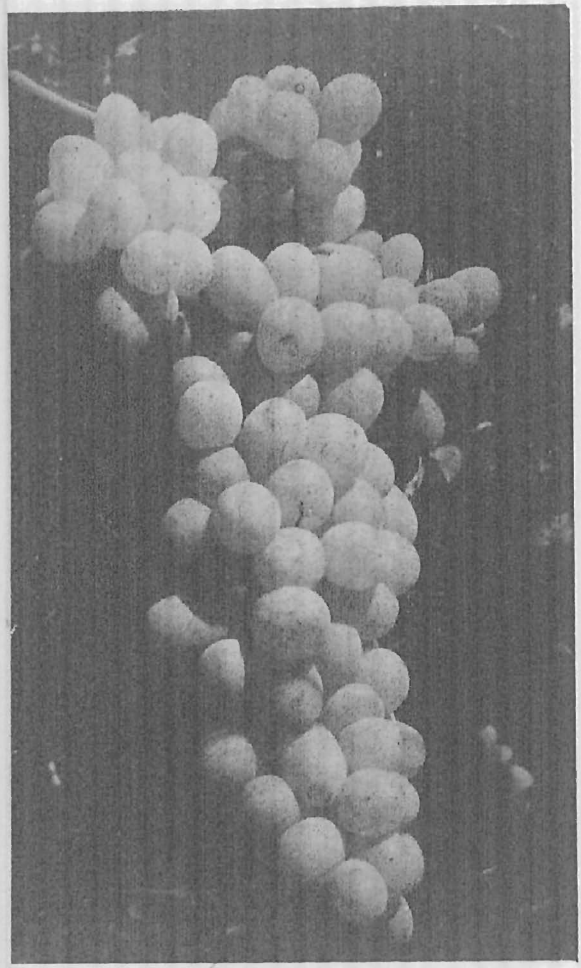


FIG. 155. A bunch of 'Anab-e-Shahi' grape. This variety has spread in Andhra Pradesh, Karnataka and Tamil Nadu.

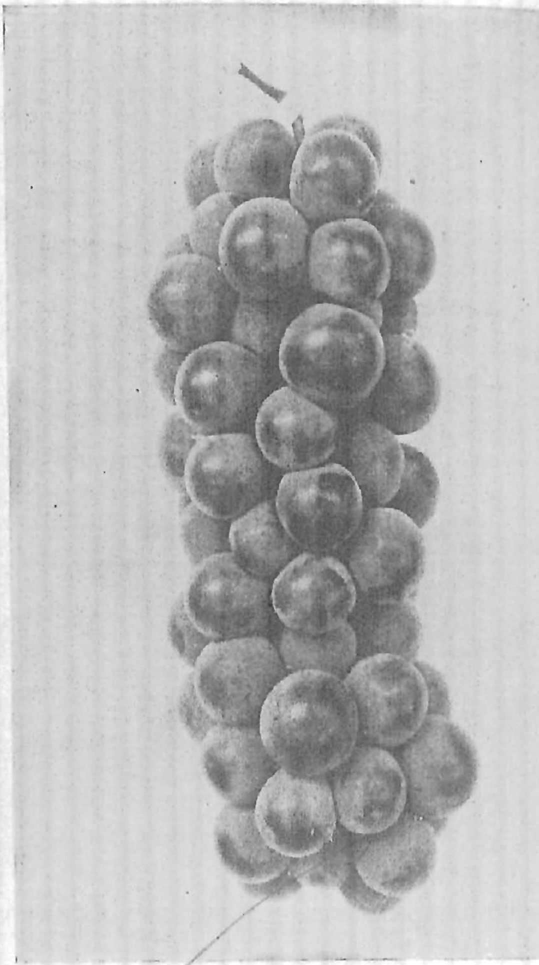


FIG. 156. A bunch of 'Bangalore Blue' grape. It is popular in Karnataka and is used for juice- and wine-making.

FIG. 157. A woman selling 'Bangalore Blue' grapes in the Mysore City.

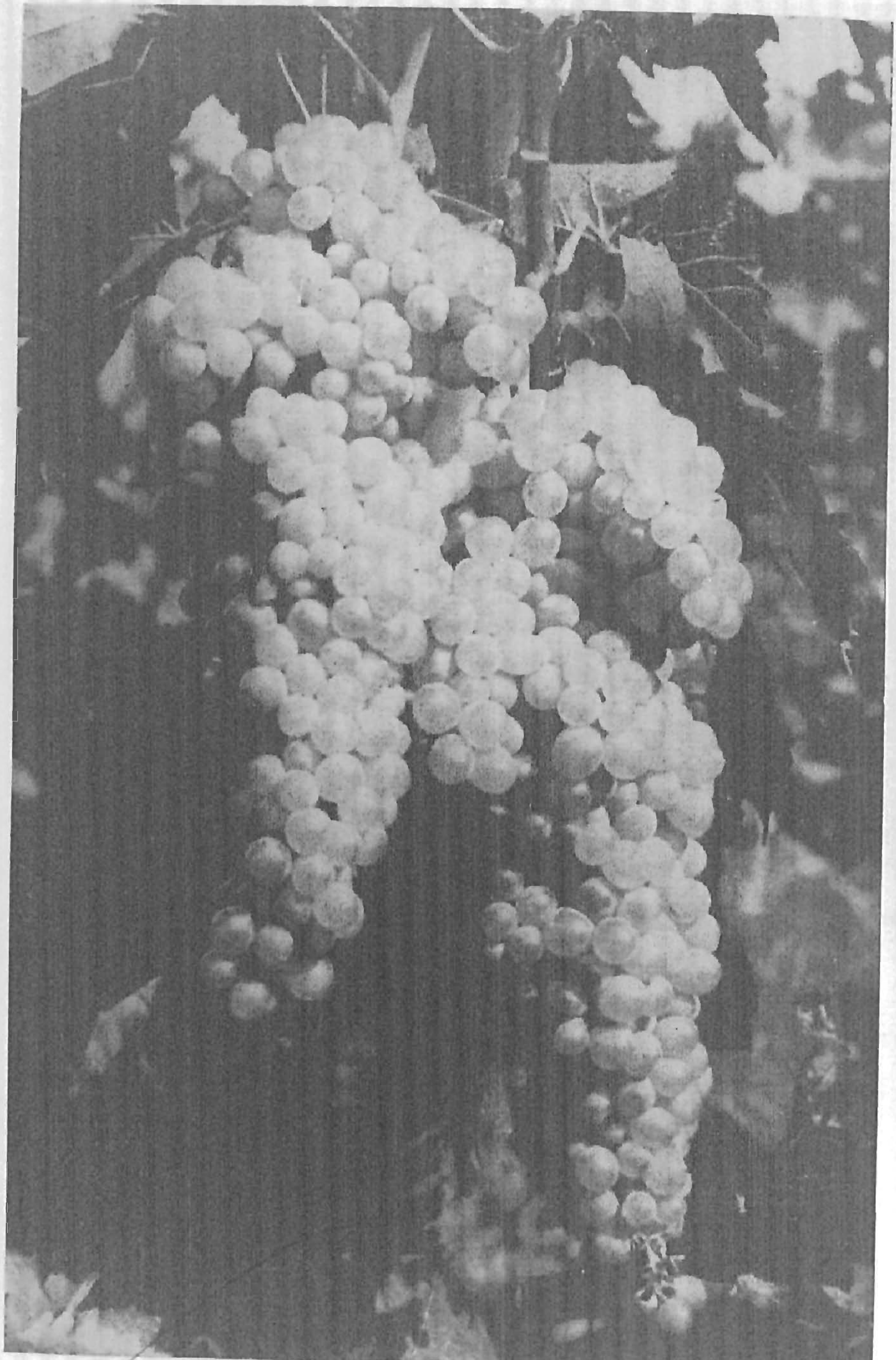


FIG. 158. 'Perlette' variety of grape has spread over a large area in northern India.

all over the country, and made a sizeable impact on the development of fruit-growing in the country. Grapes in Maharashtra cover about 1,000 hectares.

ANDHRA PRADESH, CULTIVATION OF 'ANAB-E-SHAHI' GRAPE

Grape culture in Andhra Pradesh is of recent origin and its expansion was extremely rapid. From 45 hectares in 1958-59, the area under grapes rose to 1,400 hectares in 1974-75. The most popular variety is 'Anab-e-Shahi' (also known as 'Royal Grape'), an amber-seeded grape. It is a heavy-yielding vigorous vine, with large bunches consisting of slightly shouldered, conical, well-filled, ovoid berries (Fig. 155), with excellent keeping quality. The total soluble solids are 15-17 per cent and acidity 0.6 per cent. On an average, it can yield up to 62 to 74 tonnes of grapes per hectare.

'Anab-e-Shahi' was believed to have been introduced into Hyderabad from the Middle East by a Haji (a Muslim pilgrim to Mecca). During a grape survey initiated by the All-India Marketing Board, R. Shanker Pillay, the State Horticulturist, located three vines, two of them in Hyderabad and one at Gulbarga. These varieties are now the famous 'Anab-e-Shahi' of Hyderabad.

L. Venkata Ratnam, who succeeded Shanker Pillay as Horticulturist, relates how 'Anab-e-Shahi' grape received its name and how it spread in Hyderabad. Baqar Ali Khan, a State official, obained a few cuttings of grapes from Gulbarga and planted them in Hyderabad in his home garden in 1948. Shanker Pillay, then Horticulturist, popularized this variety on a home-garden scale till 1950. At that time, this grape was grown in about a hundred bungalows in Hyderabad. It was called 'Malta' by the merchants. At the All-India Industrial Exhibition, held in 1949 at Hyderabad, the Department of Agriculture displayed some bunches of grapes grown by Baqar Ali Khan. The Nizam was attracted by them and named the grape 'Anab-e-Shahi'. 'Anab' means 'grape' and 'Shahi' means 'royal'.

'Anab-e-Shahi' was cultivated for the first time on a commercial scale in 1951 by Dr Ram Koteshwar Rao at Tolichowki near Hyderabad. He was awarded Padma Shri for producing the highest yield in India in 1963. Later, Somaraju of Jeedimetla, Hyderabad, won the Udyan Pandit award for producing 100 tonnes of grapes per hectare—considered a world record.

Venkata Ratnam found that 'Anab-e-Shahi' does not resemble any variety of grapes grown in the Middle East and has distinct characters, with satellite chromosomes. Dr G.S. Cheema, Fruit Development Adviser of the Ministry of Agriculture, Government of India, recognized it as a distinct variety. In the first All-India Grape Show, held by the ICAR in 1956, 'Anab-e-Shahi' was declared the best grape of India. On account of this recognition, the area under this grape variety increased in a remarkable manner.

The credit for formulating the package of practices for growing 'Anab-e-Shahi' grape goes to L. Venkata Ratnam. He also sent cuttings of this grapevine to many research stations in India.

Grapes are grown in Andhra Pradesh in the districts of Hyderabad, Mahboobnagar, Medak, Nizamabad, Kurnool, Cuddapah, Anantapur and Chittoor. The Hyderabad District alone produces 27,000 to 30,000 tonnes of grapes and accounts for more than 70 per cent of the total annual production in the State.

Because of the high capital investment involved in starting a vineyard, the majority of the grape-growers are well-to-do industrialists, merchants and rich farmers.

The grape industry in Andhra Pradesh has attracted Indians from foreign countries such as Kenya, Uganda and Indonesia. They have invested capital and have taken up grape culture on modern scientific lines. This effort has rapidly changed the landscape around Hyderabad, and within a radius of 48 kilometres there are many excellent vineyards.[1]

KARNATAKA

It is not known when grape cultivation started in Karnataka. There are now over 2,025 hectares under 'Bangalore Blue', a variety popular since the time of the Mughal emperors. Its bunches are medium-sized and weigh 300-350 g each. The berries are bluish black, spherical and seeded (Fig. 156). They have a thick skin, are juicy, and ripen uniformly. The variety is preferred less for table use owing to its thick skin and low sugar content. However, it is good for juice- and wine-making. Syed Sirajul Hasan, in a note on the cultivation of grapes in Daulatabad, states that "cuttings of grapes from Daulatabad have given birth to expensive vineyards in Nasik, Poona and Bangalore". For many years, the blue grape grown in the Bangalore area was known as 'Aurangabadi' (Nasik). The area under grapes in Karnataka is nearly 4,000 hectares. The prominent varieties grown are 'Bangalore Blue', 'Bangalore Purple', 'Anab-e-Shahi', 'Thompson Seedless' and 'Cheema Sahebi'. Dr Marigowda, Director of Horticulture, was mainly responsible for the widespread cultivation and popularization of grape-growing in Karnataka.

It is the intelligent, observant and educated growers who have contributed more to grape cultivation than the departments of agriculture. In the Karnataka, one such grape-grower is H.S. Rama Rao, who has a 2-hectare vineyard in the village of Channasendra in the south of Bangalore. Rama Rao has brought the cultivation of 'Thompson Seedless' to perfection. His venture in grape-growing is a saga of hard work and keen interest.

In 1969, there was no large-scale planting of 'Thompson Seedless'. It

[1]Personal Communication from L. Venkata Ratnam dated 28 July 1981

was thought that this variety could not be cultivated successfully as a commercial proposition. It fell to the lot of Rao to plant and show that this variety would suit the climate of Bangalore and the adjoining areas well and a sizeable crop could be harvested year after year. Many enthusiastic grape-growers who wanted to go in for this variety were watching the progress of this vineyard. During the first harvest of March-April 1971, Rao harvested over 16 tonnes of grapes per hectare and got a good price. In view of the onrush to plant this variety and owing to the paucity of planting material, Rao got all the prunings converted into nearly 20,000 rooted cuttings and distributed them to new growers at a nominal cost. He has been harvesting between 25 and 35 tonnes of 'Thompson Seedless' grapes per hectare and is estimating the present standing crop in one plot at about 37 to 40 tonnes per hectare. Encouraged by the continued success of this variety, many grape-growers have taken up the planting of this variety.

When asked about the attributes of a successful grape-grower, Rao says "since grape-growing demands skill and precise scientific knowledge, many times posing tricky problems, one should have a thorough knowledge which comes only with considerable experience. One must understand the fundamental physiology and anatomy of vines, the chemistry of his spray materials and their exact usage, and must be acquainted with the life cycles of the important insects and diseases encountered. One must keep abreast with the new viticultural developments in the leading grape-growing countries. One could profitably spend time in reading and developing a collection of books, professional magazines and weather reports. In addition, one has to take part in grape shows–All-India and State—and infuse a spirit of competition and progress. One should also visit progressive grape gardens and discuss problems of common interest, should personally supervise and direct the activities of the garden and, if possible, reside at the vineyard." "There is still much to do", says Rao. The consumer is paying through his nose. If a grower could produce an average good crop, economizing on his expenses without hampering production, the consumption of grapes per head would be more and, in turn, it would be necessary to bring more area under grapes. With the economic assistance from commercial banks, land-development banks and the technical 'know-how' given by the Indian Institute of Horticultural Research and the departments of horticulture, educated young men can take up grape-growing and thus reduce the pressure on the employment market.

Tamil Nadu

A variety known as 'Pachi-Draksha', akin to 'Bhokri' of Maharashtra, caught the imagination of the grape-growers in Krishnagiri and at Pattivirapatti in the Madurai District of Tamil Nadu. At Pattivirapatti, Soundriya Randya Gowder started growing this variety. He was able to obtain two crops in a year and this was not possible in Maharashtra. His record yield of over 7.4 tonnes of grapes per hectare, from two crops, attracted the attention of horticulturists in southern India. He also introduced 'Thompson Seedless' into the region.

A single vine of 'Anab-e-Shahi' grown on an overhead bower, covering about 56 square metres at Coimbatore, has made history. Some foreign visitors, who saw the vine bearing over 600 bunches of grapes, declared it a biological wonder (Fig. 154).

Selection of 'Pusa Seedless' by G. S. Randhawa at the IARI, New Delhi

From 1955-64 collections of grapes were made at the Indian Agricultural Research Institute, New Delhi; Horticultural Research Institute, Saharanpur (Uttar Pradesh) and Regional Fruit Research Station, Abohar (Punjab). At the Indian Agricultural Research Institute alone, over 350 grape varieties were collected, including some most promising ones from California, the USSR, Yugoslavia and Australia. Successful grape cultivation at these three centres proved beyond doubt the possibility of commercial grape cultivation in northern India. Dr G.S. Randhawa, Head of the Division of Horticulture, IARI, isolated 'Pusa Seedless' and also developed a large number of grape hybrids. Recommendations for commercial grape cultivation were made around 1960 when a regular programme of distribution of 'Pusa Seedless' grapevines was started. G.S. Randhawa and his team also showed that by using gibberellic acid, fruit size in several varieties of grapes could be increased. Now this is a common practice among growers.

Grapes in Punjab and Haryana

Sardar Pratap Singh Kairon, when he was Chief Minister of Punjab, decided to take up grape cultivation in Punjab on commercial scale in 1962. Accordingly, a dedicated grape expert from Maharashtra, B.M. Pansare, was appointed Grape Extension Adviser. He took up measures such as the selection of varieties, and made cultural and plant-protection schedules. One of the first steps in this programme was the distribution of 'Anab-e-Shahi' grape from Hyderabad on a large scale and later to import of 100,000 cuttings of the famous seedless Californian grape variety 'Perlette'. 'Anab-e-Shahi' spread with great speed, but was given up by the growers after ten years or so, as it is a late-maturing variety and its fruit in July gets damaged by rains.

'Perlette'

'Perlette' was introduced into India from California and was released for commercial cultivation in Punjab in 1964. It is a whitish-green, seedless grape and has attractive bunches (Fig. 158). It has given a high yield on the bower system of training. On an average, 50 to 70 bunches were harvested at various places during the first year of bearing. The variety ripens from mid-May to mid-June and thus escapes damage from rains. Its keeping quality is good. However, its major drawback is the compact nature of its bunch. This defect has, however, been overcome by another variety, 'Loose Perlette', developed in California. The plant material of this improved variety was available on a very limited scale in Punjab with Kesar Singh Lamba, a progressive grower of the Panchhi Gujran Garden Colony in Rohtak District.[2]

'THOMPSON SEEDLESS'

This variety was introduced from Andhra Pradesh. It has medium to large, attractive, cylindrical bunches, with small berries, which are seedless and greenish yellow. The amount of the total soluble solids (TSS) ranges from 18 to 22 per cent. It ripens during the second and third week of June before the onset of rains, and has a good keeping quality.

[2]*Report of the Expert Committee on Grape Industry of Punjab*, 1966

CHAPTER 38

THE MANGO—NEW HYBRIDS

PRESERVATION OF THE GERMPLASM OF SUCKING MANGOES

THE mango is by far the most important fruit crop of India; approximately one million hectares are under this crop. India is the world's largest producer of mangoes and contributes about 65 per cent of the total world production.[1] No other fruit is so closely associated with the history of Indian civilization as the mango (*Mangifera indica* Linn.). The genus *Mangifera,* to which the edible varieties of mango belong, has 41 valid species, mostly scattered in the wild state in the South Asian countries like India, Burma, Malaysia, Vietnam, Thailand, the Philippines and Indonesia. The maximum concentration of *Mangifera* spp. is reported to be in the Malaysian region, whereas only three are reported from India. However, almost all the edible varieties of mango belong to the species *M. indica* which originated in the Indo-Burma region. Truly wild mangoes are found in the Chittagong hills and Assam.

The mango tree often attains the age of a hundred years or more. The biggest and the oldest mango-tree was discovered in 1949 by me in the village of Burail near the present City of Chandigarh (Fig. 159). This tree, known by the name Chhapar, had a trunk 9.75 metres in girth, with nine branches 1.52 to 3.66 metres in girth and 21-24.5 metres long (Fig. 160). In fact, each of these trailing branches looked like a giant tree. The area over which the crown of the tree spread was 2,258 square metres, and the average annual yield of the fruit was 16.8 tonnes. It is said that once, when twenty cart-loads of mangoes plucked from this tree reached the Patiala fruit market, people thought that it was the produce of an entire garden.[2] This tree was struck by lightning in 1955, and was killed.

Mango is the most popular fruit of India and only a few countries in the world are endowed with varieties of such excellent quality. Almost all its varieties are of spontaneous seedling origin and were selected by fruit-growers, mostly the Muhammedan nobles and the Nawabs of Oudh and Hyderabad. When one considers that mango is highly heterozygous plant and a great deal of segregation is expected both in quality and productivity, the selection of these commercial varieties must be considered a remarkable achievement.

During the long history of its cultivation in the Indian sub-continent, a wealth of varieties had accumulated through the selection of superior

[1]Bondad, N.D. World mango production and trade, *World Crops*, p. 32, 160-168, 1980.
[2]Randhawa, M.S. A giant mango tree, *Indian Farming*, June 1949.

chance seedlings and their subsequent maintenance and perpetuation by grafting—a technique which became popular only during the Mughal rule. The number of varieties runs into about a thousand, though only about a score or so are of commercial importance. However, even the most popular commercial varieties lack in one or more desirable characters.

Two Types: Sucking and Table

Basically, mangoes can be divided into two types — the sucking and the table types. The sucking types have thin juice, and have more of fructose. Hence even if the juice of a large number of sucking mangoes is consumed, it causes no discomfort. In fact, it induces a mild languor. A glass of cold milk is drunk after a session with sucking mangoes. Commercial table types have thick pulp and are cut with a knife, and the flesh is eaten, with a spoon, leaving the skin. These varieties have more of sucrose, and not more than two can be eaten without discomfort.

Nomenclature of Mangoes

On account of its numerous varieties, and the fact that the same variety may be known by different names in different regions, a vast confusion prevailed in the nomenclature of mangoes. The Twelfth International Horticultural Conference held in Berlin in 1947 recommended the standardizing of the names of fruits grown in different countries. In pursuance of this recommendation, the Horticultural Workers' Conference in India decided in 1948 to start action for standardizing the names of fruits grown in India. A scheme for the mango was sanctioned by the ICAR, and was started in 1948. The researchers who participated were S.R. Gangolly, Ranjit Singh, S.L. Katyal and Daljit Singh. Complete vegetative, floral, fruit and stone characters of 210 varieties were described. In 1957, a monograph, entitled *The Mango,* was published by the Indian Council of Agricultural Research, illustrated with 224 colour plates, in which the exact size of the fruit is given.

Another attempt at the classification of mangoes was made by Dr Lal Behari Singh and his associate, R.N. Singh, at the Horticultural Research Institute, Saharanpur. They surveyed, classified and described the cultivars of mango grown in Uttar Pradesh. This work was published in the form of an illustrated monograph in two volumes by the Superintendent, Government Printing Press, Lucknow. This monograph on the mango cultivars of Uttar Pradesh, which included table as well as sucking types, was well received by the mango-growers and horticulturists in India.

North Indian Varieties

Mangoes are further classified into two categories, viz. north Indian and south Indian. The best varieties of mangoes in northern India are

'Chowsa', 'Dussehri', 'Langra', 'Rataul' and 'Safeda' of Uttar Pradesh, 'Gulab Khas' and 'Fajri' of Bihar, and 'Bombai' of West Bengal. 'Dussehri' derives its name from that of village between Lucknow and Malihabad. It owes its origin to a superior chance seedling in the garden of a Nawab. The Nawab-Wazirs of Oudh, with their capital at Lucknow, were patrons of art and connoisseurs of fruits, and mango was their favourite. A few grafts of the 'Dussehri' are reported to have been presented by the Nawab to one Alamgir Khan of Malihabad, who planted them in his garden. The parent 'Dussehri' is still alive.

'Langra' owes its origin to a superior chance seedling in the backyard of the house of a lame *fakir* of Benaras; hence the name *Langra* (meaning lame). 'Samarbehisht Chowsa' derives its name from the Village of Chowsa in the Malihabad Tahsil of the Lucknow District. The *talukdars* of Sandilla in the Malihabad Tahsil collected the stones of the choicest mango fruits of Malihabad and planted them in their village of Chowsa. One of the seedlings gave rise to a superior chance seedling, which was named 'Chowsa Samarbehisht', meaning the heavenly fruit of Chowsa. It is, indeed, a delicious variety, with sweet flesh, and some regard it as the best mango. Its only defect is that it is alternate in bearing.

'Rataul' originated as a superior chance seedling in Shohra-e-Afaq Garden in the Town of Rataul in Uttar Pradesh. It is excellent in flavour and is very sweet. 'Safeda Malihabadi' was selected by Fakir Muhammad Khan, Nawab of Malihabad.

'Fajri' originated as a superior chance seedling in the courtyard of a house belonging to a lady, named Fajri, of Bhagalpur in Bihar. It has spread in the Indo-Gangetic Plain from Bihar to West Bengal, Uttar Pradesh and Punjab.[3]

South Indian Varieties

The best six varieties grown in southern India are 'Neelum', 'Banganapalli', 'Suvarnarekha', 'Mulgoa', 'Pairi' and 'Alphonso'. 'Neelum' is a commercial variety, indigenous to Tamil Nadu. It is widely distributed in the dry districts of Tamil Nadu and the Telengana area of Andhra Pradesh. Its flesh is fibreless, taste sweet and flavour delightful. 'Banganapalli', a commercial variety of Andhra Pradesh, thrives in dry districts. Its fruit is large; its flesh is fibreless; its taste is sweet and its juice is moderate in quantity.

'Suvarnarekha' is a commercial variety of the Visakhapatnam District in Andhra Pradesh. Its fruit is deep red; its flesh is soft and fibreless; its taste is sweet and its juice is abundant. This variety is of recent origin and is fast spreading in Andhra Pradesh and Orissa.

[3]Gangolly, S.R. *et al. The Mango,* ICAR, 1957.

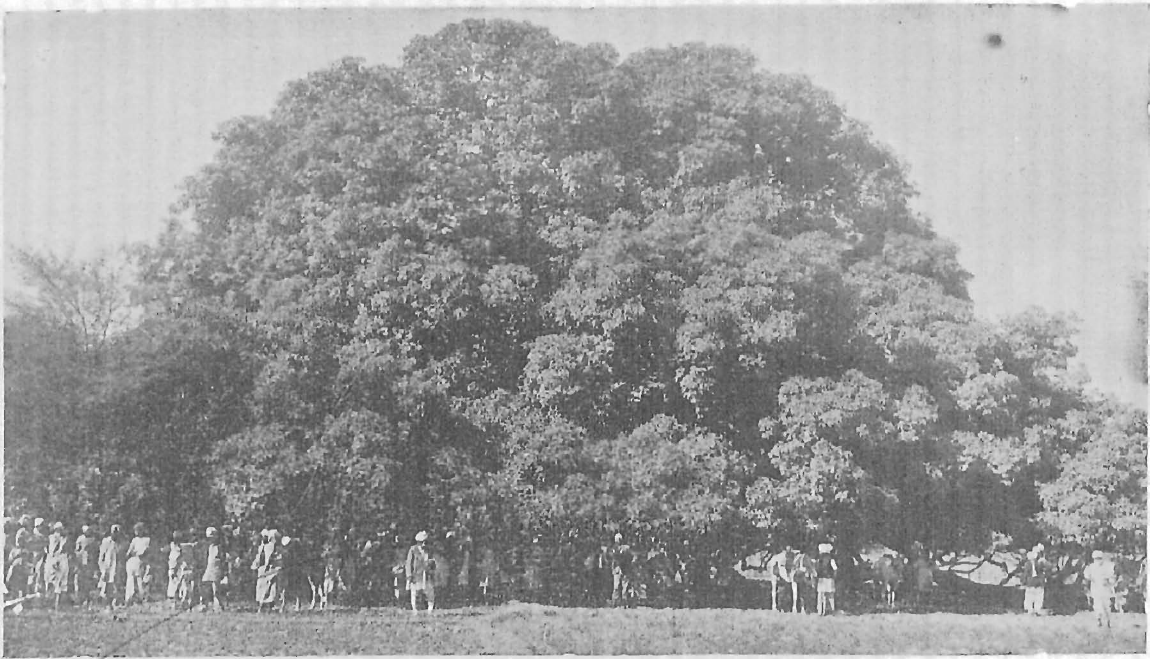


FIG. 159. The giant mango tree of the Village of Burail near Chandigarh—the largest mango tree in the world. It had a trunk 9.2 metres in girth and trailing branches having a girth of 1.52 to 3.66 metres. The crown spread over 2,258 square metres. Its average yield was 16.8 tonnes. This tree was struck by lightning in 1955 and destroyed.

FIG. 160. The main trunk of the giant mango tree at the Village of Burail, near Chandigarh. Apart from heavy yield, it gave shelter to the villagers for threshing wheat.

FIG. 161. The hybridization of mangoes has been taken up at the Indian Agricultural Research Institute, New Delhi, by Dr R.N. Singh and colleagues, 'Amrapali', a hybrid of 'Dussehri' of Uttar Pradesh and 'Neelum' of South India. It is a dwarf variety, has a regular bearing and is a good cropper.

'Mulgoa' has a large round yellow fruit. Its flesh is fibreless; its flavour is delightful and its taste is sweet. It is popular in Maharashtra, Karnataka and Tamil Nadu. The fruit of 'Pairi' is orange red and very sweet and its flesh is fibreless. It is popular in Maharashtra. 'Alphonso' is the leading variety of this State. Its fruits are yellow and very sweet.

Hybrids

In recent years, efforts have been made to evolve hybrids of mango through a series of planned crosses. The selection of parents for these hybridization programmes has been made, taking into consideration not only the obvious requirements of quality and yield, but also some of the other desirable characters, such as regular bearing, so that the trees produce fruits every year. Fortunately, the range of variability available in the mango crop in India is very great and crosses of this kind can be planned. The mango varieties found in northern and southern India are quite distinct, and it has always been considered desirable to widen the genetic base of the mango crop through a crossing programme, involving these two groups of varieties.

Improvements have been brought about in techniques to increase the efficiency of mango hybridization. Emphasis is now laid on utilizing a larger number of panicles and pollinating whatever few flowers open on a panicle in a single day, i.e. up to 15 flowers. The conventional muslin bags have been replaced by light, small polythene bags finely perforated before use. With this technique, the efficiency of mango hybridization has been considerably improved. Since 1961, about 82,000 crosses have been made and they have yielded 1,252 hybrids. This is indeed a large population.

Promising hybrids have been produced at different centres which are suited to the local agro-climatic conditions. The Fruit Research Station, Kodur, has released several well-known 'Kodur Hybrids'. At the Indian Institute of Horticultural Research, Karnataka, a number of new mango hybrids are under intensive testing for dwarfness, good eating quality and regular bearing. One of the hybrids isolated has the parentage of 'Banganapalli' and 'Alphonso'. The hybrid is sweeter than 'Banganapalli', but retains its flavour. The consistency of the pulp is that of 'Alphonso'. This hybrid is being multiplied for large-scale tests.[4]

'Amrapali', a Dwarf Hybrid Mango for High-density Orcharding

Dedicated work by a small group of scientists, headed by Dr R. N. Singh, and comprising Dr P.K. Majumder and Dr D.K. Sharma, has led to a major breakthrough in mango cultivation through the development of

[4]Randhawa, G.S. Major achievements through research in horticulture, *ICAR Golden Jubilee Symposium*, September 1979

improved varieties of mango by planned hybridization. The variety 'Amrapali', which has been evolved by these three scientists, by crossing the famous north Indian variety 'Dussehri' with 'Neelum' of the south, was selected from the hybrids raised in 1965 and was released 14 years later, after thoroughly testing its performance. This variety is precocious, distinctly dwarf, highly regular and a good cropper. Besides, it has a commercially acceptable fruit quality. The fruits, on maturity, are greenish apricot yellow and the flesh is firm and fibreless, with an attractive deep yellow colour, medium size and maturing almost a month later than the 'Dusseheri', thereby extending the period of the availability of better fruits late in the season. Besides, 'Amrapali' is very sweet and has more pulp, and two to three times more β-carotene than its parents.[5] 'Amrapali' gives an annual yield of 16 tonnes per hectare of highly delicious fruit with fibre-free pulp and thin stones. The average annual yield of traditional varieties of mango in India is a mere 8.7 tonnes per hectare.

'Amrapali' has certain other highly valuable characteristics. It begins bearing fruits in the third year of its life (Fig. 161). It bears fruits every year. As the variety is a dwarf, pest control operations and disease management are easy.

Since 'Amrapali' occupies so little space, as many as 1,000 trees can be planted per hectare. Again, since its foliage is too thin to prevent sunlight from reaching the ground, vegetables and certain short-duration leguminous crops may be intercropped with it.

The traditional varieties of mango in India start bearing in the fifteenth or sixteenth year, and except three varieties the majority bear fruit in alternate years.

Pruning of Mango Trees

The pruning of mango trees is a recent development, as evergreen trees are not pruned. At the Indian Institute of Horticultural Research, Hessaraghatta, pruning as a method for dwarfing the mango trees has been demonstrated in the case of varieties such as 'Banganapalli'. Pruning has also been demonstrated to induce heavy bearing in old trees at the Tamil Nadu Agricultural University, Coimbatore. May unproductive trees of 'Mulgoa' variety were induced to bear heavy crops by pruning.

Preservation of Germplasm of Sucking Mangoes

Though some sucking varieties of mangoes are unrivalled in taste and digestibility, no attention had been given to preserve this source of germplasm. The Hoshiarpur District of Punjab has a large number of gardens of sucking mangoes and some of them are of excellent quality. I started

[5] Improvement of mango, *Res. Bull. 26, IARI*, 1980

in 1972 a research station at the Village of Gangian, three kilometres from Dasuya, on the Dasuya-Hoshiarpur road. Outstanding trees were evaluated and those possessing ideal sucking qualities, such as oblong shape, unruptable skin, thin and abundant juice, scanty fibre, small stone and red blush on the skin, wherever possible, were finally selected. These varieties ripen in the middle of July. Out of more than 200 trees, the following seven were considered ideal.

1. *'GN 1' ('Gangian 1')*. This tree growing in the Village of Daffar, near the Fruit Research Station, Gangian, is large, spreading dome-shaped, and is a regular bearer of a medium crop. Its fruit, of medium size, is ovate. The skin is smooth and remains green on ripening, and the stone is small. The pulp is orange; its juice is thin and abundant, with about 19 per cent sugar.

2. *'GN 2'*. This tree was given in dowry by a Muslim of Samrala in the Ludhiana District to his daughter who was married to a resident of the Village of Jahan Khelan, near Hoshiarpur. The tree is of spreading habit, dome-shaped, and is a heavy bearer, but suffers from the defect of being an alternate bearer. Its fruit is medium to large, ovate-oblong, with thick skin not adhering to the flesh. The pulp of the fruit is yellow with about 25 per cent sugar.

3. *'GN 3'*. This tree, with its high-quality fruits, still exists in the Village of Piplanwala, near Hoshiarpur. The tree is large, dome-shaped, spreading in habit, bears regularly and is a heavy cropper in alternate years. Its fruit is ovate and is medium in size. Its skin is thick, smooth and spinach-green. Its pulp is yellow and its juice is abundant, with a sugar content of about 22 per cent.

4. *'GN 4'*. This tree is located in the Village of Bajrauver, near Chabbewal, on the Hoshiarpur-Chandigarh road. The tree is huge, with drooping limbs, and bears regular crops. Its fruit is extra-large and ovate-oblong. The skin is yellowish green, with sparse glands. The juice of the fruit is abundant, somewhat thick, with about 21 per cent sugar.

5. *'GN 5'*. This tree is located in front of the Military Rest House at Haryana on the Dasuya-Hoshiarpur road. It is famous for its high-quality, late-ripening fruits, which bring handsome income to the owner. The fruit is ovate and medium in size. Its skin is thick and smooth and its juice is slightly thick and abundant, with about 22 per cent sugar content.

6. *'GN 6'*. This tree is located in the Village of Tharoli, near Jahan Khelan, in the Hoshiarpur District. The tree is small, spreading, dome-shaped and bears alternately. Its fruit is large, oblong, highly coloured and beautiful. The skin is yellow, with a red blush at the basal end. The pulp of the fruit is yellow and the juice is abundant, with a pleasant flavour. The sugar content is about 17 per cent.

7. *'GN 7'*. This tree is growing in an orchard belonging to Sardar

Harbans Singh, at Chhauni Kalan, near Hoshiarpur, and is known as '*Chhalli*'. The tree is medium in size, dome-shaped, bears medium crops, more or less regularly. Its fruit is medium in size and oblong. The pulp is orange, with plentiful tasty juice.

All these varieties are now being multiplied by using the grafting method, so that they remain true to type.

CHAPTER 39

NEW VARIETIES OF VEGETABLES

LUSCIOUS MUSK-MELONS AND HIGH-YIELDING TOMATOES

INDIA is a predominantly vegetarian country, and vegetables have an important place in the diet of Indians. In the Colonial period, a number of vegetables were introduced into India from Europe and the New World. Since Independence, excellent work has been done in the selection and breeding of vegetables, and by primary introductions of vegetable varieties from foreign countries by the Indian Agricultural Research Institute, New Delhi, and the agricultural universities.

Dr Harbhajan Singh (b. 1916, d. 1974) was outstanding among the vegetable breeders. He had a rural background and came of a Sikh Jat family of the Village of Marauli Kalan in the Rupar District of Punjab and was born at Pusa (Bihar) on 6 February 1916, where his father was employed. He had his early education in his village and at the Khalsa High School, Kharar. He passed his B.Sc. from the Khalsa College, Amritsar, in 1936 and obtained his Master's degree in 1938 from the Agra University. He obtained the associateship of the Indian Agricultural Research Institute in 1940. The same year, he joined the Botany Division of the Indian Agricultural Research Institute as Research Assistant. By dint of his devoted scientific work, he won promotions as Assistant Botanist (1947), Vegetable Specialist (1955) and Plant Introduction Officer (1957), and was appointed the Head of the Division of Plant Introduction in the year 1962.

VIRUS-RESISTANT OKRA, 'PUSA SAWANI'

Okra or *bhindi (Abelmoschus esculentus)* is a favourite vegetable in Indian homes. In 1958, it was wiped out because of virus diseases. On a visit to the *bhindi* fields, all that one could notice were yellow leaves and a few *bhindi* pods. To meet this challenge, Harbhajan Singh decided to breed a variety of *bhindi* resistant to the virus.

The variety 'Pusa Sawani' bred by him was a phenomenal success throughout (Fig. 163). It was the first successful attempt at breeding a high-yielding okra variety free from the symptoms of the yellow-vein mosaic.

Harbhajan Singh collected and established a new wild species (*Abelmoschus tuberculatus* Pal *et* Singh), related to the cultivated okra. Later, his colleagues at the Institute established that this wild species had a new chromosome number (n=29), not hitherto reported in the taxon and which also appeared to contribute to one of the two genomes (29 and 36 chromosome genomes) of the alloploid cultivated okra (n=65).

A few years before his death, Harbhajan Singh discovered immunity to the yellow-vein mosaic virus in a cultigen obtained by him from Ghana. The material was received as okra, but as he used it in crosses with the local cultivars it became apparent that the introduced accession might belong to some other taxon under *Abelmoschus*. He was on the verge of selecting desirable recombinations when he was stricken by an incurable and painful disease.

Harbhajan Singh made a rich contribution to olericulture by selecting and breeding varieties of tomato, brinjal (egg-plant), cluster-bean (*guar*), cowpea, pea, French-bean, cucumber, luffa, bottle-gourd, water-melon, musk-melon, sweet-potato, onion, carrot, turnip, radish, cabbage, capsicum and cauliflower. Some of the varieties selected and bred by him are shown in Fig. 166.

Harbhajan Singh was the first in India to develop techniques for the commercial production of the winter-type 'Snowball' variety of cauliflower in the Himalayan ranges. These techniques converted the country from an importer into one self-sufficient in the seed of this variety. By crossing the European-type carrot of biennial habit with the local annual varieties, he developed strains capable of producing seeds in the warmer plains of northern India.

He developed a number of varieties of cabbages and cauliflower and also the techniques for producing the seeds of these crops. Varieties developed by him found recognition not only in India but also in some of the South-East Asian countries. The producers of the seeds of vegetables from many parts of India often sought his advice. In his village Marauli Kalan, he trained the farmers in raising the seed of 'Pusa Sawani'.

Harbhajan Singh also selected varieties of oat suitable for breakfast food industry and for green forage. He was one of the earliest plant breeders to realize the importance of the soybean crop in this country. The Indian Council of Agricultural Research nominated him as the Project Co-ordinator for the Soybean-Improvement Project. The cultivation of the small-flowered (Pompon) varieties of chrysanthemum is now possible in northern India because he selected varieties adapted to this region. His contributions to horticultural crops include the isolation of low-chilling varieties of temperate fruits, such as apple and peach.

Plant Exploration

Known internationally for his contributions to vegetable breeding, Harbhajan Singh was the prime mover of research programmes for the conservation of germplasm resources and their utilization in crop improvement. He was among the first to realize the immense possibilities of crop improvement in India through systematic plant introduction, exploration, maintenance and evaluation of large exotic and indigenous germplasm

FIG. 162. Dr Harbhajan Singh (b. 1916, d. 1974) was Head of the Division of Plant Introduction at the IARI. He is remembered for his work on vegetables. He also made a systematic collection of diverse germplasms from exotic and indigenous resources of a wide variety of plants of economic value. The varieties of vegetables bred and introduced by him are cultivated by millions of farmers in India. (Portrait by G.S. Bansal, Hall of Fame, MSR Library, Punjab Agricultural University, Ludhiana)

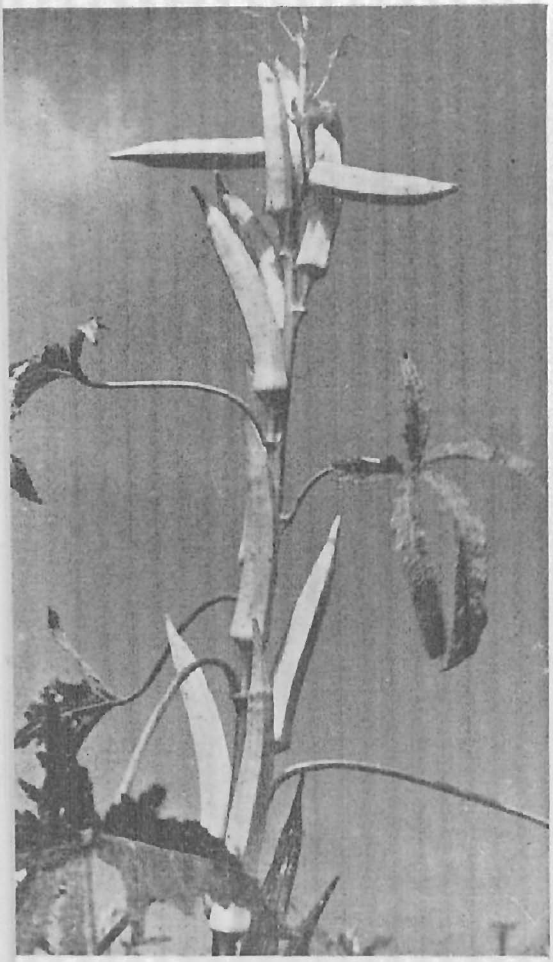


FIG. 163. Okra, or *bhindi* (*Abelmoschus esculentus*) is a favourite vegetable in India. On account of infection with the yellow-vein-mosaic virus, it almost disappeared from the market. Harbhajan Singh evolved the variety 'Pusa Sawani' shown above, which is resistant to the yellow-vein mosaic, with the result that the cultivation of this vegetable has revived.

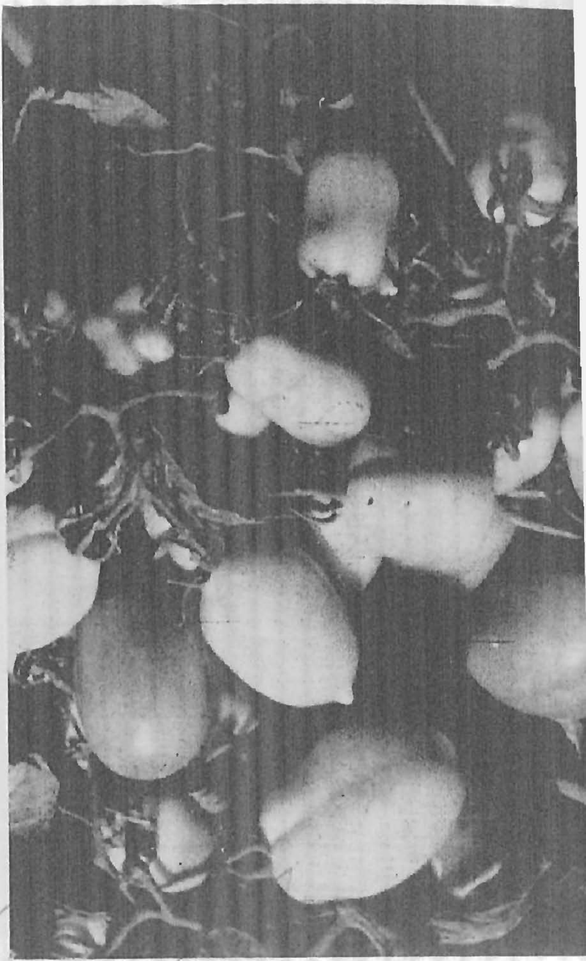


FIG. 164. The 'Punjab Chhuhara' variety of tomato, evolved by Dr K.S. Nandpuri, at the Punjab Agricultural University, Ludhiana. It gives a yield of about 800 quintals per hectare, and stands well long-distance transportation in trucks. This variety has revolutionized tomato cultivation in Punjab.

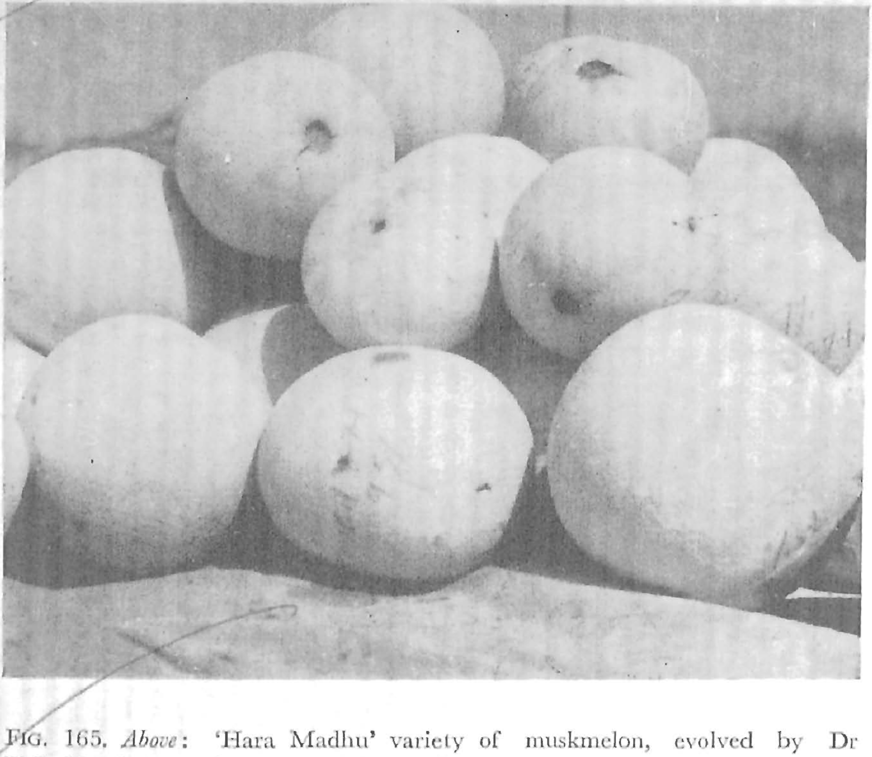


FIG. 165. *Above*: 'Hara Madhu' variety of muskmelon, evolved by Dr K.S. Nandpuri, of the Punjab Agricultural University, in 1967. It is juicy, with excellent flavour, and is very sweet. *Below*: 'Punjab Sunehri' released by the PAU, Ludhiana, in 1974 is a high-yielder. Its fruits are sweet and juicy. They are resistant to field rot and are excellent for long-distance transportation.

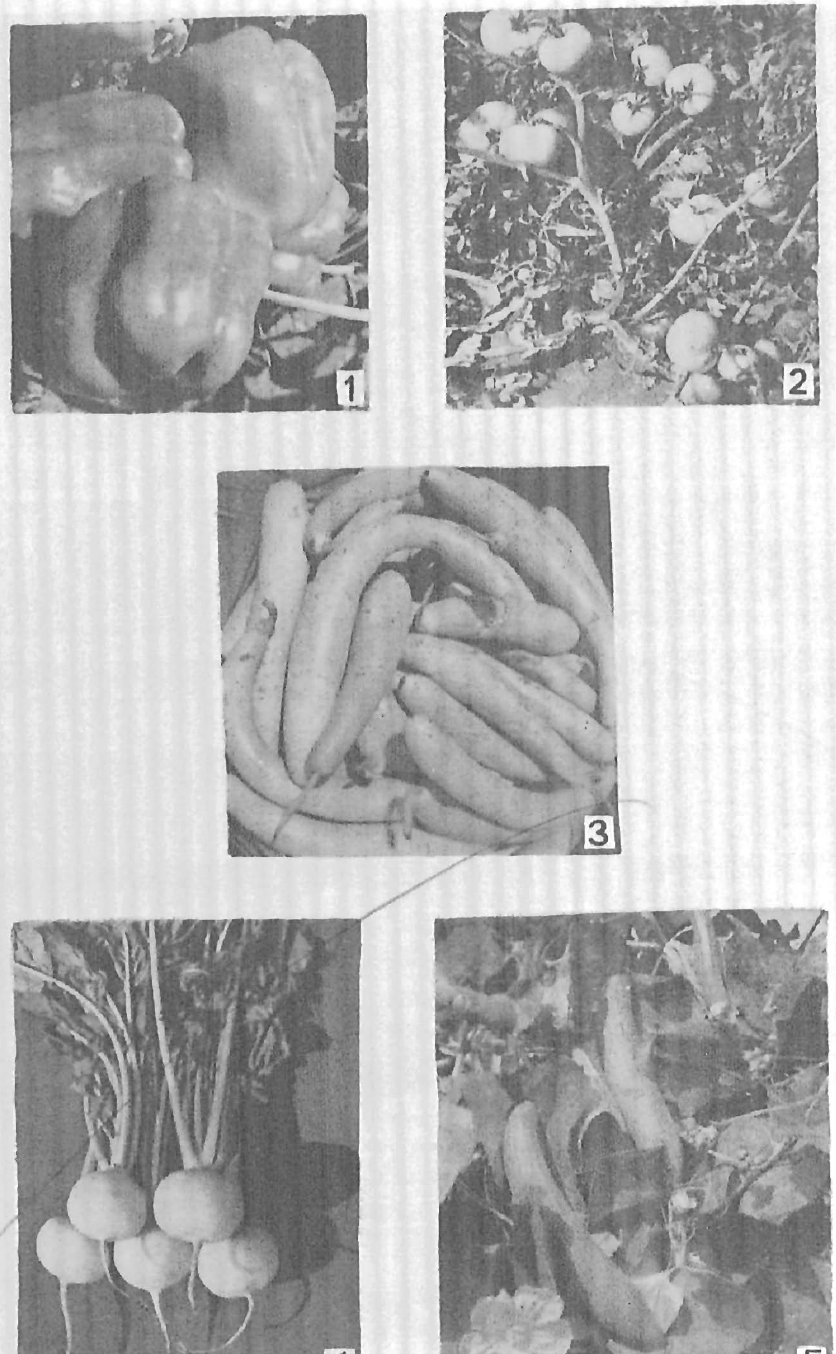


FIG. 166. Some outstanding varieties of vegetables developed by Dr Harbhajan Singh at the Indian Agricultural Research Institute, New Delhi. 1. 'Simla Mirch', *Capsicum annuum*; 2. Tomato 'Pusa Ruby', an early variety, fruit red, good for juice and ketchup; 3. Bottle-gourd (*Lagenaria siceraria*) 'Pusa Meghdoot', early and high-yielding; 4. Turnip 'Pusa Sweti' roots pure white and round; and 5. Right or sponge gourd (*Luffa acutangula*) 'Pusa Chikni' (*ghia tori*), early, prolific bearer, fruit smooth and green.

collections of a wide array of agricultural crops at the Indian Agricultural Research Institute. An ardent plant-explorer, he travelled extensively, hunting for plants in India, Sikkim and Nepal. He also visited Australia and the USA in connection with this work. He carried out systematic explorations for almost 25 years for the collection and conservation of primitive types of crop plants occurring in the tribal areas and elsewhere in India. Plant breeders the world over, and those in India in particular, benefited from this activity. He was quick in spotting good traits of plants, such as resistance to frost, diseases and pests in the collected material and in natural stands. He made special surveys of weeds occurring in crops during different seasons in various parts of India.

In 1971, the President of India conferred on him the Padma Shri award for his meritorious contributions. In the same year, the Punjab Agricultural University bestowed on him the degree of Doctor of Science (*Honoris Causa*). His portrait adorns the Hall of Fame in the Library Building of this University.

Harbhajan Singh was an unusual blend of scientific and human excellence. Reticent and self-effacing, he believed in getting the best out of his colleagues by example rather than by asserting authority. While on his death-bed, he expressed great regret that he could not have a span of life long enough to fulfil all his research and publication commitments. He worked, advised and guided his colleagues almost to the day of his end. He believed and worked with the firm conviction that example was better than precept.

The varieties of vegetables bred and introduced by Harbhajan Singh are cultivated by millions of farmers in India. They are giving happiness and satisfaction to countless consumers. His example shows how the work of one modest man can influence the lives of millions, who will hardly ever know the name of their benefactor.

New Varieties of Musk-melon and Tomato

After Dr Harbhajan Singh, the most distinguished vegetable breeder in India is Dr Karam Singh Nandpuri, of the Punjab Agricultural University, Ludhiana. He comes of a farming family of Sikh Jats of the Village Nandpur in the Amritsar District. He got his B.Sc. degree from the Punjab Agricultural College and Research Institute, Lyallpur (now in Pakistan, and renamed Faisalabad), and his Ph.D. degree from Oregon State University, USA. In 1964 he took over as Vegetable Botanist at the Punjab Agricultural University, Ludhiana. From 1967 to 1977, the Department of Vegetable Crops was greatly expanded. For every crop there were an adequate number of researchers, and intensive work was started on important vegetable crops. Out of these, the most rewarding work has been done on musk-melon and tomato.

'Hara Madhu', a Luscious Musk-melon

Musk-melon is considered to have its secondary centre of origin in India. There is an immense variability in this crop in India, but very limited work had been done on the varietal improvement of this crop. The Vegetable Botanist of the State Department of Agriculture, Punjab, Dr S.S. Purewal, collected the germplasm from different sources within the country in 1960. This material was passed on to the Department of Horticulture of the Punjab Agricultural University in 1962. The variety 'Hara Madhu' developed by Nandpuri, as a result of inbreeding and selection within a type obtained from Uttar Pradesh, was released in 1967 for cultivation in Punjab, Haryana and Himachal Pradesh. The vines of this variety are long and vigorous, with sparsely lobed and light-green, long-petioled leaves. The fruits are round, with a tapering stalk-end and ten prominent green sutures (Fig. 165, top). The rind of its fruit is thin, smooth and pale yellow at maturity, and its flesh is green, juicy, and very sweet, almost melting in the mouth. The sugar content of the fruit is about 13 per cent compared with 7-8 per cent of the fruits of most of the varieties available in the market. When the choice was between 'Hara Madhu' and grapes, since they ripen at the same time, I always preferred 'Hara Madhu'. Its average yield is 125 q/ha. By virtue of its excellent flavour, sweetness and texture, it is no doubt one of the best varieties of musk-melon in the world.

'Punjab Sunehri' Musk-melon

To get over the shortcomings of 'Hara Madhu', i.e. the short post-harvest life and the poor transportability, hybridization between 'Hara Madhu' and some exotic varieties was undertaken by Nandpuri in 1969. Consequently, 'Punjab Sunehri', selected from a cross between 'Hara Madhu' and 'Edisto' of the USA, was released in 1974. This variety has medium-long vines, with lobed, dark-green, short petioled leaves, and round to elliptical fruits, without distinct sutures (Fig. 165, below). The rind of the fruit is thick-netted and light yellow: its flesh is thick, orange, fairly juicy and sweet. It matures about 10 days earlier than 'Hara Madhu'. Its average yield is about 160 q/ha. This variety has become very popular with the growers because of its earliness, resistance to rotting in the field and because of its ability to stand long-distance transportation. It is estimated that about 50 per cent of the area under musk-melon in Punjab is covered by these two varieties.

Tomato

Some work on the varietal aspects of tomato had been started by the Department of Agriculture, Punjab, before the establishment of the Punjab Agricultural University. However, it was primarily confined to the assessment of the commercial cultivars introduced from the USA. Based on their relative performance, varieties such as 'Sioux', 'Best of All' and 'Marglobe' were recommended for cultivation. All these varieties required a long growing season, and under the climate prevailing in Punjab, they did not express their full yield potential. Systematic work on the improvement of tomato was started in 1962 by Nandpuri. 'S 12' was the first variety to be released by the Punjab Agricultural University in 1967 as the result of mutation-breeding. The plants of this variety are dwarf, bushy and vigorous. Its fruits are medium-sized, compressed-round, uniformly coloured when immature, and red at maturity, multilocular, juicy, highly acidic and resistant to radial fruit-cracking. Its average yield is 450 to 575 quintals per hectare. On account of its high yield potential and wide adaptability the variety was recommended for cultivation throughout the country.

In 1971, three varieties differing in their maturity period were released to extend the span of harvesting from the middle of April to the first fortnight of June. They were 'Keck-Ruth Ageti' and 'Keck-Ruth', selected from the segregating material obtained from Bulgaria. The third one, 'Punjab Tropic', was selected from the material obtained from the USA. 'Keck-Ruth Ageti' and 'Keck-Ruth' were withdrawn from cultivation in 1978 after the release of other varieties superior to them.

'Punjab Tropic' has tall and vigorous plants, with abundant and compact foliage protecting its fruits against sun-burn. Its fruits are attractive, large, round and green, when unripe, and red at maturity, multilocular, with small cavities and with less numerous seeds. It is excellent for table purposes and for juice-making. It is late-maturing. Its average yield is about 610 quintals per hectare.

'Punjab Chhuhara' : a High-yielding Tomato Variety

Consequent upon the cultivation of high-yielding varieties, there was a phenomenal increase in the production of tomatoes in Punjab, and it exceeded the requirements of the local markets. During the main harvesting season, prices fell below the cost of production, thus causing financial loss to the growers. Such a situation necessitated the development of varieties which could stand the stress of long-distance transportation. Thus a glut in the local markets could be checked. Keeping these requirements in view, the variety 'Punjab Chhuhara' was developed by Nandpuri from a cross between 'Punjab Tropic' and 'EC 55055'. It was released for general cultivation in 1975. It possesses a higher yield potential than the earlier-released varieties and is suitable for long-distance transportation. The plants of this variety are dwarf and bushy; its fruits are medium-sized, pear-shaped, firm, fleshy, less seedy, thick-walled and are moderately resistant to plant viruses. The variety is early in maturity and gives an average yield of 750-800 quintals per hectare. It is surprising to see how a small plant of 'Punjab Chhuhara' can support such a heavy fruiting (Fig. 164).

The variety has been recommended for cultivation throughout the country. It has replaced other varieties in Punjab and is also gaining popularity in other States. There is an unlimited demand for the seed of this variety. The National Seed Corporation supplied its seed to some international seed companies for testing outside the country and favourable reports regarding its performance were obtained from Australia and some other countries. This variety has revolutionized tomato production in the country. During May and June, tomatoes are grown nowhere in the country except in Punjab, Haryana and Rajasthan. By taking up the cultivation of this variety, the growers of these States send truck-loads of tomatoes to Delhi, Bombay and other distant markets during this period and earn handsome income.

In recognition of his outstanding research contributions to the field of vegetable breeding, Nandpuri was awarded a plaque by the Punjab Agricultural University in 1969. A gold medal and scroll of honour was awarded to him by the farmers of Punjab in 1972 in appreciation of his research contribution to olericulture. He was awarded the Dr P.B. Sarkar Endowment Prize for the triennium 1971-74 by the ICAR. In 1981, The Rafi Ahmed Kidwai Memorial Prize for Agricultural Research for the biennium 1978-79 was awarded to him by the ICAR for his outstanding contribution to the field of vegetable-growing.

WORK ON VEGETABLES IN OTHER INSTITUTIONS

Dr B. Chaudhary, the Head of the Division of Vegetable Crops and Floriculture, at the IARI, has done good work on the micronutrient problems of vegetables and on the use of plant hormones for increasing vegetable production. He was also associated with the development of 'Arkel' pea and 'S 120' tomato. Dr Vishnu Swarup contributed greatly to the development of cauliflower varieties. As Project Co-ordinator (Vegetables), he was responsible for organizing research on vegetables in the country. For the hilly areas, particularly Himachal Pradesh, Dr S.S. Saini, of the Horticultural Complex, Himachal Pradesh Agricultural University, Solan, developed a number of vegetable varieties. He also developed technology for producing the seed of chicory. Dr Kirti Singh, of the Haryana Agricultural University, has done good work on the nutritional requirements of vegetables as well as on other aspects of vegetable-growing. At the Horticultural Research Institute, Hessaraghatta, Bangalore (Karnataka), Dr Prem Nath, Vegetable Breeder, has done excellent work on the resistance of vegetables to insect pests and diseases and has developed a number of varieties of cucurbits. Dr Mathukrishan at Coimbatore, Dr Kamla Singh at Jabalpur and Dr H.N. Singh at Kanpur have also contributed significantly to the development of vegetable varieties and to the working out of the nutritional requirements of vegetables.

CHAPTER 40

PLANTATION CROPS

SELF-SUFFICIENCY IN ARECANUT HYBRID COCONUTS, METHODOLOGY FOR HIGHER PRODUCTION OF CASHEWNUT, INTRODUCTION OF CACAO, AND MULTI-STOREYED CROPPING

MAJOR achievements of research and extension in plantation crops are the achievement of self-sufficiency in the production of arecanuts, the development of hybrid coconuts, the development of a methodology involving plant protection, manuring and the planting of superior cultivars of cashew capable of doubling cashew production in five years, and the development of multiple-cropping systems, including intercropping, multi-storeyed or multi-level cropping and mixed farming in the case of plantation crops with a view to increasing productivity from a unit area of land and increasing the employment potential.

SELF-SUFFICIENCY IN ARECANUT

At the time of the partition in 1947, India lost 50 per cent of its area under arecanut to East Pakistan (now Bangladesh). In 1951-52, India was producing about 60,000 tonnes of arecanuts, which was 50 per cent of its annual requirements. The Indian Council of Agricultural Research then established the Indian Central Arecanut Committee to tackle the problems of arecanut cultivation and marketing. The Committee initiated a vigorous research and development effort in developing self-sufficiency in arecanut. For this purpose, the Central Arecanut Research Station, Vittal, and its Regional Stations at Peechi, Palode, Hirehalli, Mohitnagar and Kahikuchi were established. These centres initiated an active research programme. At first, an appropriate technology was developed for selecting seeds and raising seedlings and distributing them. In the first ten years ending 1961-62, the Indian Central Arecanut Committee distributed 1,700,000 seedlings. Subsequently, the research programme involved the development of suitable manuring and irrigational recommendations for arecanut for the various agro-climatic regions of the country. Appropriate recommendations were made for controlling the major pests and diseases affecting arecanut. Finally, towards the end of the 1960s, the Institute released 'Mangala', the first and only improved cultivar of arecanut. By adopting all these recommendations, and aided by a tariff protection provided by the Government of India, the country was able to attain self-sufficiency in arecanut in 1965 by producing 140,000 tonnes of it. The problem in the 1970s has been one of overproduction, and research efforts are now being directed towards developing alternative and better uses for arecanut.

Hybrid Coconuts

The development of hybrid maize and its commercial exploitation is reckoned as the finest achievement in plant breeding. The scientists of the Coconut Research Station, Kasaragod, were among the first to study the suitability of this method in improving coconut. They produced the first hybrids between the tall and dwarf palms in 1932, and they found that the hybrids yielded 2-3 times more nuts than each of the parents (Fig. 168). This observation has since been confirmed by coconut breeders all over the world. Today, most of the coconut-growing countries of the world have taken up the production and popularization of hybrid seedlings as one of the major measures for increasing the productivity of coconut plantations.

A recent survey of Kerala has shown that hybrids between tall and dwarf palms perform better only with good management. This experience is similar to that obtained from the use of high-yielding varieties of cereals. Further, it has been observed that the hybrids involving dwarfs as female parents are superior to those having talls as female parents.

Towards Higher Cashewnut Production

Cashew earns about 1000 million rupees annually in foreign exchange. Until the mid-1960s, India held a virtual monopoly in the international trade in cashew. For this purpose, India was importing 70,000-180,000 tonnes of raw nuts annually from East Africa to supplement the domestic production of about 150,000 tonnes of raw nuts. With the development of mechanical processing facilities in East Africa, the availability of raw nuts became increasingly difficult. At present, India is able to import only 20,000-40,000 tonnes of raw nuts and its share of the international trade in processed nuts has come down to about two-thirds.

The processing of cashew in India is highly labour-intensive, involving about 200,000 workers. The shrinkage in the imports of raw cashewnuts has resulted in considerable unemployment. It has been estimated that India needs over 500,000 tonnes of raw nuts annually, if it has to maintain a reasonable level of employment and retain the present share of the international market of processed nuts. For this purpose, it has to more than double its production from its present annual turnover of 180,000 tonnes of raw nuts.

The work carried out at the Central Plantation Crops Research Institute and under the All-India Co-ordinated Cashew and Spices Improvement Project has made it possible to develop suitable agro-techniques for doubling the production of cashew in five years. These techniques include the control of the tea mosquito, which is by far the most serious pest of cashew in India, and the adoption of suitable manurial practices. By adopting the recommendations made by this Institute for controlling the tea mosquito, it is possible to increase production by over 30 per cent.

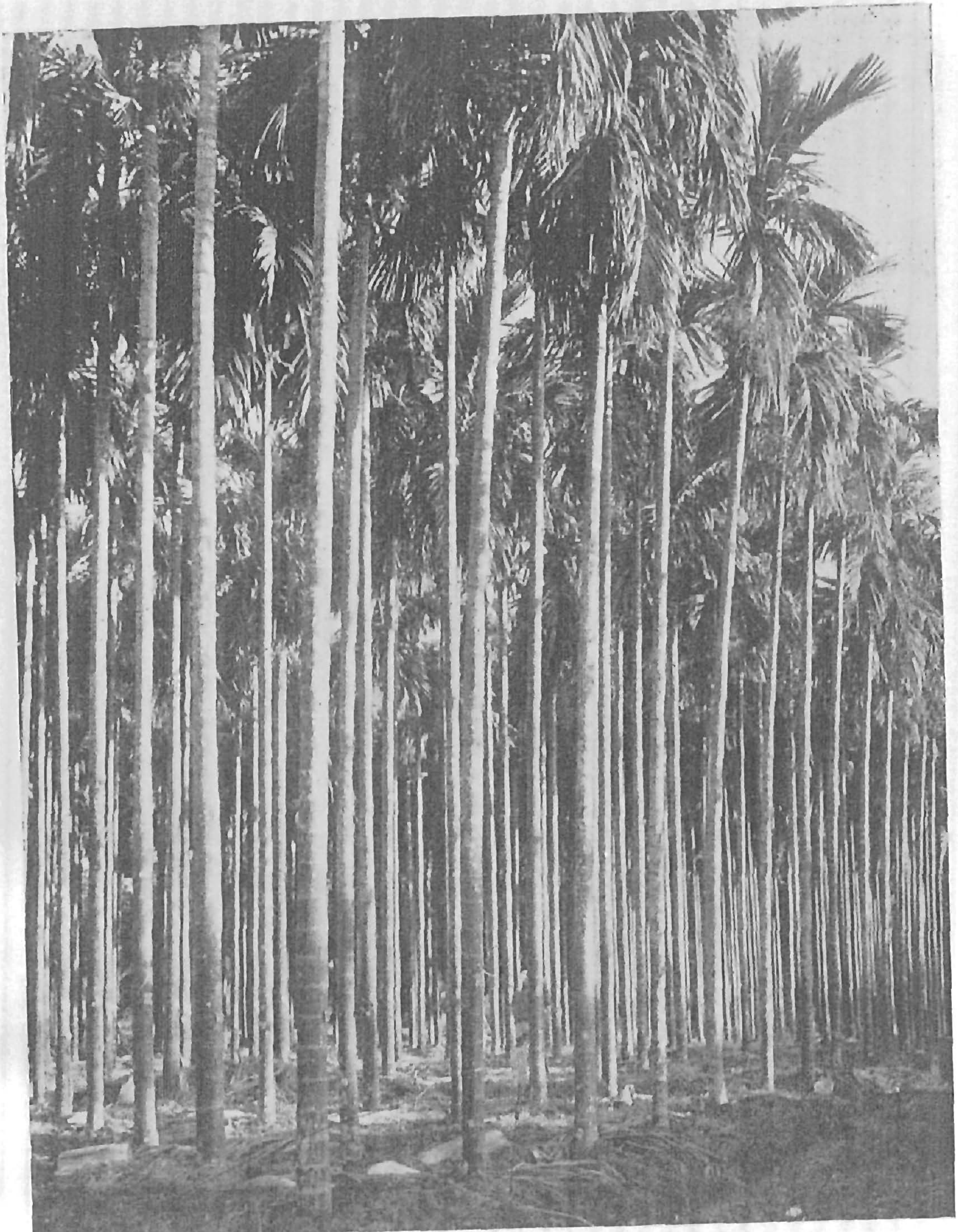


FIG. 167. An arecanut grove. Arecanut palms are grown in Kerala, Karnataka, Tamil Nadu, Assam and West Bengal. India became self-sufficient in arecanut in 1965.

FIG. 168. A hybrid coconut—result of cross between a tall female and a dwarf male palm. Such hybrids yield 2-3 times more nuts than either of the parents.

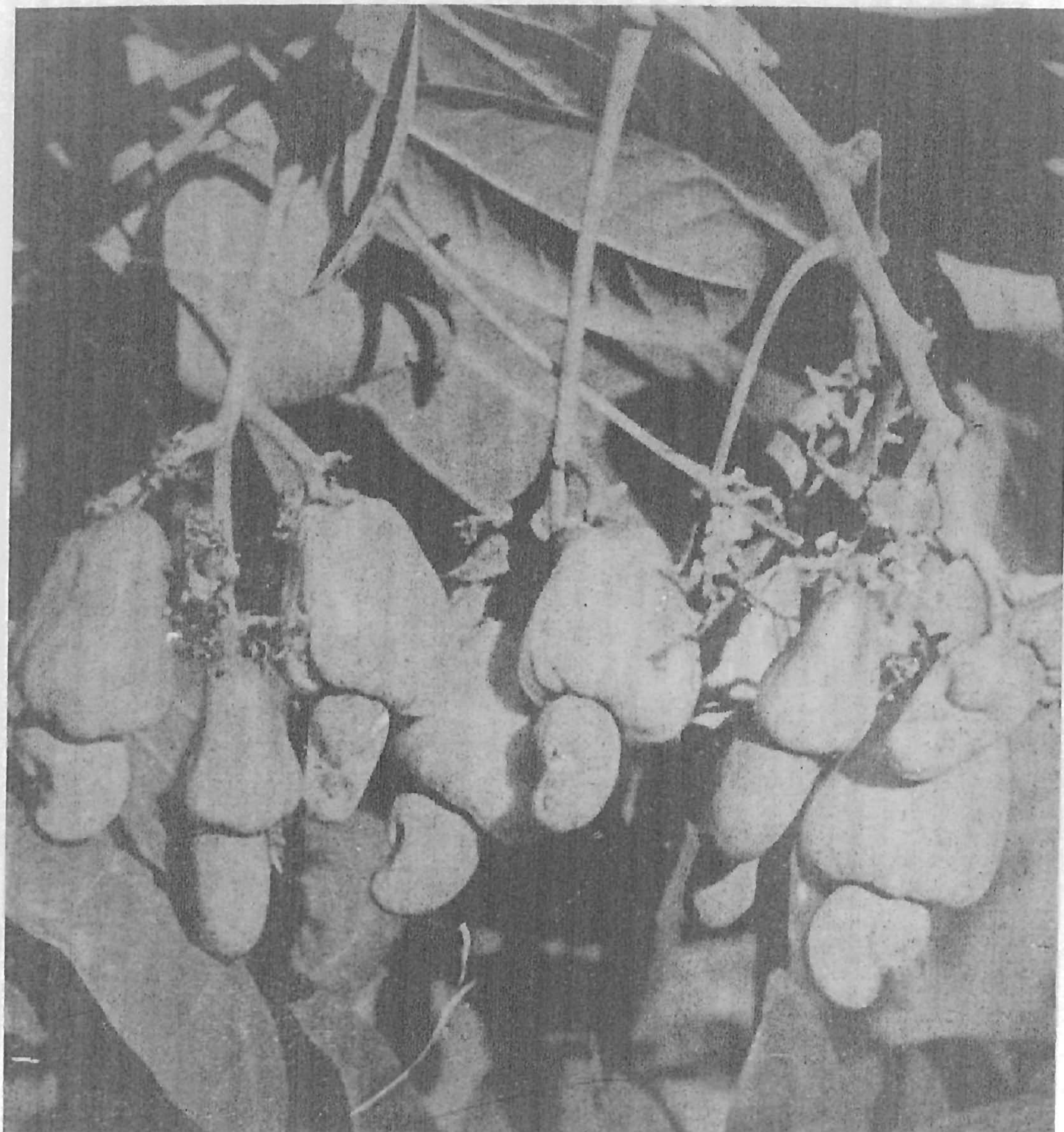


FIG. 169. India produces 1,80,000 tonnes of raw cashew-nuts. By manuring and control of pests, the yield can be raised 50-150 per cent.

FIG. 170. A cacao tree bearing pods. The pod contains seeds (beans) from which, after curing, cocoa powder and chocolate are manufactured. Cacoa is grown as an intercrop in coconut and arecanut gardens in Kerala, Karnataka and Tamil Nadu.

Further, minikit trials show that by manuring, the yield can be raised by 50-150 per cent. The Central Plantation Crops Research Institute has also released 16 hybrids for pre-release multiplication for cultivation in the various parts of the country.

Introduction of Cacao : the Chocolate Tree

Theobroma cacao (Sterculiaceae) is a small tropical American tree, 3.6-8.6 metres high with large oblong, pointed leaves. It bears a profusion of small pinkish or yellowish flowers in bunches on the stem and older branches. The fruit is a large warty pod, yellow or grey when ripe (Fig. 170). Each pod contains 25 to 36 large seeds, closely packed in a central column and coverd with white mucilage. On ripening, the pods are cut off and collected in heaps. Then they are broken open and the seeds (beans) are carried to the curing-house and placed in a stray wooden box to undergo fermentation for 36-48 hours. The seeds are turned over and washed with water once a day. Then they are spread out on mats in the day time to dry. When the curing is complete, the seeds are bagged. It is from these seeds that cocoa and chocolate are manufactured.

Apart from South America, cacao was cultivated in the West Indies, Gold Coast of Africa, Java and Sri Lanka. With an expanding middle-class, the demand for chocolate has risen. Until 1965, cacao was known in India only as an ornamental tree, or as a novelty planted in some gardens and seminaries. India has been importing more than 1,200 tonnes of cacao beans annually to meet its demand. By the early 1970s, cacao became the most successful and popular of intercrops in coconut and arecanut gardens. Today, almost 5,000 hectares of garden land has been mix-planted with cacao in Kerala, Karnataka and Tamil Nadu, and the annual production is estimated at about 600 tonnes cacao beans. It is estimated that India will be in a position to export cacao beans within the next five years. The development of cacao beans as a mixed crop has made it possible to increase the returns from a cacao-arecanut garden to Rs 28,000 per hectare against Rs 13,000 from a pure arecanut garden.

Multi-storeyed Cropping

Studies on the canopy size and the root distribution of coconut have shown that in a fully grown garden about 75 per cent of the root-system is concentrated in 25 per cent of the total area and also that only 25-60 per cent of the incident sunshine is availed of by coconut leaves, thus indicating the possibility of utilizing the vertical space more profitably. Accordingly, a number of crop combinations were tested at the Central Plantation Crops Research Institute. A multi-storeyed cropping system, involving pineapple as the ground floor, either cacao or cinnamon at the first floor, pepper trained on coconut as the second floor and the coconut itself as the third floor, has been recommended. Several variations in this system have also been proposed. In addition to increasing the income by 50 to 125 per cent, the multilevel cropping increases the employment potential of graden land two or three times, depending on the crops grown. Mixed cropping also helps to build up the organic matter of the soil.[1]

[1]Nayar, N. M. *Major achievements through agricultural research in India: Plantation Crops*, ICAR, 1979

CHAPTER 41

INTRODUCTION OF SOYBEAN, 'KINNOW' ORANGE, 'FLORDASUN' PEACH AND JAPANESE MINT

IMPROVEMENTS in agriculture in India have taken place by the introduction of new varieties of crops from foreign countries, and through the genetic improvement of crops which are already growing in the country. In the eighteenth and nineteenth centuries, numerous crop plants were introduced into India. However, the process has not come to an end. The introduction of high-yielding varieties of soybean, 'Kinnow' orange, and peaches from the USA, and the Japanese mint from Japan took place recently and hold out promise to enrich our agriculture.

SOYBEAN (*Glycine max* (L.) MERRILL)

Soybean was one of the five sacred grains of China, believed to have been given to the Chinese people by the semi-mythical Emperor Shen-nung, the Divine Husbandman, about the twenty-ninth century B.C. This crop, with about 40 per cent protein and 20 per cent oil, was the favourite crop of the East Asian countries where milk was not an important item in the menu of the people. For centuries, soybean has meant meat, milk, cheese, bread and oil to the people of China, Japan, Korea and Manchuria. In these countries, very often soybean has been mentioned as 'gold from the soil' or as 'cow of the field'.

Soybean is an annual herb, which belongs to the family Leguminosae and the subfamily Papilionoideae. The plant of the cultivated soybean is erect and leafy and may vary in height from 30 to 180 cm. Given sufficient space, it branches profusely. The plant characters differ slightly from variety to variety. Most of the soybean varieties have a dense, tawny or grey pubescence on the stems, pods and leaves. The flowers are borne in clusters of three to fifteen and are purple or white or rarely a combination of both. Soybean is primarily a self-pollinated crop. Because of small flowers, artificial pollination is tedious. The fruit is a lomentum, with two- to three-seeded pods. The number of grains per pod ranges from one to three, depending upon the variety and the conditions of growth. At the time of maturity, the plant sheds all its leaves, and the pods remain intact on the stalks. Some varieties shatter heavily, whereas others do not shatter at all. The colour of the seed-coat may be yellow-green, brown or black or a combination of these colours. Most of the varieties of industrial importance have creamy seeds.

Soybean in the USA

Soybean was sent from China to France as early as 1740 and was grown in the Botanic Garden of Paris. Benjamin Franklin, the scientist-statesman, who was the United States' Ambassador to France, sent some seeds of soybean to his country in 1779, and urged that they should be given a trial. However, the soybean remained merely a curiosity in the USA for more than a century.

In the early twenties of the current century, P.H. Dorsett, a plant-explorer, travelled widely in northern China and collected many varieties of soybean and sent them to the USA. The climatic conditions prevailing in south-eastern China are similar to those of east central and south-eastern USA. Besides, there are a large number of Chinese restaurants in the USA and they served as a ready market for the new crop. As such, soybean found a congenial home in the USA and also a market there. In 1924, about 1,782,000 acres (721,150 hectares) was planted with soybeans in the USA and the average yield was 11 bushels per acre (8.2 tonnes/ha). In 1942, the area increased to about 15 million (more than 6 million hectares) and the yield rose to 18.7 bushels per acre (13.84 tonnes/ha).[1] Production rose from 4 million bushels (1.21 million tonnes) in 1922 to 1.17 billion bushels (35.39 million tonnes) in 1971. Soybean furnishes approximately 27 billion pounds (1,224.7 million kilograms) of protein per annum in the USA, by comparison milk produces only 4.7 billion pounds (213.19 million kilograms) of milk protein. Soybean meets about 80 per cent of the demand for edible oil in the USA. It is used here as human food and as feed for hogs and poultry. It contains amino-acids of the kind usually found in meat, but not occurring abundantly in vegetables other than soybean. That is why soybean has provided a substitute for milk and milk products in the far eastern countries. A chain of soybean-based industries has come up in the USA and they extract oil and convert the defatted protein-rich meal into various food and feed products. The soybean oil is used for making oleomargarine. It is also used in the paint and varnish industry and in making linoleum, oilcloth and waterproof goods, including artificial leather as well as in making soap.

Soybean in India

Despite India being geographically near China, soybean has not become a significant food or forage crop in this country. In the hilly districts of the sub-Himalayan range, soybean was grown in scattered pockets. The farmers of southern Madhya Pradesh and of the adjoining areas of Maharashtra have also been growing soybean on a small scale. It has been known in India under different names, such as *Bhatmas, Bhat, Bhatman, Kalitur,*

[1]Swingle, W.T. 'Our Agricultural Debt to Asia' in *The Asian Legacy and American Life*, New York, 1945, p. 88

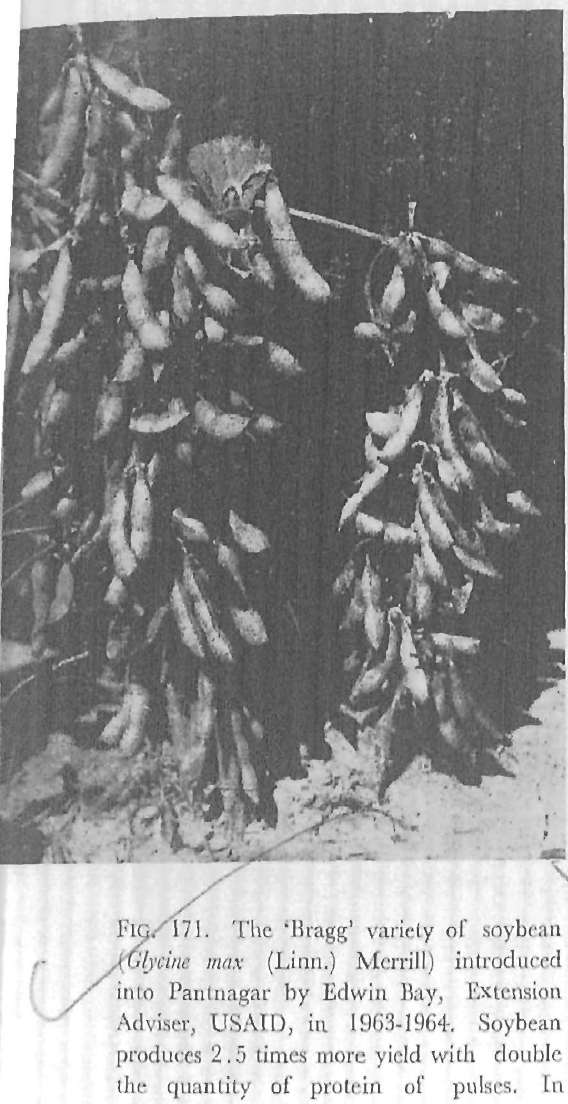


FIG. 171. The 'Bragg' variety of soybean (*Glycine max* (Linn.) Merrill) introduced into Pantnagar by Edwin Bay, Extension Adviser, USAID, in 1963-1964. Soybean produces 2.5 times more yield with double the quantity of protein of pulses. In 1980-81 it was grown over an area of 480,000 hectares in Madhya Pradesh with a yield of 375,000 tonnes.

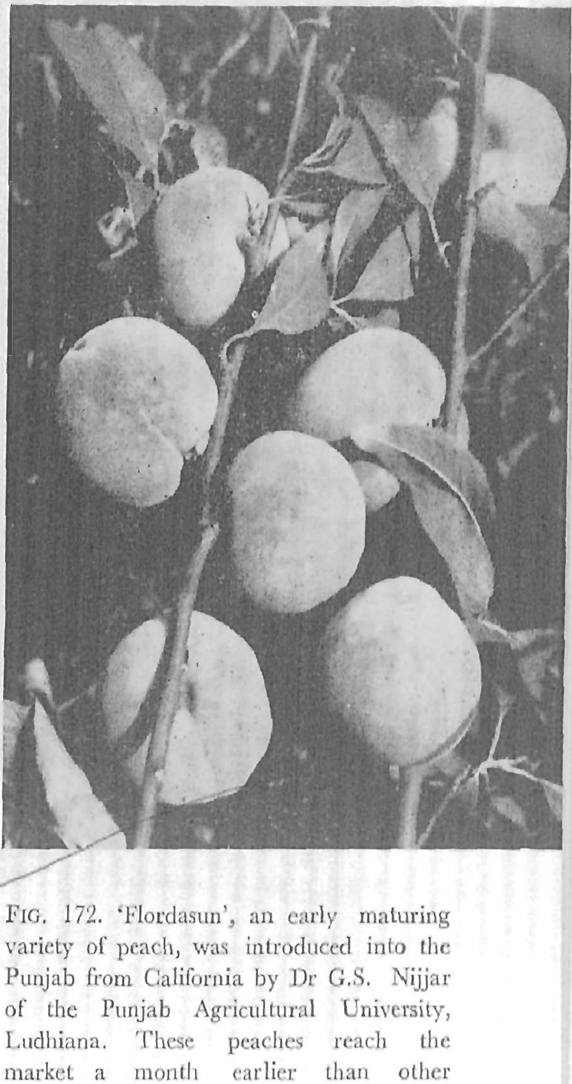


FIG. 172. 'Flordasun', an early maturing variety of peach, was introduced into the Punjab from California by Dr G.S. Nijjar of the Punjab Agricultural University, Ludhiana. These peaches reach the market a month earlier than other varieties.

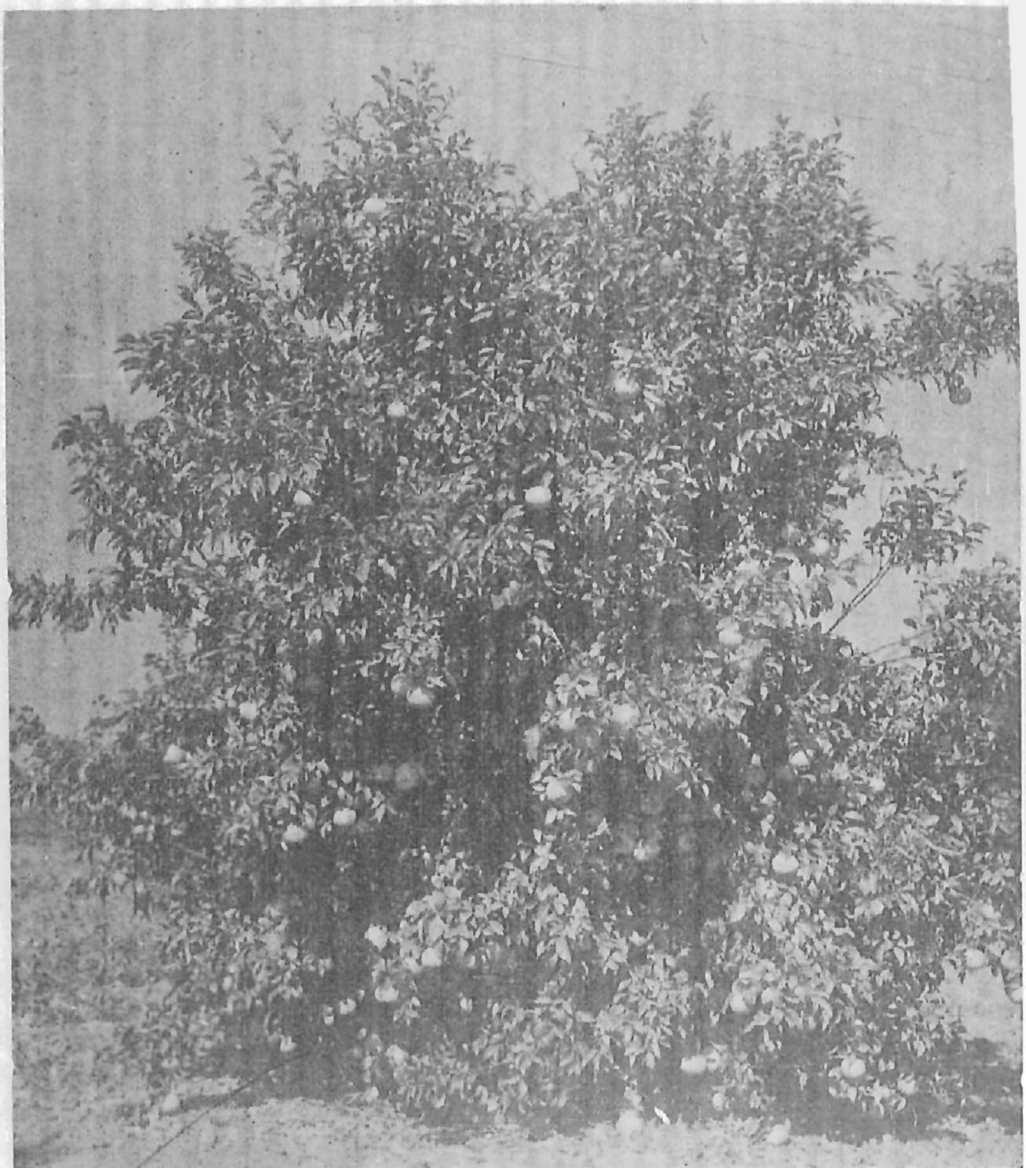


FIG. 173. A full-grown 'Kinnow' mandarin orange tree bearing fruit in a private orchard in the Hoshiarpur District, Punjab. The 'Kinnow' mandarin orange was introduced by Sardar Lal Singh from Riverside, California, at the Rasalewala Research Institute, Lyallpur, in 1939. It is only since 1960 that 'Kinnow' became popular in India.

and *Teliakuth.* Almost all these varieties are black-seeded, tend to make profuse viny vegetative growth, enter the reproductive phase at a very late stage, and yield scantily. Even improved Indian varieties take long to mature and are not suitable for double-cropped areas. This is perhaps one reason that soybean could not create interest among the farmers in the plains. Besides, it has been used as a pulse, and its taste is not the same as that of our favourite pulses.

American Agricultural Scientists Introduce Improved Varieties, 1953-1965

Isolated attempts to test the suitability of some of the American erect, early-maturing varieties, with cream-coloured grain, were made in 1953 by Dr R. N. Davis, an American Consultant, associated with the All-India Co-ordinated Research Project on Large-seeded Legumes. He imported the seeds of several varieties through the courtesy of Dr J.L. Carter, Director of the US Regional Laboratory, Urbana, Illinois. The former conducted trials in Yeotmal (Maharashtra) till 1963. Those trials showed that there were prospects of growing soybean as an economic crop in India. Small-scale preliminary varietal trials were conducted at the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, in 1963 and 1964, during *kharif* by Edwin Bay, Extension Adviser of the USAID Team. Although the yields were low, it was proved that the American varieties could be introduced into India and could be acclimatized here. Similiar information came from the trials conducted at a government farm in Madhya Pradesh. The interest in soybean-growing in India got a fresh impetus in 1965, when Dr Earl Leng, in collaboration with Dr W.D. Buddmair, inititated extensive studies at Pantnagar and Jabalpur. Some of the US varieties, such as 'Bragg', yielded about 30.36 quintals of grain per hectare, and this yield was almost three times that of the traditional *kharif* pulses (Fig. 171).

All-India Co-ordinated Research Project of the ICAR on Soybean, 1967

The success of a new crop in a country, with conventional cropping patterns, depends on a number of factors, viz. competition with the existing crops, physical displacement of any of the important crops with a possibility to disturb the commodity balance, and its agricultural feasibility *vis-a-vis* other crops. In addition, a deeper insight into the problems of cultivation, viz. varietal identification, genotypic improvement and the optimum crop demand for remunerative production is needed. With these objectives in view, the Indian Council of Agricultural Research launched an All-India Co-ordinated Research Project on Soybean in 1967. Initially, the project had 3 main centres and 6 subcentres. However, during the Fifth Five-

Year Plan, the project was expanded, with two special centres (Pantnagar and Jabalpur), 3 main centres (Parbhani, Bangalore and New Delhi) and 12 subcentres (Palampur, Ranchi, Kalyani, Dharwar, Koraput, Jorhat, Majhera, Ludhiana, Pune, Coimbatore, Amravati and Junagarh) to cover different agro-climatic regions of the country. In addition, a number of voluntary centres have also been collaborating in the soybean research project.

PRODUCTION OF SOYBEAN IN INDIA

With the modest beginning of about 300 hectares of soybean during the *kharif* of 1968, the area under it steadily increased to about 600,000 hectares during the *kharif* of 1980. The total area under it during the *kharif* of 1978 was about 307,087 hectares, with more than 293,414 million tonnes of production. The fastest expansion of soybean cultivation has been in Madhya Pradesh, with 447,600 hectares and in the low hills and foothills of Kumaon (Bhabar) in Uttar Pradesh, with 131,745 hectares under this crop, with the yield ranging from 20 to 36 quintals per hectare. It gave higher net return per hectare than any other crop.[3]

'KINNOW' MANDARIN

'Kinnow' is a hybrid between 'King' and 'Willow Leaf' mandarin (*C. nobilis*, female × *C. deliciosa* male). The cross was made by Dr H.B. Frost at the Citrus Experiment Station, Riverside, California, in 1915. The variety was named and distributed in 1935 along with its sister cross 'Wilking'. Most of the good characters of 'Kinnow' have been inherited from its 'King' parent.

The 'Kinnow' mandarin orange was introduced into Punjab by Lal Singh in 1939 from Riverside, California. It was under observational trials at the Rasalewals Research Station, Lyallpur. Its cultivation spread in West Pakistan after 1947 and it established a solid reputation as an excellent citrus fruit (Fig. 173).

The Agricultural Institute, Naini, Allahabad, also imported this variety from California in 1950. Twelve budded plants of this variety, received from the Naini Agricultural Institute, were planted in the Government nursery at Jullundur on 15 February 1955. The plants propagated from this source were sold to the fruit-growers in Punjab. Some fruit-growers on their own initiative got 'Kinnow' plants from Pakistan. The budwood of 'Kinnow' was imported from California in 1958 for the Fruit Research Station, Abohar, Punjab. Later, the virus-free budwood of this variety was received from the USA on 19 October 1970 and 17 March 1971 and is being maintained in a screen-house at the Punjab Agricultural University,

[3]Bhatnagar, P.S. 1981. Country report, presented at the INTSOY International Conference on Soybean Seed Quality and Stand Establishment, held at Colombo (Sri Lanka) during 25-31 January 1981

Ludhiana. The cultivation of 'Kinnow' has spread in Punjab and Himachal Pradesh.

'Kinnow' is comparatively dwarf, and a larger number of plants than those of the local oranges can be accommodated in one hectare. Its skin is smooth and deep orange, and the fruit is juicy, with very good taste. It starts fruiting 2-3 years after it is planted and bears heavy crops. Its defects are a tendency towards alternate bearing and top-drying.

'Flordasun' and 'Florda-red' Peaches

Dr G.S. Nijjar, Professor of Horticulture, Punjab Agricultural University, Ludhiana, had the opportunity of working with Professor R. H. Sharpe at Gainsville, in Florida, USA, during 1957-59. At that time, the peach-breeding programme at Gainsville was in full swing. He requested Professor Sharpe to supply some of his new varieties for cultivation in Punjab. In 1968, he received from him 'Flordasun' (Fig. 172) and 'Florda-red' varieties, which have given an outstanding performance in northern India. These are early varieties which ripen in May.[3]

Japanese Mint

The Japanese mint (*Mentha arvensis*) was introduced into India in 1952 by Sir Ram Nath Chopra, then Director of the Regional Research Laboratory, Jammu, with the idea of extraction of menthol. However, not much progress was made, and for a long time it remained confined to the farm of the Regional Research Laboratory.

Systematic work, which included the selection of suitable areas, the development of a package of practices, including agronomy, and plant protection and its extension to the fields of farmers, was done successfully by a private company, Messrs Richardson Hindustan Limited, from 1968 onwards. A survey was made to identify suitable areas for large-scale cultivation of Japanese mint. After this, a research and development programme was formulated. It included a study of soils, planting techniques, rhizomatous planting, use of chemical fertilizers, irrigation, weed control, pest control and harvesting techniques. This work was carried on in a 16-hectare piece in the village of Bilaspur in the Tarai of Naini Tal. A root-rot resistant variety and an early-maturing drought-tolerant strain were selected. It was further discovered that the application of gibberellic acid increased the herb and oil yield by 15 per cent.

Most of the scientific findings remain on paper, because no arrangements are made to extend them to the farmers. This is a problem which Messrs Richardson Hindustan Limited effectively met by starting a programme of technical assistance. The Company engaged 20 guides to

[3]Nijjar, G.S. 1973. 'New peach varieties for north Indian plains', *Haryana J. hort. Sci.* 2 (1 & 2): 23-25

meet individual farmers and to explain the technology of growing mint. This step promoted the cultivation of this plant successfully.

The extraction of menthol is crucial in this work. By developing a model distillation unit, the yield of extracted menthol was increased from 45 per cent to about 67.5 per cent.

The cultivation of Japanese mint has benefited about 8,000 farm families in the Tarai of Naini Tal in Uttar Pradesh and in Punjab and Haryana. It has been of particular benefit to small and marginal farmers. It saved the Government Rs 130 million in foreign exchange and India became self-sufficient in menthol.

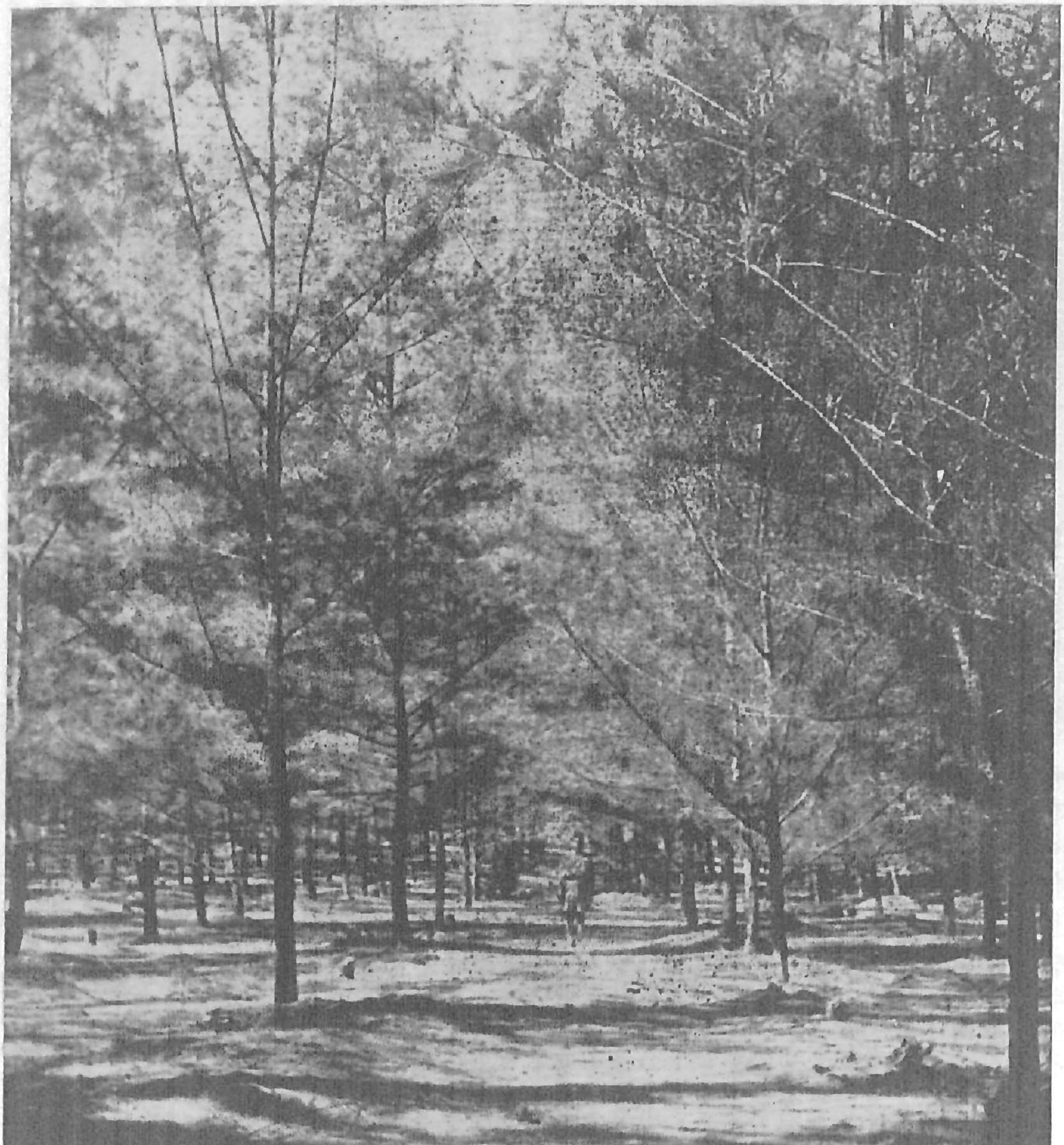


FIG. 174. Casuarina has proved a boon for raising fuel plantations on the sandy soils of south India. A six-year-old casuarina plantation in Tamil Nadu.

FIG. 175. Introduced in 1962, hybrid eucalyptus has transformed the landscape of the Punjab. It is a hardy, quick-growing tree, commonly grown along the road-sides, boundaries of farms and along the banks of canals. The photograph shows a plantation of eucalyptus on the Sirhind Canal at Neelon, Ludhiana District, Punjab.

FIG. 176. *Leucaena leucocephala* (*subabul*) has been recently introduced into India. It is drought-resistant, and tolerates high degree of salinity and alkalinity. It is a fast-growing tree which does not damage field crops. Its leaves provide fodder for cattle, sheep and goat. Its wood provides excellent fuel.

CHAPTER 42

FARM FORESTRY

AGRICULTURAL FORESTS, FUEL AND FODDER RESERVES
CASUARINA PLANTATIONS ON SANDY AREAS IN SOUTHERN INDIA
FAST-GROWING TREES—HYBRID EUCALYPTUS AND *KUBABUL*

AT the time of its creation, about 1866, the Forest Department found the forests of the country fast disappearing before the spread of cultivation, and before the reckless destruction carried on by the people. Agricultural resources were vanishing, and the climate was, not improbably, being affected injuriously. The Forest Department stepped in to prevent the entire deforestation of the country, which would most certainly have taken place. As the demand for cultivation spread, so would the forest have disappeared before the plough, had not a strong hand been interposed to save what was still remaining.

Left to themselves, people had never been able to manage forests properly, nor to understand how forests may be conserved and utilized to the best advantage. Their practice had been simply to cut and clear the forests to make room for cultivation; and, as soon as the virgin soil was spent, they pushed on, broke up fresh land and cleared more forest. And this, if allowed, would have gone on as the farmers lack farsight and think only of the immediate present and not of the future.

The Forest Department intervened and stopped in a great measure the work of destruction, and ensured a continuous revenue to Government. When it began its work the chief duties of the Forest Department were the preservation and development of large timber forests, such as the *sal* forests of Oudh, and the *deodar* forests of the Himalayas, and the forests of the Western Ghats. Its objects were in no sense agricultural, and its success was gauged mainly by fiscal considerations; the Department was to be a revenue paying one. In fact, its interests were opposed to agriculture, and its intent was rather to exclude agriculture than to admit it to participation.

AGRICULTURAL FORESTS

It was Dr Dietrich Brandis, the founder of the Imperial Forest Department, who in 1873 suggested the need of growing agricultural forests. He assisted the Madras Government in framing their policy of agricultural forests, and it was largely due to his efforts that in Madras Presidency so much was done to make the Forest Department serve agricultural interests.

FUEL AND FODDER RESERVES

Dr J. A. Voelcker in his Report on the Improvement of

Indian Agriculture (1897) strongly recommended the establishment of fuel and fodder reserves for the primary purpose of supplying wood to take the place the cowdung as fuel. He also emphasized the usefulness of tree growing for the shelter and protection which they provide from violent winds and the burning sun, and the usefulness of their leaves for litter and manure. He also pointed out that agro-forestry practices help to minimize soil erosion and to conserve soil moisture. Leaves of trees add to the organic matter in the soil and increase humidity by drawing more water from the deeper layers of the soil. The roots of trees reduce the run-off and increase infiltration in the soil.

Casuarina Plantations in Southern India, 1868 onwards

Casuarina is now commonly grown on sandy land in Tamil Nadu, Karnataka, Andhra Pradesh and Coastal area of Maharashtra (Fig.174). In fact, it is the main source of fuel for the villages and the towns in these States. *Casuarina equisetifolia* was first introduced in southern India in 1868. The first *Casuarina* plantation is reported to have been established at Ullal, Southern Canara District of the former Madras Presidency. In the same year, it was introduced in South Canara District near Karwar in the former Bombay Presidency. There is also a report of *Casuarina* plantation in Colaba District of erstwhile Bombay Presidency near Alibag in 1883.

FAST-GROWING TREES

With the rapid depletion of fossil fuels the problem of renewable sources of energy is receiving world-wide attention. Now land must be used not only for production of food and fibre, but also for energy production. Quick-growing trees provide an answer for fixation of solar energy and its use for various purposes. Through agro-forestry, by the simultaneous production of crops and trees, farmers can produce not only food and fibre, but also fuel, timber and industrial raw materials. Out of the fast-growing trees, hybrid *Eucalyptus* and *Leucaena* appear to be most promising solar-energy fixers.

Eucalyptus

Species of Eucalyptus have been introduced into India from Australia from the nineteenth century onwards. They changed the aspect of the Nilgiris in southern India to such an extent that these mountains have an Australian look.

After Independence large-scale plantation of Mysore gum (Eucalyptus hybrid) was undertaken in several parts of India, including Assam (1950),

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[4]Letter dated 20 April 1981 from Dr R.N. Kaul, Director, Forestry Research, Forest Research Institute, Dehra Dun

Tamil Nadu (1954), Andhra Pradesh (1957), Karnataka (1960) and West Bengal (1961). The real momentum came in 1962, when it was grown on a massive scale as a road-side avenue tree in Punjab due to the initiative of Sardar Partap Singh Kairon, who accepted innovations and gave a strong support to the planting programme. As a result the landscape of Punjab changed totally and *Eucalyptus* hybrid became a favourite road-side tree and was also planted along the banks of canals, as well as in farms as a shelter belt (Fig. 175). Now it has spread far and wide and absentee land-owners, who are unable to look after their land, have taken up its planting on a large-scale on inferior lands.

Planting of hybrid *Eucalyptus* was taken up in 1963 in Gujarat, Madhya Pradesh and Orissa, and in 1964 in Maharashtra.

Eucalyptus in Rajasthan (1961-63)

In July 1961-62 and 1962-63, 43 species of *Eucalyptus* were introduced from the lower rainfall regions of Australia for trial at Jodhpur and Pali in Rajasthan to study their adaptability to different habitats and to select the most promising ones for large-scale plantation in similar areas in arid and semi-arid zones. It was observed that the species with wide latitudinal distribution and belonging to summer rainfall regions in their native habitat had done better than the species with narrow latitudinal distribution and belonging to winter rainfall areas. In general, *Eucalyptus melanophloia*, *E. terminalis* and *E. camaldulensis* proved to be the most promising species and were recommended for large-scale planting in the region. However in Pali region with calcareous soils, *E. tessellaris* gave the best performance.[5]

Being fast-growing, now hybrid *Eucalyptus* is a favourite fuel and timber tree in India. For utilizing solar energy, no other plant is so efficient. Besides the crowns of Eucalyptus trees sway with the mildest breeze and hence birds do not build nests in them. There is slight reduction in crop yield in such farms, but it is offset by the value of the trees which can be harvested after ten years. After cutting, the trees rapidly regenerate, and in a couple of years they make good growth.

Kubabul *(Leucaena leucocephala)*

Credit is due to the Bharatiya Agro-Industries Foundation (BAIF) for the introduction of Hawaiian Giant type of *Leucaena* in Maharashtra. *Kubabul* (*Leucaena leucocephala*) is a new plant to India with great potential to support the rural industry and provide gainful employment for the rural families. The most important characters of *kubabul* are fast growth, prolific regeneration, easy propagation by seeds, strong tap-root system, drought

[5]Kaul, R.N., Jain, M.B. and Gyan Chand, 'Performance of eucalyptus in the Indian arid zone', *Qual. Bant. Mater. Veg.* XVII, 2: 131-147, 1969

resistance and alkali tolerance. Its foliage, containing 24 per cent protein, makes an excellent fodder, and the wood can be used for fuel, timber for rural housing, charcoal, paper and pulp. *Kubabul* can also be grown for green manure, soil reclamation and erosion control and as a wind break (Fig. 176).

Kubabul is one of the fastest-growing species with good regeneration capacity. Its initial growth rate is 5-6 meters per year. Hawaiian Giant Leucaena trees can grow as tall as 15-18 meters, with a trunk diameter ranging from 9 to 15 cm, in a period of three years. The foliage can be harvested for fodder at an interval of 25-40 days throughout the year and the trunk can be cut for wood and pole timber even at two years' age, though 3-4 years' interval is ideal. New shoots emerge when the trunk is cut at the crown level and again grow tall to yield wood and pole timber. Leucaena has a life of more than 50 years.

During the process of establishment, *kubabul* fixes atmospheric nitrogen and adds rich organic matter to the soil. It helps in the degeneration of rocks and stones in the soil and improves the soil texture. Its plants absorb a large quantity of salts, thus bringing down the pH of the soil. As a result, productivity of the soil improves within a short period.

Kubabul grows erect with weak side branches. The size of the leaflets is small. Hence these *Leucaena* trees do not damage the field crops due to shade, when planted on the farm bunds and borders.

Kubabul wood has a specific gravity of 0.5 -0.6, with a good burning quality. It can also be used as a fuel to replace oil in industry. It is also used for making quality charcoal. It can be used for paper and pulp production. Plantations can also be established for extracting gum.

Low productive soils, farm bunds, river banks, bunds of canals, drains and tanks, road-sides, hilly slopes and reserve forests are ideal for growing *kubabul*.

CHAPTER 43

SOIL CONSERVATION AND RECLAMATION

H. L. UPPAL'S WORK ON TAMING THE SIWALIK *CHOS*
AND THE RECOVERY OF LAND FROM RIVER-BEDS IN PUNJAB AND JAMMU
DRAINAGE MEASURES IN PUNJAB

Soil is a precious resource, which the weathering of rocks over millions of years has built up. It is a medium for the growth of plants and is the basic source of all human and animal food as well as that of most of the industrial raw materials. It is under constant attack from wind and water, and it should be our constant endeavour to save it.

Soil Conservation

It has been estimated that out of 328 million hectares constituting the geographical area of our country, nearly 150 million hectares is subject to soil erosion. Up to the end of the Fifth Five-Year Plan, we have been able to treat at a total cost of 5,080 million rupees only 22 million hectares, which comes to about 14 per cent of the total area needing treatment with erosion control measures.

The Central Soil and Water Conservation Research and Training Institute, Dehra Dun, and its centres at Chandigarh, Kota, Vasad, Agra, Ootacamund and Bellary deal with problems of conservation of soil and water as natural resources and their management for higher production under various land uses.

Erratic, short-duration, high-intensity rainfall, the loose and friable nature of the soil, the steep slopes and the undulating terrain, interference with natural vegetable cover, faulty agricultural practices, improper land use by way of overgrazing and other biotic interferences have combined to aggravate the situation, resulting in deep gullies (commonly known as ravines) in Uttar Pradesh, Rajasthan, Gujarat and Madhya Pradesh.

The measures to control the ravines include the closure to grazing, gully-plugging and stabilizing active gully heads.

The research carried out at the Vasad and Agra centres of the Central Soil and Water Conservation Research and Training Institute, Dehra Dun, has shown that it is possible to manage the marginal land on the slopes of hillocks by resorting to proper planting on watershed basis.

TAMING THE SIWALIK *CHOS*

Outstanding work has been done on the reclamation of land from the beds of rivers and monsoon torrents in Punjab and Jammu after Independence, and is described in the following account.

The Siwaliks and the *Chos*

Below the Himalayas, extending from Jammu to Assam, are the Siwalik mountains, composed of river deposits, layers of clay, pepper-like sand and of boulders, some of which may have diameter of more than 1 metre, and of rounded pebbles varying in size from an orange to a man's head. According to geologists, these are river deposits. A great old river, the Siwalik River or the Indo-Brahm, which received the combined discharge of the Indus, the Ganga and the Brahamaputra, once flowed below the Himalayas. By the elevatory movements of the earth, it was gradually uplifted. The boulders and pebbles, embedded in a matrix of clay and sand, were folded and uplifted, resulting in the chain of hills, the Siwaliks of the present day.

From the Siwaliks, a large number of *chos* emanate at close distances and cause serious damage to land, crops, villages and roads. The *chos* are broadly divided into the Jammu Siwalik *chos*, the Punjab Siwalik *chos*, the Uttar Pradesh Siwalik *chos* and the Eastern Siwalik *chos*. Although each region bordering on the Siwaliks suffers from the action of the *chos*, the devastation caused by them in the Hoshiarpur District of Punjab is the worst.

A *cho* is a local name of an ephemeral stream or a monsoon torrent flowing down from the Siwaliks. When in flood, it is like a river; when the flood is over, it is nothing but a bed of sand. The *chos* have a small catchment area. Immediately after a rainfall in the catchment, the *cho* swells into a flood. As the slope of the bed is steep, the velocity of flow is high. Since the catchment area of a *cho* has in it an incoherent material, viz. stones, sand, silt and clay, the water is charged with a heavy sediment load. In the hills, a *cho* is narrow, but as it reached the plains, it spreads out over a vast area, depositing coarse sand over fertile fields, making them unproductive. In the plains, the *chos* divide and subdivide and start meandering over a large flood-plain. After flowing down for 15 to 20 kilometres, the *chos* generally become blind, i.e. vanish in the surrounding area.

Controlling the *Chos* of the Punjab Siwaliks

The *chos* of Punjab have their origin in the Siwaliks. In the Hoshiarpur District alone, there are about 108 *chos* in a length of 120 km emanating from the hills at short distances and flowing in the foothills and through the plains, parallel to one another, cutting through fertile land, roads, railways, eroding villages and depositing large quantities of sand. About 40 per cent of the land in the Hoshiarpur District (about 170,000 hectares) is affected by the *chos*. Most of the *chos* are turbulent streams, carrying as high as 35,000 to 45,000 cusecs (990 to 1,275 cumecs) discharge during floods and cause a deluge in the countryside. They take a heavy toll of human and cattle lives annually and cause much damage to crops and fields.

FIG. 177. Dr H. L. Uppal, soil conservationist. As a result of his research, project planning, designing and execution of plans, over 20,234 hectares of wasteland has been brought under cultivation in the Punjab. He also canalised the Sutlej and Beas Rivers, thus salvaging 105,218 hectares of land for agriculture. He tamed the *chos* in the Hoshiarpur District and thus reclaimed over 60,700 hectares of land.

FIG. 178. Embankments of sand were constructed by H. L. Uppal on both sides of the Nasrala *cho*. Thus the *cho* was confined to a narrow bed, and the land on the sides was protected from flooding.

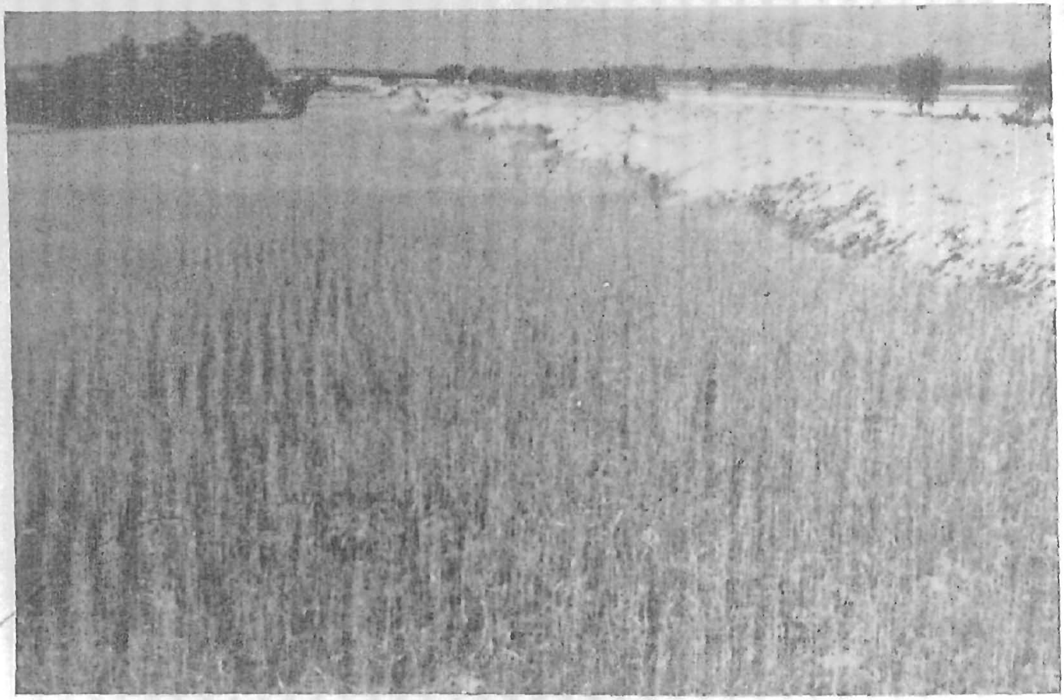


FIG. 179. A bumper crop of wheat was raised on the land protected by the embankments.

The menace of *chos* had been spreading with the passage of time. The area affected by them in 1852 in the Hoshiarpur District was only 19,000 hectares. It increased to 32,000 hectares in 1887 and to 170,000 hectares in 1951. Deforestation in the Siwaliks and destruction of vegetation by cattle and goats over the ages were the main causes of this situation.

VEGETAL TREATMENT

The measures adopted in the early twentieth century comprised vegetal treatment carried out by the Forest Department. A Cho Act was passed by the Punjab Government in 1895 and soil-conservation work consisting in the planting of *Vitex negundo, Saccharum arundinaceum,* and *Dalbergia sissoo* (*shisham*) in the beds and at the sides of the *chos* was taken up. The work was continued for several decades but did not prove to be effective. The devastation by the *chos* continued to occur and increased with time. Since the pattern of rainfall in the Siwaliks is of a heavy cloudburst type, sometimes the work of several years of soil conservation gets washed away during a single heavy cloudburst.

In 1951, the Punjab Government reviewed the situation. It came to light that the plantation of vegetation on the bed of a *cho* in many cases worsened the situation. Where a thick plantation of *shisham* was raised on the bed of a *cho*, the *cho* left that course and adopted a new one, devastating another chunk of fertile land.

DR H. L. UPPAL'S PLANNING AND DESIGN OF *Cho* CONTROL BY ADOPTING ENGINEERING MEASURES

It was decided by the Punjab Government in 1952 that engineering measures should be taken up along with soil-conservation measures. The man to whom credit is due for taming the *chos* of the Siwaliks, reclaiming their beds and flood plains, canalizing of the Sutlej and Beas rivers, and salvaging 105,220 hectares, is Dr Harbans Lal Uppal. He is a scientist, with chemistry as his subject of specialization, and is not an engineer. Yet his life's work is land reclamation. Early in his career, he worked as an adviser on anti-tank obstacles in the Defence Department of the Government of India in 1939 and later as the Adviser to the Air Ministry, London. He joined the Irrigation Research Institute, Lahore, in 1940 and since then he had continued working as the Head of the Hydraulic Department and Deputy Director of the Institute. After Partition, he was appointed Director, Land Reclamation, Irrigation and Power Research Institute, Amritsar, and Chief Engineer, Flood Control and Drainage by the Government of Punjab. During his 35 years' service at the Institute, he devoted himself to the problems of designing hydraulic and hydro-electric structures, design of channels, sediment control in rivers and canals, flood-control, river-training, river-diversion, bank-protection, *cho*-control, and canalizing rivers, rivulets and *khads*. He carried out detailed surveys—hydraulic, ground, soil, sediment, hydrological and aerial—of the areas ravaged by the *chos*. Research and investigations were also carried out by constructing models to determine the behaviour of the *chos*. It was observed that the *chos* in the hills transported all the heavy sediment load brought from the catchment on account of its small width, single channel, high velocity of flow and high discharge intensity. As the *chos* emerged from the hills and reached the plains, they spread over a vast area accompanied by a considerable reduction in the velocity of the flow and in the intensity of discharge. The reduced velocity and low discharge could not transport the sedimentary material brought by a *cho* while flowing through the hill and, therefore, allowed it to be deposited over the fields in the plain. The division and subdivision of the *chos* in the plain further aggravated the devastating action of the *chos*.

Uppal realized that the remedy to control the *chos* lay in reversing the conditions of flow in the plains, restore these, as far as feasible, to those in the hills and lead the discharge in a controlled channel to the main drainage of the tract to the river. In order to achieve this objective, the contiguous *chos* in the plains were to be grouped together to increase the discharge, the velocity of flow and the sediment-transporting power. The 118 *chos* between Rupar and Mukerian (in the Hoshiarpur District) were divided into ten major *cho* groups or *cho* systems (Fig. 180). The contiguous *chos* were integrated into the major *chos* of the system which was trained and canalized along its course up to the main drainage system of the tract. The *chos* of Nasrala, Mehangarwal, Mehlanwali, Rajni Devi and Kingerwal were planned to be controlled by this method.

The method developed consisted in the construction of canalization embankments of sand on both sides, spaced apart by a narrow width and a cunette. The embankments were protected at strategic points by armoured spurs.

Another method of tackling the *chos* was also evolved, viz. intercepting the *chos* at the foot of a hill by excavating a channel parallel to the hill ranges. The water of all the *chos* was dropped into the major *cho* and was led to the nearby river. This method was applied to the 26 *chos* emanating from the Katar Dhar and flowing down into the plain between the towns of Tanda and Dasuya. A channel 20 km long at the foothills and parallel to the hill range intercepted the *chos*, and then dropped the discharge into the major *cho* of the tract, the Langarpur-Dasuya *cho* already flowing at right angles to the excavated channel. After traversing 20 km, it joined the Beas river (Fig. 180). The method comprised the excavation of a cunette, 13 metres wide, with an embankment at some distance from the cunette on the left side. There was no embankment on the right side. This scheme was carried out at a cost of about Rs 35 million.

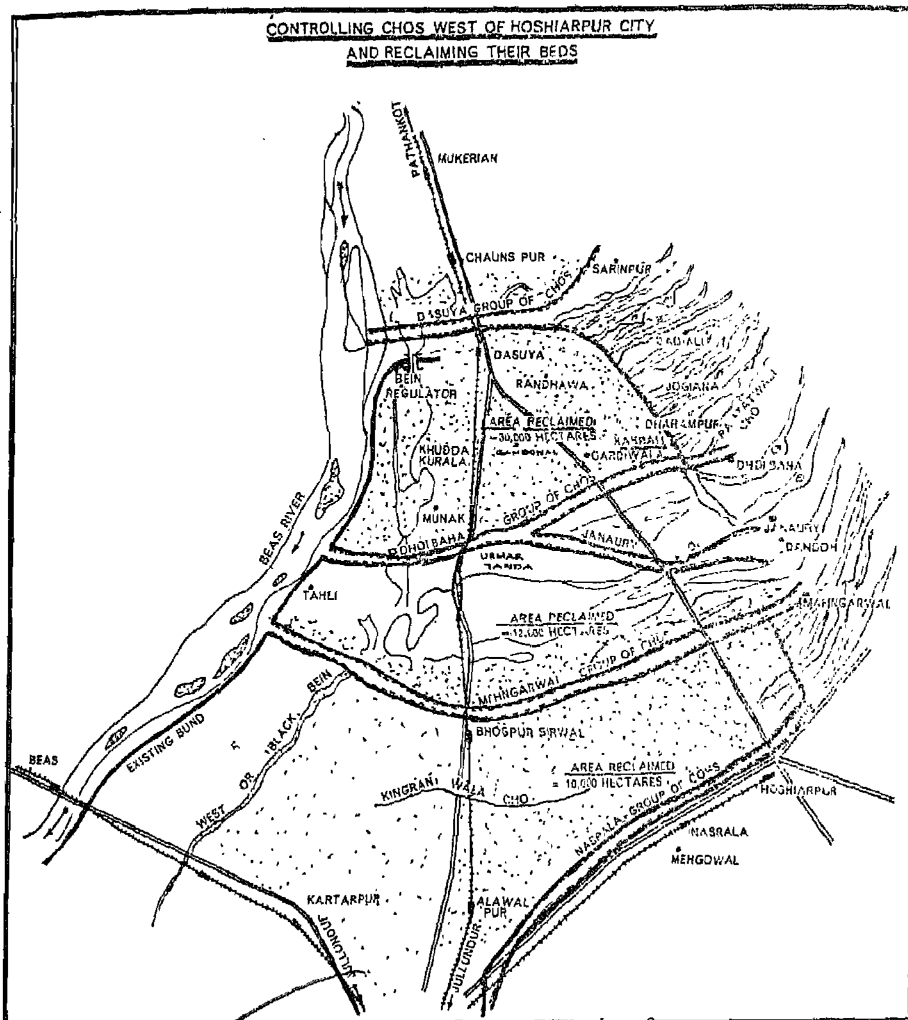


FIG. 180. A method developed by Dr H. L. Uppal was that of interception of the *chos* at the foot of the Siwalik hills by excavating a channel parallel to the hill range. This method was applied in Dasuya Tahsil of the Hoshiarpur District. The discharge of *chos* intercepted was dropped into the Langarpur-Dasuya *cho*, the major *cho* of the tract, which joined the Beas River.

NASRALA *Cho* CONTROL

The work of the *cho* control in Punjab was started first on the Nasrala *Cho*, which passed through the Hoshiarpur Town, was the largest of all, and was also the most destructive. The Nasrala *cho* during floods affected the Hoshiarpur Town, spread over a vast area several hundred square kilometres, submerged about 25 villages of the Hoshiarpur and Jullundur Districts, the Jullundur-Hoshiarpur road and the railway track, and the aerodrome at Adampur. Serious damage occurred every year. The work was inaugurated on 22 February 1953. Later, a length of 16 km below the Hoshiarpur Town was canalized on an experimental basis. The canalization of the *cho* in this reach proved a great success and paved the way for further extensive work. The entire length of the Nasrala *Cho*, 55 km, was canalized from the foothills to the East Bein at a cost of 4 million rupees. The Punjab Government, the Railway Department and the Defence Department each contributed one-third of the cost. The canalization proved to be a boon to the people of the area. No flooding occurred, and the fields, the roads, the railway track and the aerodrome became absolutely safe.

Canalizing the Mehangarwal, Mehlanwali, Taragarh and Kingarwal *Chos* in the Hoshiarpur District

Encouraged by the success that attended the control of the Nasrala *cho*, the Mehangarwal *Khad* consisting of several branches in the Haryana area (Hoshiarpur District) was canalized and trained for a length of 60 km from the foothills to the Beas River at a cost of 8.5 million rupees. The Mehlanwali *cho* on the east of Hoshiarpur, also causing heavy devastation, was canalized into a small width for a length of about 40 km at a cost of about 2 million rupees. Similarly, the Taragarh and Kingarwal *chos* were canalized.

Diverting the *Chos* at the Base of the Foothills

On the Langarpur-Dasuya *cho*, the technique of diverting a large number of *chos* at the foothills into one *cho* and then dropping it into the Beas River was developed by Uppal. This technique proved to be a great success. It was more economical, less of land—and that also practically barren—was taken for the cunette and the embankment. The tract between Tanda and Dasuya was protected against the ravages of flood and a large chunk of land has been brought under intensive cultivation.

From 1953 to 1966, a number of *cho* systems were canalized and trained, with the result that the *cho* menace in the area to the west of Hoshiarpur up to Dasuya was practically eliminated.

The *cho*-control work carried out in 1953-1966 resulted in the reclamation and development of about 80,000 hectares, providing additional annual food production of 600,000 tonnes, valued at Rs 600 million.

The Diversion of the Patiala-ki-Rao into the Jainti-Devi-ki-Rao (Sirhind *Cho*) and the Diversion of the Combined Flow into the Satluj via the Siswan Nadi

In the Siwaliks above Chandigarh a number of *Raos* emerge. *Rao* is another name for a *cho*. The Patiala-ki-Rao originates in the Kalka range of hills and flows past Chandigarh after it debouches into the plains. In the plain, it flows near the towns of Rajpura and Patiala, causing extensive damage to land, crops and property. After traversing 125 km, it used to drop into the Ghaggar River. Hefty flood protection works were constructed in the past to prevent the flooding of the Rajpura and Patiala areas. Waterlogging and salinity occurred in the flood plain of the Patiala-ki-Rao. Uppal diverted the Rao at Dado Majra, Chandigarh, into the Jainti-Devi-ki-Rao through a 1 km long connecting channel. The scheme was executed in 1963 and 12,000 hectares of land was reclaimed.

After receiving the water of the Patiala-ki-Rao, the Jainti Devi-ki-Rao, which also originates in the Kalka Hills and flows parallel to the Patiala-ki-Rao was diverted to Siswan at Thaska. In order to admit water and silt into the original bed of the Jainti-Devi-ki-Rao for the siltation of the bed and irrigation, a regulator was constructed. The Jainti-Devi-ki-Rao, flowed past Sirhind, Sangrur, the Sunam Towns and caused heavy flooding, waterlogging, salinity and ultimately joined the Ghaggar River. After its diversion to the Satluj, the entire valley of the Sirhind *cho* comprising 15,000 hectares has been reclaimed and developed. The work cost 12.5 million rupees in 1963. It protected the valley land against annual flooding. The additional food production was 75,000 tonnes, valued at Rs 75 million.

Canalizing the Himalayan Rivers and Reclaiming their Beds and Flood Plains

The Himalayan rivers, after their debouchment into the plains, meander and occupy a large area under their beds. They also divide and subdivide into a number of channels with large islands between them. River avulsion also occurs and the stream abandons its original course and takes a new one. Thus by bank erosion, by the shifting of their courses by their meandering action, and river avulsion, the rivers occupy a large flood plain and cause extensive devastation to agricultural land.

All this large width which the rivers occupy in the plains is not required by the rivers for the passage of floods. In the past, since the pressure on the land was not great on account of limited population, no notice was taken of this devastation of the land by the rivers. With the growth of population, land has become scarce and it can no longer be allowed to be wasted.

Research was carried out during the last three decades by Uppal to develop the techniques and procedures to train the rivers, salvage the excessive land under their beds and develop it for agriculture, horticulture, animal husbandry and agro-industrial purposes.

Reclaiming the Kanuwana Chhamb in the Beas River (Gurdaspur District)

The Kanuwana Chhamb in the Beas River, extending over 256 square kilometres, was a marsh, cut up by the river creeks, overgrown with tall grasses. It served as a hiding-place for lawless elements.

In 1960, Uppal reclaimed the Kanuwana Chhamb by cutting out the river channel, flooding the *bet* area by constructing a flood-protection embankment, 44 km long, from Mirthal to Sri Hargobindpur. The land behind the embankment protected against flooding was drained by constructing a network of drainage channels. A number of tube-wells were installed by the farmers, and this area is now the granary of the Gurdaspur District and produces 15 million tonnes of foodgrains annually.

Reclaiming the Ravi River-bed

Between 1955 and 1960, a large number of 1.5-2.5 km long reclamation bund-cum-spurs were designed and constructed by Uppal in the flood plain of the Ravi River between Dera Baba Nanak and Kakar Munj (70 kilometres). The spurs helped to reclaim 10,000 hectares, resulting in the production of 50,000 tonnes of foodgrains annually.

Satluj Canalization between Rupar and Harike (160 km) and the Reclamation of 80,000 Hectares of the River-bed

The flow of the Satluj River was harnessed by the construction of the Bhakra Dam in 1960 and water was stored in the vast Lake of Gobindsagar. Only occasional releases of water were through the spillway. The discharge in the River below the dam became diminished. Uppal felt that the width of the River which was 8 to 10 km below the Rupar Headworks could be reduced to reasonable dimensions, and land could be recovered. He prepared a scheme in 1960 of canalizing 160 km of the Satluj River between the Rupar Headworks and the Harike Barrage into a one kilometre-wide single-channel, thereby reclaiming 80,000 hectares from under the river-bed. The scheme was executed from October 1962 and was completed by October 1964 at a cost of 800 million rupees. Flood-protection earthen embankments, 3-5 metres high, were constructed on both sides, with a number of armoured spurs. Since 1965, the works have been functioning efficiently.

After the construction of the embankments, the reclaimed river-bed was brought under cultivation by the farmers. About 80,000 hectares was reclaimed and brought under intensive cultivation by installing tube-wells and are producing about 600,000 tonnes of foodgrains annually. Two large farms have been established on the reclaimed bed for seed production. Besides the reclamation of the river bed, extensive riverain land in Sidhwan and Raipur on the left bank below Phillaur has been protected against inundation. This 80 km long and 10-15 km-wide belt has developed into a rice and wheat belt.

Drainage Scheme for Waterlogged Areas in Punjab

In 1952-59 Punjab developed serious waterlogging. About 1.6 million hectares had a water-table less than 1.5 metres below the surface. Agricultural production was badly affected, and annual loss was about Rs 400 million.

Anti-waterlogging measures were adopted on a large scale. Between 1959 and 1967, a network of drainage channels was built at a cost of Rs 300 million. Each *doab* was provided with main drainage channels, subsidiary channels and drains, besides opening up the natural drainages. Some of the drainage channels were several hundred kilometres long, each running with a discharge of several thousand cusecs. Such a gigantic drainage system has not been constructed anywhere else in the world.

The construction of the drainage system was instrumental in removing the waterlogging menace to a considerable extent. After the establishment of the drainage system, waterlogging vanished almost entirely. From 1.62 million hectares in 1956-57, the waterlogged area is now only a few thousand hectares in certain pockets. The elimination of the waterlogging menace has boosted agricultural production greatly and has also reduced the salinization of the soils considerably.

Controlling the *Chos* of Jammu Siwaliks and Reclaiming their Beds and Flood Plains

There are many *chos* emanating from the Chenab catchment of the west Jammu Siwaliks which devastated the land in the valley. Since the holdings of the farmers are small, they suffer great hardship and misery. Since 1978, considerable work has been carried out under the guidance of Uppal, on controlling these *chos*. A large number of gravel, boulder or crate bars, each several hundred metres long, were constructed to control the *chos* and reclaim their beds. Instead of the multiple-channel streams, single-channel streams, deep and narrow, have been formed. An area of about 5,000 hectares has been reclaimed and brought under cultivation.

The *Chos* of the Jhelum River Catchment of the West Jammu Siwaliks

The work of canalization was taken up on the *chos* in 1976-1980 by constructing a cross-bar made from gravel, boulders or stones in wire-crates, starting from the bank and extending several hundred kilometres on to the beds of the nallahs. About 7,000 hectares of land has been reclaimed and developed for agriculture and horticulture. The greatest advantage which has accrued from the canalization of *chos* is the stoppage of cultivation on the hill slopes. Having been deprived of their land in the valley, as it was washed away by the *chos*, people started cultivating the slopes of the hills, resulting in a speedy denudation of the soil. They have now come back to their holdings in the valley and have started cultivating it.

Controlling the *Chos* of the Jammu East Siwaliks

The Jammu East Siwaliks are formed of hill ranges lower than those of the Jammu West Siwaliks. A very large number of *chos* and *khads* emanate from these hill ranges in a length of about 100 km. In this region, canalization has been taken up on Magar, Kathua, Kathera *Khad* II and Hira Nagar *Khad*. The canalization of the Kathua *Khad* and the Hira Nagar *Khad* helped to reclaim a sizeable urban area, besides protecting houses and roads.

Canalizing the Chenab River below Akhnoor and Reclaiming its Bed and the Flood Plain

The Chenab River, which has a width of 300 metres in a single channel at Akhnoor (Jammu), spreads over a width of 8-10 km, with a number of channels and islands in between. During 1977-80, Uppal canalized the river from 8-10 km into less than a kilometre in width and closed all the subsidiary channels, confining the stream to the central creek. This step helped to protect a large number of villages, vast areas and crops against inundation, and about 10,000 hectares was reclaimed.

Diverting Nikki Tawi into the Waddi Tawi and Reclaiming Their Beds and the Flood Plains, 1977-80

The Tawi River, which flows at the Jammu City bridge at a width of about 300 metres, spreads a kilometre below over a width of 10 km and flows in four channels. About 65 villages were ravaged by floods. Uppal planned and diverted all the Nikki Tawi channels to the single Waddi Tawi River with the help of deflectors, closure bunds and spurs and canalized the Waddi Tawi along its length. The work had been put to severe test during July 1981, when a high flood occurred. Practically no damage occurred. About 6,000 hectares of land has been reclaimed from the river-bed, besides a vast area, and a large number of villages were protected against floods.

FIG. 181. *Above*: Soil samples being taken from a (alkali; *kallar*) field. *Below*: Gypsum being applied to the same field for reclamation.

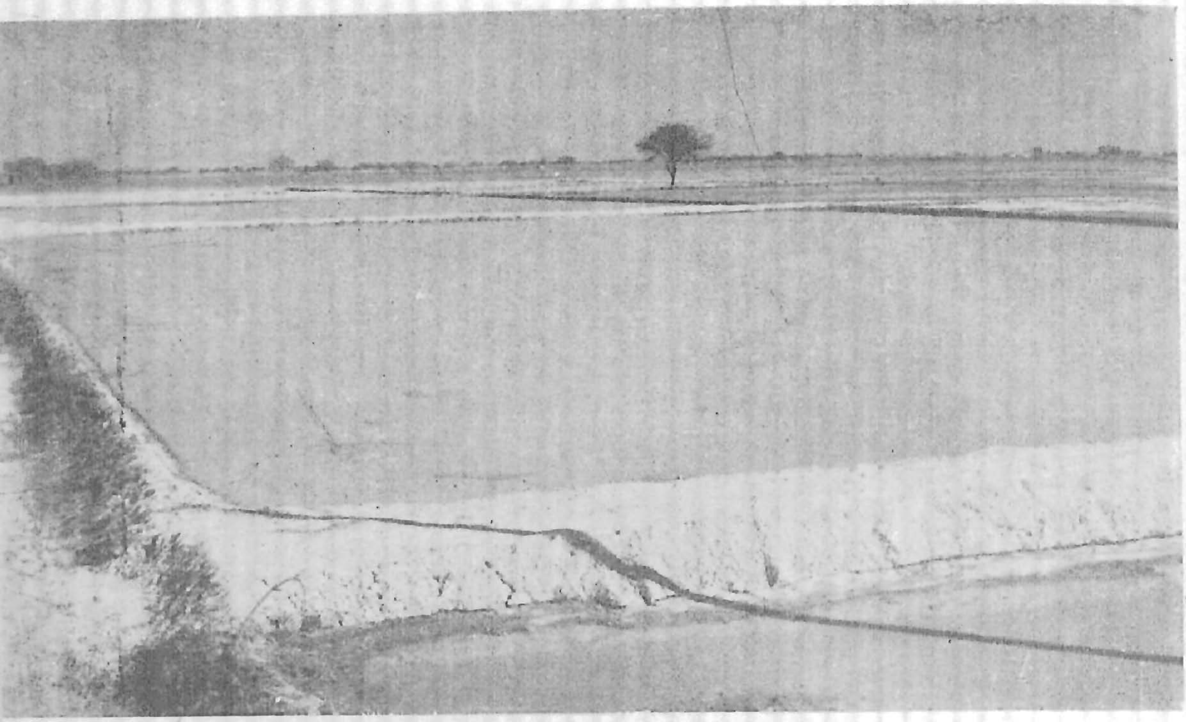


FIG. 182. Leaching of salts from a saline-alkali field. Bunds are built along the boundaries and water is impounded.

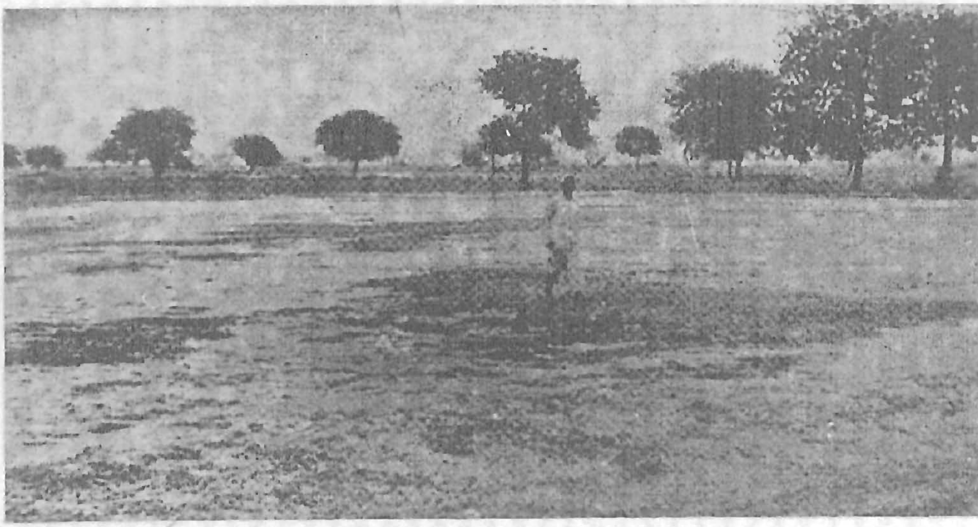


FIG. 183 A. A field with a heavy cover of alkali salts.

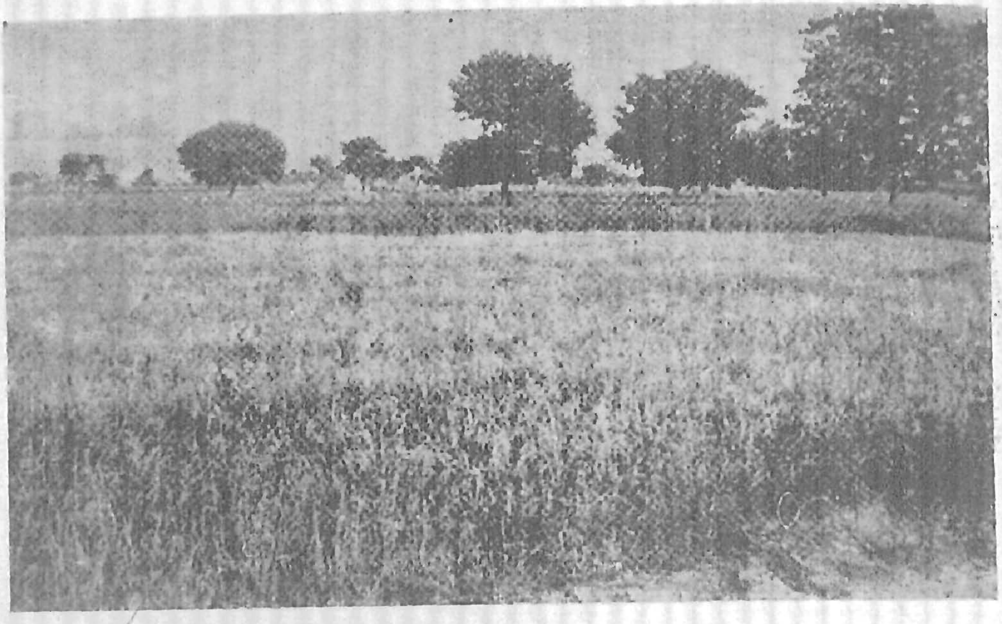


FIG. 183 B. The same field after reclamation with the application of gypsum and farmyard manure, bearing a bumper crop of wheat.

RECLAMATION OF SALINE AND ALKALI SOILS

DESERT CONTROL, SOIL AND WATER CONSERVATION IN DRYLANDS

SALT-AFFECTED soils in different parts of the country are known by local names, such as *reh* and *usar* in Uttar Pradesh, *kallar* and *thur* in Punjab and Haryana, *khar* and *looni* in Gujarat, *chopan* and *kalal* in Karnataka, *chowdu* in Andhra Pradesh and *uppu* in Tamil Nadu. When soils contain excess salts, which interfere with the growth of crop plants, when their pH is less than 8.5 and their content of exchangeable sodium is low, they are called saline. Saline soils occur in the coastal areas and in arid and semi-arid regions of the country. They are recognized by the presence of a white puffed crust of salts on the surface, by a relatively high permeability to water and by a poor and patchy growth of crops. Alkali soils are mostly confined to the Indo-Gangetic Plain. These soils have not as high a salt content as saline soils but have a high content of exchangeable sodium. The surface shows a black coloration on wetting and cracks develop on drying. These soils support only a few short-statured grasses and have a barren look (Fig. 176).

Salt-affected soils have existed in India since a very long time. There are references to such soils in the *Adi-Granth* in the poetry of Guru Nanak, a contemporary of Ibrahim Lodi and Babur. In the past, people simply ignored such soils because there was much less pressure on land. Besides, there was no suitable technology to reclaim saline-alkali soils. Thus the cultivation of such soils was considered a fruitless effort. The introduction of canal irrigation accentuated the alkalinity-salinity problem. Complaints about the development of salinity in the Karnal District of the Haryana region of Punjab were received around 1855, in the Ganga Canal Irrigation System in 1876, in the canal-irrigated region of the Deccan in 1905, and in the Canal Colonies of western Punjab in 1918.

It is estimated that in India nearly 7 million hectares is affected with salts and is mostly lying uncultivated. The worst-affected States are Uttar Pradesh, Gujarat, West Bengal, Rajasthan, Punjab, Maharashtra and Haryana. Many areas which before the introduction of canal irrigation were fertile and productive have now been affected with waterlogging and soil salinity, e.g. the area in the Chambal command in Madhya Pradesh and Rajasthan, that in the Gandak command in Bihar, that in the Nagarjunsagar Project in Andhra Pradesh, that in the Tungabhadra and Malprabha Project in Karnataka, that in the Purna-Jaikwari Project in Maharashtra, that in the Kakarpara Project in Gujarat and that irrigated by the Western Yamuna Canal in Haryana. This ailment of the soil is mainly due to a rise in the water-table and the concentration of salts in the top layers. As one flies over these areas, vast stretches of land appear white. The State-wise distribution of these areas is given in Table 1.

TABLE 1. THE EXTENT OF SALINE AND ALKALI SOILS IN DIFFERENT STATES OF INDIA (ABROL AND BHUMBLA, 1971)

Name of the State	*Area under saline and alkali soils (hundred thousand hectares)*
Uttar Pradesh	12.95
Gujarat	12.14
West Bengal	8.50
Rajasthan	7.28
Punjab	6.89
Maharashtra	5.34
Haryana	5.26
Orissa	4.04
Karnataka	4.04
Madhya Pradesh	2.24

SOURCE : Central Soil Salinity Research Institute, Karnal

From the point of view of management, salt-affected soils are grouped into two categories, viz. alkali (sodic) soils and saline soils. Alkali soils are largely predominant in the Indo-Gangetic Plain, including Punjab, Haryana, and Uttar Pradesh and parts of Bihar and Rajasthan. Isolated patches of alkali soils also occur in some other States. Saline soils are found mainly in Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Gujarat. Certain areas near the sea-coast have the problem of coastal soil salinity. Alkali soils have an excessive amount of sodium in the exchange complex and are dominated by carbonates and bicarbonates, mainly of sodium. The soil pH is high, being more than 8.2 and often exceeding 10. Saline soils, on the other hand, have an excessive concentration of neutral salts, mainly chlorides and sulphates of sodium. These soils have a pH less than 8.2, but higher electrical conductivity. The physical condition of these soils is generally satisfactory.

RECLAMATION OF SALT-AFFECTED SOILS

The first attempt at reclaiming salt-affected soils in India was made with the application of excess irrigation water, coupled with the growing of rice. These attempts were not based on any knowledge of the basic principles involved in the removal of exchangeable sodium and soluble salts through leaching. This treatment partly succeeded in saline soils by resorting to efficient internal drainage, but leaching did not prove to be effective in areas with high exchangeable sodium.

Reclamation of Saline Soils

The reclamation of saline soils involves the removal of excess salts through leaching or flushing. For the reclamation of highly saline soils in the coastal areas, when sodium chloride is the principal salt, the soils are leached to lower the salt content. The amount of water required for leaching depends upon the initial salinity of the soil and the efficiency of leaching and the quality of the water used for leaching. The aim is to lower the salt content to levels tolerated by crops. Drainage is provided along with leaching, so that the salts are taken away through drains to a nearby outfall. Gypsum is used when leaching raises the soil pH and the soil clay gets dispersed. Salt-tolerant crops are recommended during the reclamation stages.

Reclamation Technology, 1973

The Central Soil Salinity Research Institute, Karnal, has developed techniques for reclaiming saline and alkali soils, for which credit goes to Dr D.R. Bhumbla, the Founder-Director of the Institute, and his colleague, Dr I.P. Abrol. In recognition of this work, they received in 1973 the Rafi Ahmed Kidwai Award from the ICAR and Guinness Award for scientific achievement from the Guinness Trust of the UK in 1978. The methods for the reclamation of saline and alkali soils differ according to the nature of the problem, the extent of alkalinity and salinity, the availability and quality of irrigation water, the depth of the water-table, the presence or absence of calcium carbonates, the layering sequence in the soil and the nature of the amendment available in the vicinity.

The reclamation of alkali soil starts with levelling of the field and removal of representative soil samples from the affected area (Fig. 181). Soil samples are tested in the laboratory to determine the gypsum requirement of the soil. The amendment is evenly spread on the soil and mixed in the surface soil with a light ploughing. The soil is then leached with abundant quantity of irrigation water (Fig. 182). After 2-3 leachings the field is prepared for planting rice. Judicious application of fertilizers ensures a good rice crop even in the first year. After rice, wheat, barley or some legume fodder can be grown in the *rabi* season. The cultivation of the green-manure crop helps in checking the rise of salts during summer and in reclamation due to root activity and decomposition products of the green-manure. In the second year, rice is grown again and the cycle is repeated for two or three years. By this time, the soil gets sufficiently reclaimed for growing other crops.

Gypsum is transported from Rajasthan to the saline-alkali areas and is supplied to farmers on a subsidized basis by Land-Development Corporations, particularly in Punjab, Haryana and Uttar Pradesh.

The schemes for reclaiming alkali soils came into operation in 1974-75.

Over 150,000 hectares has been reclaimed in Haryana, Punjab and Uttar Pradesh, as detailed in Table 2.

TABLE 2. PROGRESS OF RECLAMATION OF ALKALI SOILS IN THE AFFECTED STATES

State		*Year*		*The alkali-affected area reclaimed (ha)*
Haryana		1974-75		1,613
		1976-77		1,838
		1977-78		4,402
		1978-79		5,363
		1979-80		4,944
		1980-81		2,052
			Total:	20,212
Punjab		1975-76		1,486
		1976-77		3,740
		1977-78		9,348
		1978-79		26,990
		1979-80		30,000
		1980-81		Exact figures are not available
			Total:	71,564
Uttar Pradesh	Up to	1977-78		3,847
		1978-79		11,448
		1979-80		18,812
		1980-81		17,065
			Total:	51,172

SOURCE: Director, Central Soil Salinity Research Institute, Karnal

The progress made in Punjab is most remarkable, particularly in the Amritsar, Kapurthala and Sangrur districts, where extensive waterlogging existed. This work, perhaps, has very few parallels in the world. On account of the reclamation of *kallar* areas, bumper crops of rice are now being raised there.

Besides gypsum, iron pyrite is used for reclamation in Bihar and eastern Uttar Pradesh. Pyrite is mined at Amjhore in Bihar. On oxidation, it produces sulphuric acid. The acid reacts with calcium carbonate of the soil to release calcium for exchange with the sodium associated with clay. The other steps of reclamation are similar to those used in the case of gypsum-treated soils. Pressmud, a sugar-factory waste, spentwash from distilleries and organic manures are also used for reclaiming alkali soils. These methods are, however, time-consuming.

Reversal of Degradation

In one of its operational research projects at the Village of Sukhmajri, near Chandigarh, the ICAR has been able to demonstrate an excellent example of the reversal of degradation processes and creation of a permanent food security in the areas of rainfed agriculture through the construction of small farm ponds. With appropriate watershed-management practices, the sediment loss was brought down from more than 150 tonnes to less than 10 tonnes per hectare per year. In a year of severe drought in 1979, the farmers of this village could harvest normal crops from the command area of these ponds. This has opened up new prospects for the future in submontane areas.

Technology for Non-irrigated Land

Under its Dryland Agriculture Research Project, the ICAR has developed a technology which can enable us to effect an increase of about 50 per cent over the average yield of food crops. It has been shown that crops such as mustard and safflower give higher yields and economic returns in many of the non-irrigated areas of the north-western plains. Contrary to the belief, the ICAR scientists have shown that crops in the non-irrigated areas make an excellent use of small doses of chemical fertilizers, whose application, however, needs the use of specially evolved seeds and the right placement of fertilizer doses.

Desert Control

Work on the stabilization of sand-dunes and sylvipastoral system done by the Central Arid Zone Research Institute, Jodhpur, has won international recognition. Information on arid-land resources, sand-dune morphology and desert afforestation has been gathered and schemes have been formulated.

Cropping Systems for Drylands

Research on cropping systems has shown that crop production on dry lands can be stabilized through the diversification of crops, the intercropping of legumes in perennial desert grasses, and other dryland crops (pearl-millet, green-gram, sunflower, castor) and the recycling of run-off water in the event of drought. *Cenchrus ciliaris*, cluster-bean and castor have been identified as potential crops capable of imparting stability to crop production on drylands. In a year of good rainfall (500 mm), with an extended rainy season, the double-crop system of pearl-millet (*bajra),* followed by mustard was found to be most remunerative for such lands.

Soil and Moisture-conservation Measures

Earlier studies have shown that stubble-mulching and wind-strip-cropping are the basic remedies for the maladies caused and accentuated by wind action. In a recent experiment a 1-m-wide strip of pearl-millet planted as a shelter barrier against the prevailing wind direction reduced the wind speed by 63 per cent and increased the yields of summer okra and cowpea by 190 and 90 per cent respectively. To cut down losses owing to deep percolation, a technique of incorporating a partial moisture barrier has been developed at the Institute. The technique works very well when the barrier and run-off concentration systems are combined.

CHAPTER 45

ANIMAL HUSBANDRY

INDIGENOUS BREEDS OF CATTLE AND BUFFALOES
BREEDING POLICY—DUAL-PURPOSE BREED OF CATTLE
CONTRIBUTION TO NATIONAL ECONOMY

CATTLE are indispensable to the rural economy. They provide the motive power for various agricultural operations, including ploughing, irrigation and transport, produce manure for the fields, and supply milk and milk products, which are only source of animal proteins in the diet of the predominantly vegetarian population of the country. The farmers and the landless Harijans supplement their income by selling milk and milk products.

The bovine population of India was 235 million, of which 178 million were cattle and 57 million were buffaloes (1972 census.). Of them, there were about 30 million buffaloes of medium yield (1000-1500 litres per lactation), about 50 million cows of very low production, and less than half a million good dairy cows.[1]

Generally, good cattle are found in areas where fodder crops are grown in plenty. Leguminous fodder crops not only produce a highly nutritious and inexpensive cattle feed, but also supply the green manure for the fields.

INDIAN BREEDS OF CATTLE

The Indian breeds of cattle have a high reputation in foreign markets on account of their suitability for tropical countries and their resistance to drought and major cattle plagues and tick-borne diseases. When the European colonists found that in countries with hot, arid or humid climates and short growing seasons for pastures, as in northern Australia, Brazil, and some southern States of northern America, the cattle introduced by them from temperate zones could not easily withstand either the climatic stress or the fluctuations in the feed supply, they introduced the zebu cattle from India for crossbreeding with a view to combining the productiveness of the European breeds with the hardiness and disease-resistant qualities of the Indian breeds. It was found that about 30 per cent of the Indian blood in cattle ensured the constitution necessary for withstanding the rigours of the tropical environment.

CLASSIFICATION OF BREEDS

Cattle

Broadly speaking, the Indian breeds of cattle can be classified into

[1]Sundaresan, D. *Major Achievements through Research in Livestock Production*, ICAR, 1979

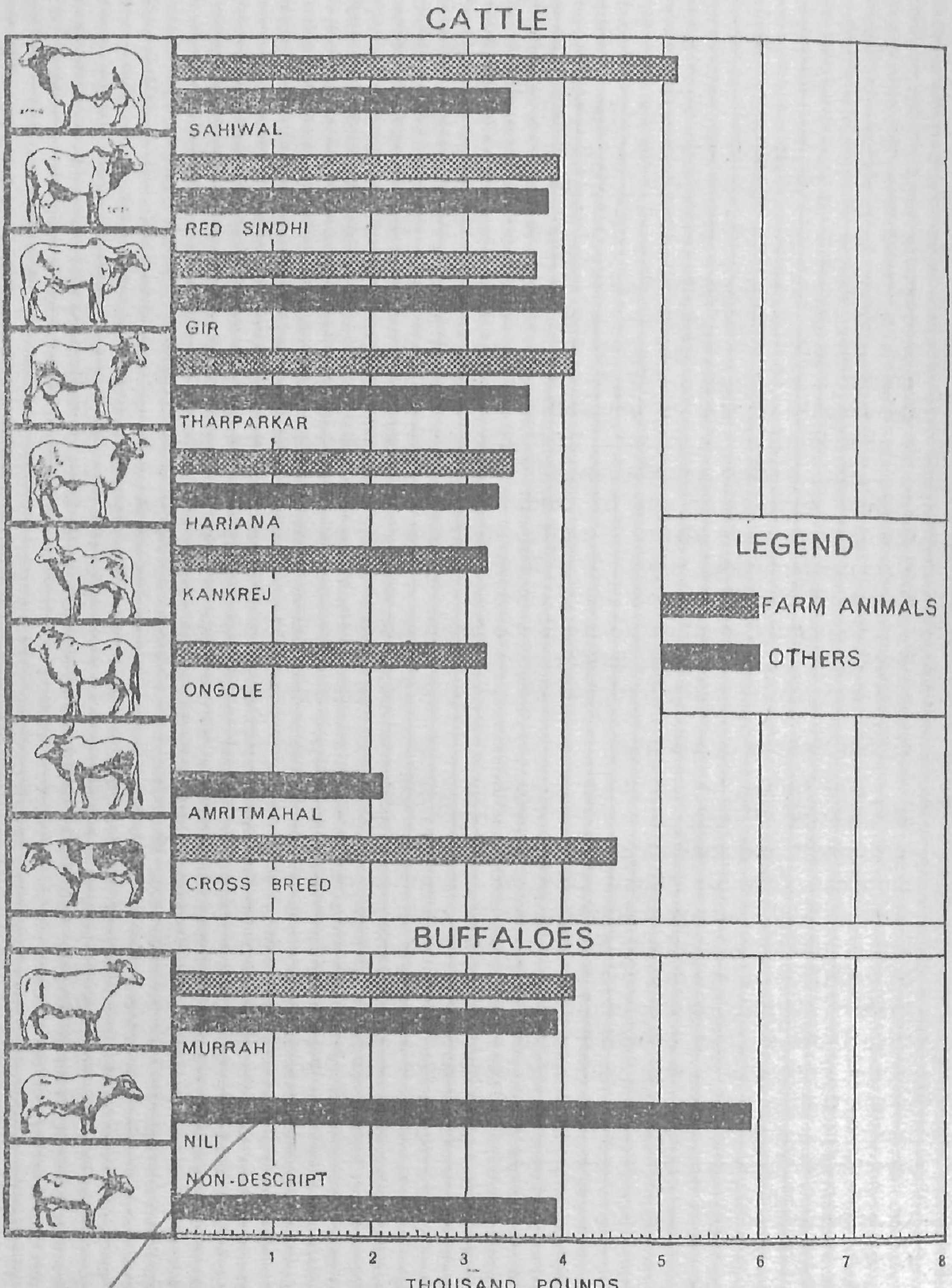


FIG. 184. The average milk yields of important breeds of cattle and buffaloes.

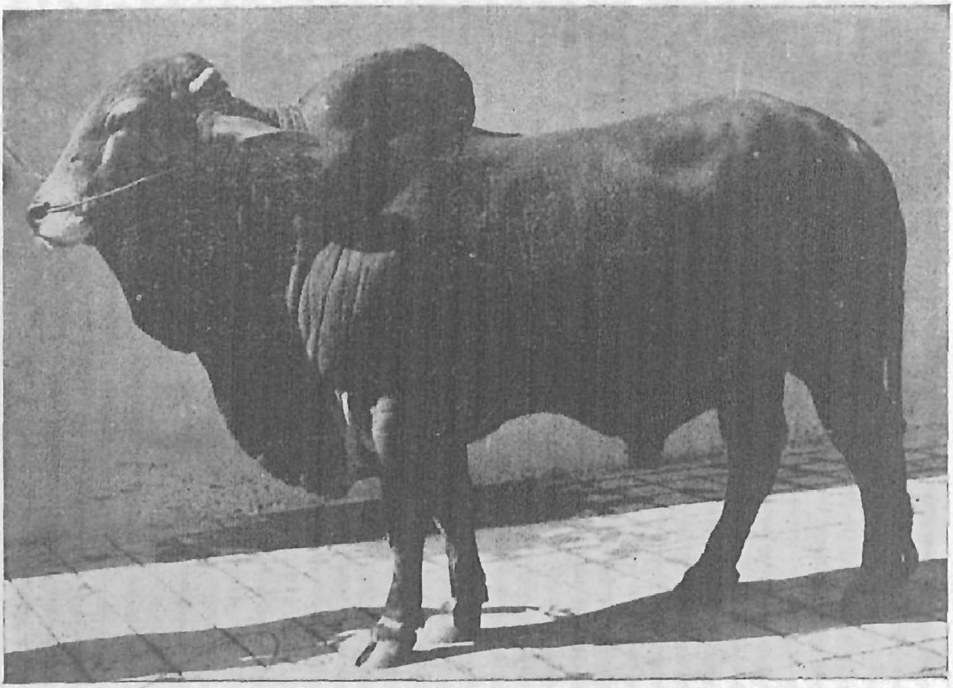
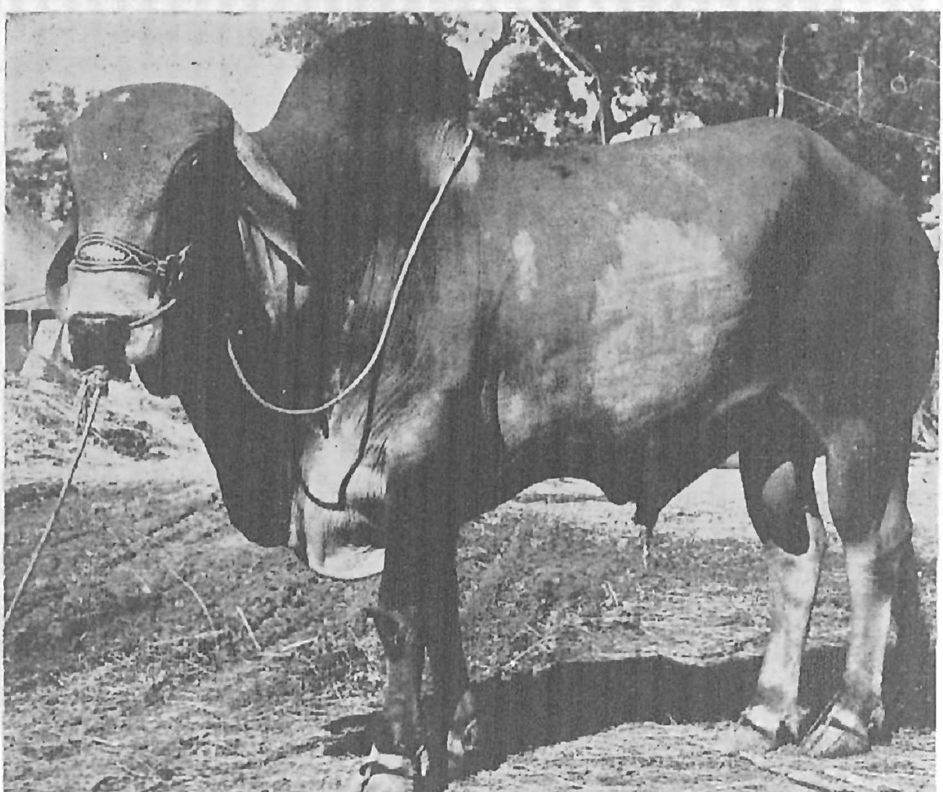


FIG. 185. The bulls of Red Sindhi (*above*) and Gir (*below*). These are high-yielding breeds from Sind (Pakistan) and Gujarat respectively.



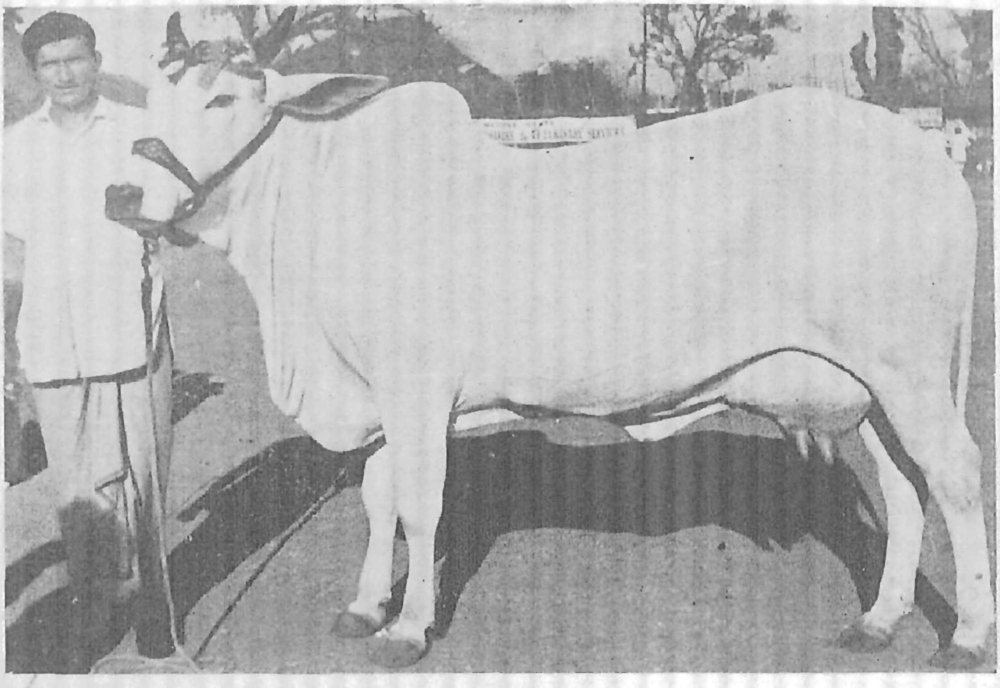
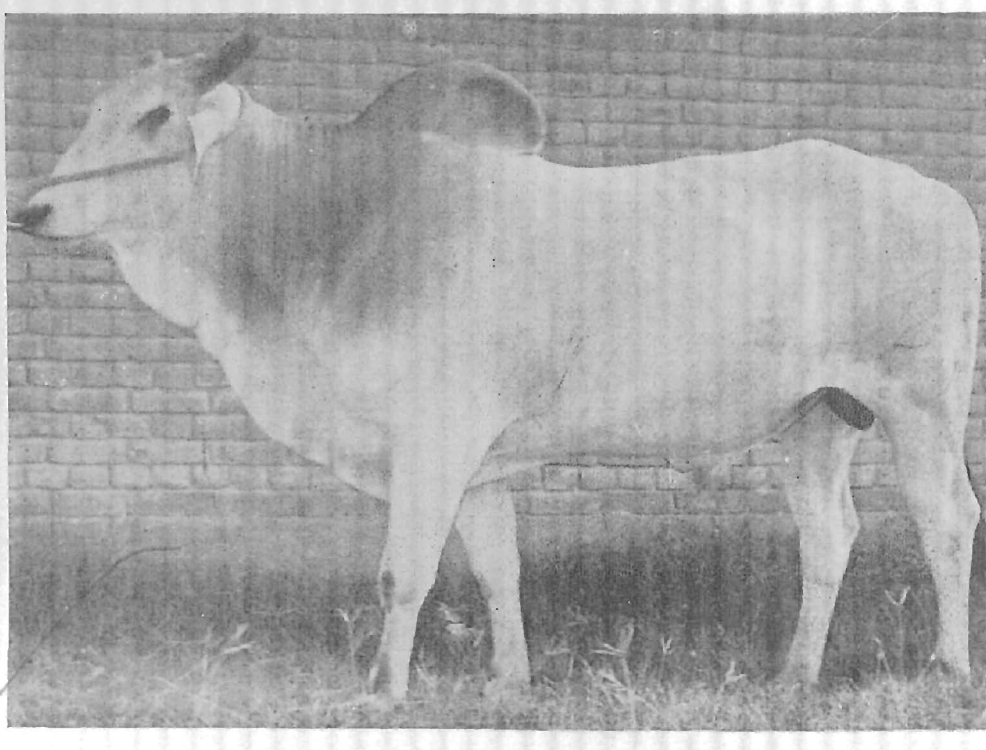


FIG. 186. Hariana is a dual-purpose breed for draught as well as milk production. The cow shown above, giving a yield of 10 kg of milk a day, was adjudged the best in an all-India cattle show.

FIG. 187. Hariana bullocks are excellent draught animals and are extensively used in agricultural operations in northern India.



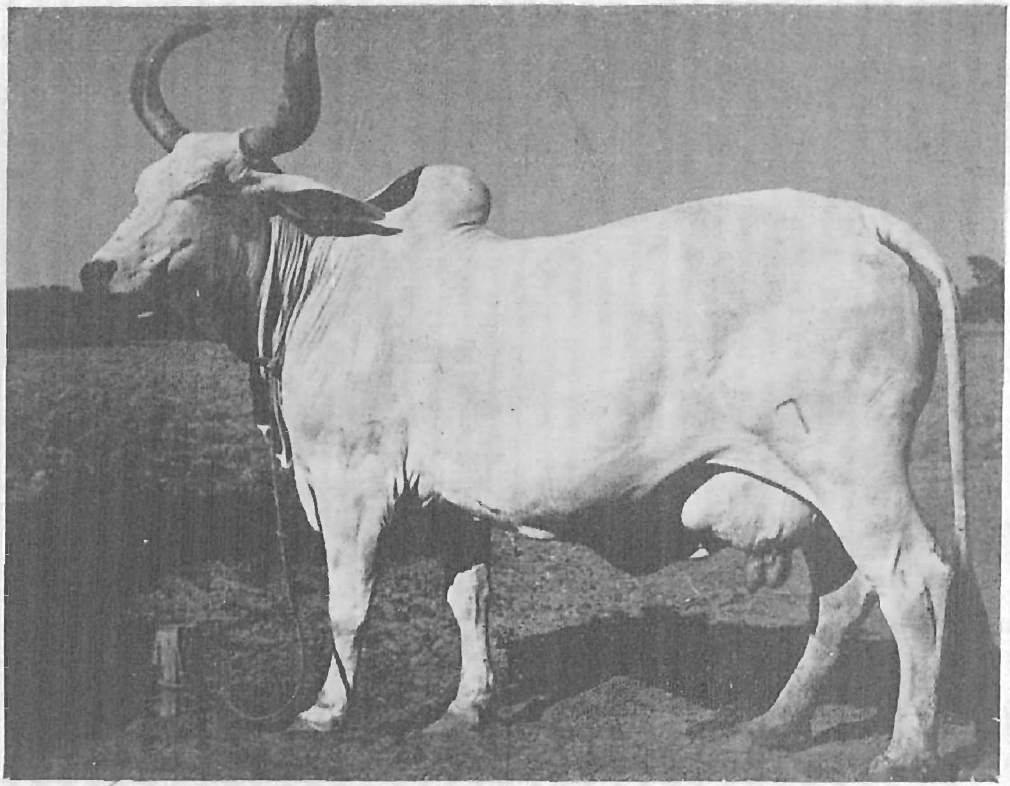
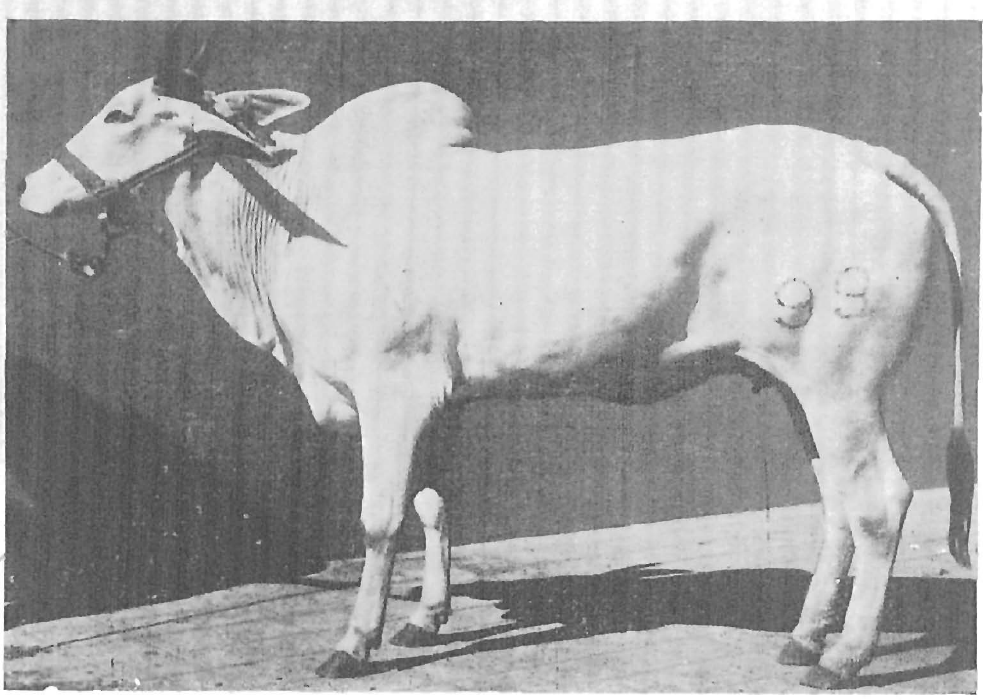


FIG. 188. A Kankrej cow from Gujarat. Kankrej cows are good milkers.

FIG. 189. A Nagori cow. Nagoris are short-horned, white or light-grey cattle with poor milk yield.



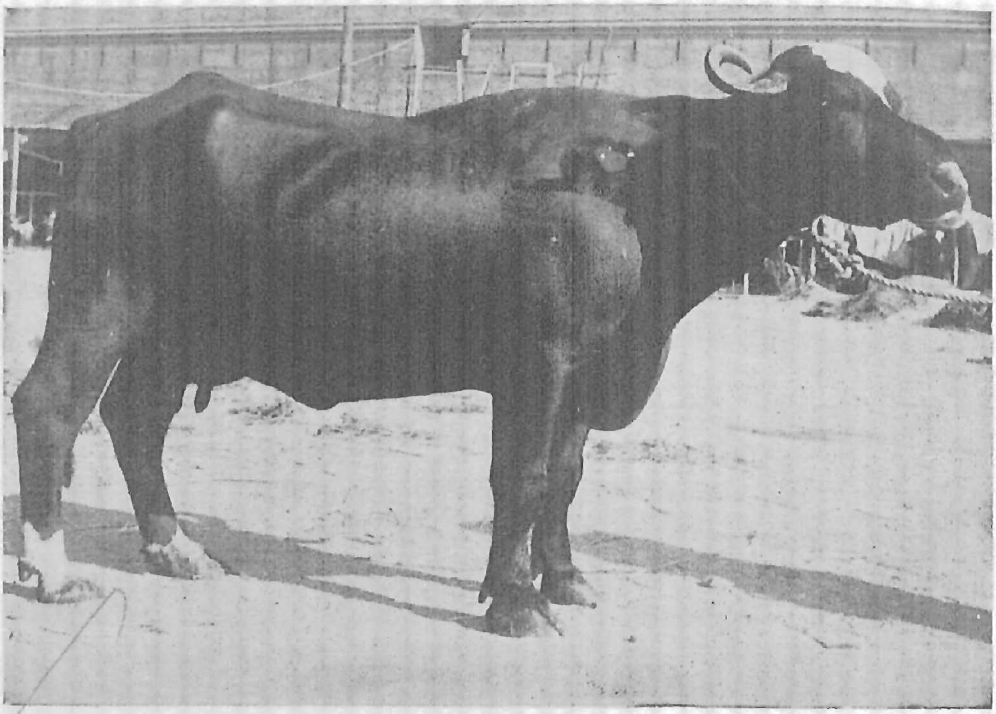
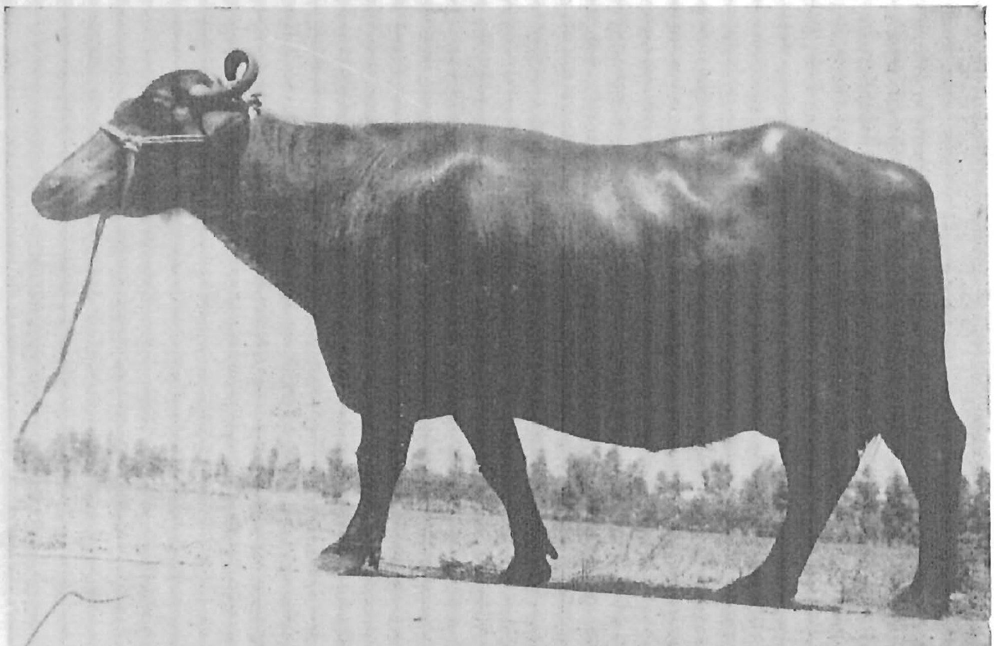


FIG. 190. The buffalo is still the most popular dairy animal in India. Buffaloes are able to digest rough feeds and their milk has high fat content. Their best varieties are: Nili Ravi (*above*) and Murrah (*below*). The Nili Ravi buffalo has white patches on pasterns, forehead and tail. It is found in the Ferozepur riverain in Punjab bordering the River Ravi. Murrah is wide-spread all over Punjab and Haryana.



the following three heads:

(a) *Milch breeds:* The cows are high-yielders; the bullocks are of moderate type or of poor draught quality. The animals are generally ponderous in build, with a pendulous dewlap and sheath, and have lateral and often curled horns. The Sahiwal, Sindhi, Gir, and Tharparkar are some of the outstanding breeds of this group (Fig. 184). The Red Sindhi and Gir are from Sind (Pakistan) and Gujarat respectively (Fig. 185).

(b) *General-utility breeds*: The cows are fairly good milkers, and the bullocks are good for draught. In this group, there are two types of cattle:

(i) Short-horned, white or light-grey cattle, with long coffin-shaped skull and face, slightly convex in profile, e.g. Hariana, Ongole, Gaolao and Krishna Valley. Of these, the Hariana is a dual-purpose breed for draught and milk production (Figs 186 and 187).

(ii) Lyre-horned, grey cattle, deep-bodied, with a wide forehead, prominent orbital arches, flat or dished-in profile, and good draught capacity, e.g. Kankrej. Kankrej cows are good milkers (Fig. 188) and the bullocks are powerful draught animals.

(c) *Draught breeds*: The cows are poor milkers, but the bullocks are excellent draught animals. In this group, there are four types of cattle:

(i) Short-horned white or light-grey cattle, with long coffin-shaped skull and face, slightly convex in profile, e.g. Nagori (Fig. 189).

(ii) Lyre-horned grey cattle, with a wide forehead, prominent orbital arches, flat or dished-in profile, deep body and powerful draught capacity, e.g. Kenkatha, Malvi and Kherigarh.

(iii) 'Mysore type', characterized by a prominent forehead, with long and pointed horns, which rise close together. The animals are, with a few exceptions, poor milkers, e.g. Hallikar, Amritmahal, Kangayam and Khillari.

(iv) Small black, red or dun cattle, often with large patches of white markings, found in the rugged mountainous areas of the Himalayan region or at the foothills. They have tight sheaths and are either short-horned or slighly lyre-horned. They are active, and are useful for light ploughing and miscellaneous work, but their milk yield is poor. They are able to thrive where large animals cannot survive. Ponwar and Siri are notable breeds of the group.

Buffaloes

The best indigenous breeds of buffaloes are Nili and Murrah (Fig. 190). Although the population of buffaloes is much less than that of cows, more than 50 per cent of the milk produced in India, at present, is buffalo's milk, as shown in Table 1.

On account of the higher fat percentage in the buffalo's milk (average 7.5 per cent), it is more commonly used for the manufacture of dairy products, e.g. butter, *ghee*, cheese and *khoa*, and it yields a much greater return than the cow's milk. Moreover, buffaloes are able to digest rougher feeds. Male buffaloes after castration are used for heavy transport as well as for ploughing. They are generally not worked during the hot part of the day. Light-coloured brownish breeds, such as Bhadawari can, however, stand heat better than the jet-black ones.

TABLE 1. PRODUCTION OF MILK (ALL-INDIA FIGURES IN THOUSAND TONNES)

Year	*Cow's milk*	*Buffalo's milk*	*Goat's milk*	*Total*
1951	7,743	9,184	479	17,406
1956	8,180	10,976	561	19,717
1961	8,753	11,087	535	20,375
1968	8,904	1,660	636	21,200
1971	9,450	12,375	675	22,500
1979	9,744	12,760	696	23,200

SOURCE: *Department of Agriculture, Ministry of Food and Agriculture, Government of India*

There are various types of livestock combinations in India. Cattle are predominant in the central belt, comprising Madhya Pradesh, Maharashtra, eastern Uttar Pradesh, Bihar and Orissa. A cattle-buffalo combination is found in the Punjab, Haryana, western Uttar Pradesh and Gujarat. The best dairy animals are found in this belt. A combination of cattle, sheep, goats and camels is seen in Rajasthan (Fig. 191).

The Indian Council of Agricultural Research has been making a systematic study of the indigenous breeds, and the more important breeds of recognized cattle and buffaloes in the country have been defined. The Central and the State governments have established farms for the development of breeds in different parts of the country, so that superior bulls may be available for studs in their respective areas. Side by side, the ICAR established herd books for the registration of all the cattle which conform to breed characteristics and come up to the prescribed minimum standard of production and pedigree. The minimum milk-yield qualifications have been prescribed at 1,134 kg for Kankrej, and Sindhi, at 907 kg for Gir and Hariana, and at 1,136 kg for Sahiwal and Murrah breeds in a lactation not exceeding 300 days. Breeding and milk records are being maintained and cattle at the government farms and elsewhere are registered. The records are being used for selecting stud bulls, and progeny-testing is being gradually introduced into the breeding programme.

Dual-purpose Breeds

In 1928, the Royal Commission on Agriculture laid stress on the production of draught cattle, stating that in attempting to secure more milk from the draught type, there was a real danger of losing the draught qualities. It was also pointed out that the production of dual-purpose cattle might be limited to districts where feeding conditions were good. In 1937, Dr Norman C. Wright, a dairy expert from the UK, recommended the introduction of milk into draught breeds, without bringing about any deterioration in the draught quality. He advised against cross-breeding and laid great stress on the environmental conditions under which the animals were kept. It should be borne in mind that when these recommendations were made tractors and tube-wells were nowhere to be seen in India. Earlier research on cattle breeding had, therefore, been directed towards improving the milking quality of the indigenous breeds. To achieve this objective, the ICAR undertook in 1937 an enquiry in selected breeding tracts to determine the actual levels of production of the various breeds. In 1939, the enquiry was followed by a systematic programme of defining the characteristics of various breeds to facilitate the selection programme. The definition of the characteristics of 25 breeds of cattle and of 7 breeds of buffaloes were finalized through schemes financed by the ICAR. Further, to ensure the improvement of breeds, a programme of pedigree registration was taken up in 1941 with respect to the breeds of all-India importance. A cattle-breeding policy for the country was laid down. Its main feature was to develop the dual-purpose cattle by increasing the milk-yielding capacity of the indigenous breeds without impairing their draught quality. A long-range research programme to evolve the dual-purpose Hariana cattle was started in 1941 in Punjab. A similar programme with respect to the Kangayam breed of Tamil Nadu was taken up in 1942.

Pepperall, another expert in animal husbandry invited by the Government of India in 1944, also cautioned against large-scale cross-breeding in India and recommended that the indigenous breeds should be improved through selective breeding only.

Key-Village Scheme

The ICAR formulated the Key-Village Scheme, a comprehensive programme of cattle improvement in selected compact areas of the breeding tracts of the recognized breeds, where superior pedigree bulls raised at government farms were multiplied. Each such area consisted of a cluster of villages (the Key-Village Block) having 6,000 breedable cows. The scrub males were castrated. An adequate provision for disease control and feeding and marketing of milk were made. The Key-Village Blocks also produced a large number of bulls for distribution in the breeding tract,

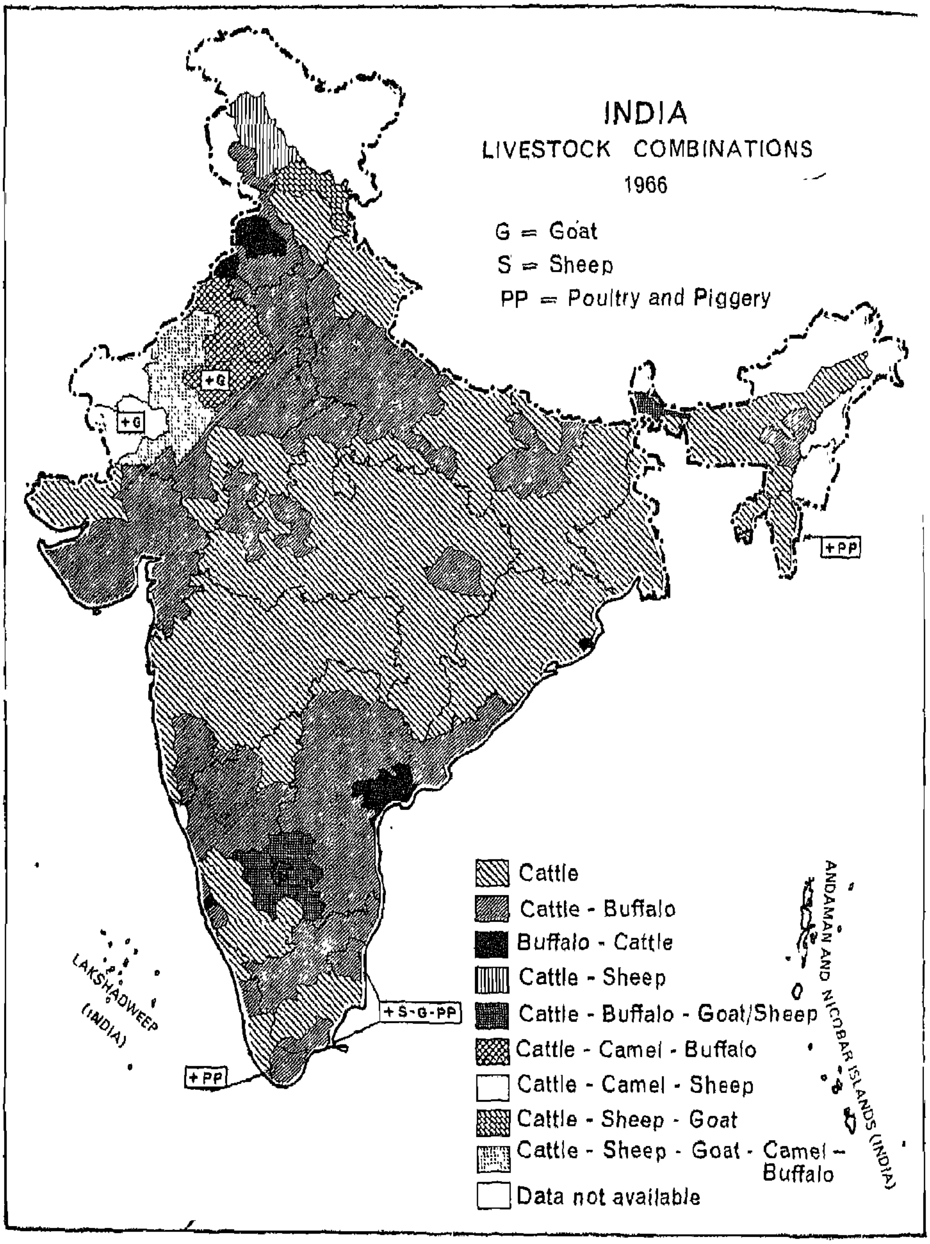


FIG. 191. A map of India showing livestock combinations. Cattle-buffalo combination is predominant in Punjab, Haryana, western Uttar Pradesh, Gujarat and Andhra Pradesh. (After Dr Jasbir Singh, Kurukshetra University, Kurukshetra)

but as the scheme got under way the bulls were used in areas having non-descript cattle for upgrading the latter.

The First Five-Year Plan envisaged the establishing of the Key-Village Blocks and Artificial Insemination Centres. By September 1954, 112 Key-Village Blocks and 340 Artificial Insemination Centres were functioning. The coverage of each block was soon extended to 10,000 breedable cows and buffaloes, and, on the average, each block had eight or nine functional Artificial Insemination Centres. During the Second Plan, 343 Key-Village Blocks were operating, and by the end of the Fourth Plan, 583 blocks were in existence. Thus nearly six million breedable cows and buffaloes were served by the Key-Village Scheme.

Upgrading of Indigenous Breeds: a Slow Process

The inheritance of milk production in dairy cattle is controlled by a large number of genes. Each gene has a small effect and the effect of other similar genes is additive. It has also been established that the heritability of this character on milk production is of low magnitude, being between 0.2 and 0.3. With a heritability of 0.3 and the average production of a selected population of 25 million females around 600 litres of milk per lactation, to increase the average production of their offspring to about 2,500 litres of milk will need about 25 generations of selection, and would take about 150 years.[2] Thus it became evident that the upgrading of indigenous breeds was a painfully slow process, and if any significant advance in milk production were to be made, the country would essentially have to take up crossbreeding with high-yielding foreign breeds.

The Contribution of Livestock to the National Economy

In statistical terms, the yearly contribution from animals, excluding pigs and poultry, to Indian economy in 1933 was nearly Rs 19,500 million, which exceeded the estimated value of crops.[3] In 1951, the estimated annual contribution was Rs 50,000 million.[4]

The export trade in hides and skins alone in 1935 netted nearly Rs 96 million to the country. The foreign-exchange earning from this source in 1966-67 was Rs 691.5 million out of the total export income of Rs 880 million from animal products.[5]

The contribution of animals to agricultural operations was estimated at 28 million horse-power in 1973, and it came mostly from cattle.[6] The

[2]Sundaresan, D. *Major Achievements through Research in Livestock Production*, ICAR, 1979

[3]Olver, A. and Vaidyanathan, N. 'An assessment of the annual contribution of livestock in India to Indian economy', *First Meeting of Animal Husbandry Wing, Board of Agriculture*, 1933, page 268

[4]Datta, S. 1951. Cited by Dhanda and Lall, 1965 *Gosamvardhana* 13:1

[5]Gupta, S. N. 1967. in *Indian Farming, Animal Science Special Number* 17: 65

[6]Swaminathan, M.S. 1973. *Sardar Patel Memorial Lecture*

cash-cost equivalent of this energy obtained from bullocks comes to about Rs 91,720 million. If this much energy were obtained from diesel tractors, it would cost Rs 61,480 million. Thus it is reasonable to deduce that draught animals contribute at least 61,480 million rupees worth of energy every year to the national economy.

Calculating on the 1978-79 production level, the contribution from animal products to the national economy was Rs 87,000 million from milk, Rs 530 million from wool, Rs 10,500 million from meat, Rs 3,100 million from raw hides and skins, Rs 200 million from poultry products,[7] Rs 73 million from bones, Rs 24 million from casings, Rs 45 million from hair and Rs 71 million from bristles. Thus the total annual contribution by animal industry to the economy of the country comes to Rs 171,540 million approximately.

[7]Panda, P.C. and Srihari, B.R. 1970. *Indian Poultry Gazette* 53: 8 (Poultry products in 1970 were valued at 171.5 million rupees. Since then, the egg production has doubled.)

CHAPTER 46

LIVESTOCK HEALTH

THE NATIONAL RINDERPEST-ERADICATION PROGRAMME, 1954-1980
MEASURES FOR THE CONTROL OF THE FOOT-AND-MOUTH DISEASE
HAEMORRHAGIC SEPTICAEMIA AND BLACK-QUARTER
VETERINARY DISEASE INVESTIGATION
VETERINARY HOSPITALS AND DISPENSARIES

SINCE Independence, important schemes have been launched for the control of rinderpest, the foot-and-mouth disease, haemorrhagic septicaemia and black-quarter. Rinderpest (or cattle plague as it is called) is the most virulent disease affecting cattle and buffaloes. The main symptoms are fever, lasting for three or four days, with a temperature of 104-106°F (40-41°C) and constipation, followed by profuse diarrhoea, accompanied with much straining. The faeces are dark and characteristically foetid and are mixed with blood, mucus and epithelial shreds. Shortly after these symptoms disappear, the fever abates, but characteristic lesions appear on the mucosa of the gums, the lips and the undersurface of the tongue. These are pinhead-sized vesicles which burst and leave ulcers that coalesce to form large eroded areas covered with a bran-like deposit. The animal progressively becomes weak and dies in seven to ten days from the onset of the symptoms. Mortality due to the disease varies from 20 to 50 per cent among cattle in the plains, and from 70 to 90 per cent among those in the hills.

The widespread use of the Goat-Tissue Vaccine (GTV) in the country reduced the total losses from contagious diseases by 21 per cent during the six-year period ending March 1938. Rinderpest has remained the most dangerous scourge of cattle in India and Pakistan as singly it killed approximately as many cattle as did all other bacterial and viral diseases. Some 8,000 outbreaks of the disease occurred in India every year, killing about 20,000 bovines.

NATIONAL RINDERPEST-ERADICATION PROGRAMME, 1954

The National Rinderpest-Eradication Programme was put into operation on 1 October 1954. In the first phase, about 16 million cattle and buffaloes in Karnataka, Maharashtra and Andhra Pradesh were vaccinated. This number constituted about 90 per cent coverage of the bovine population. With the experience thus gained, the programme was extended to the rest of the country during the Second and Third Plans. It was planned to vaccinate at least 80 per cent of the bovine population within five years. The follow-up programme consisted in vaccinating 20 per cent of the bovine population and fresh lots of calves every year till the country finally got rid of rinderpest. Besides, the check-posts on the major cattle-movement routes were set up for immunizing animals on the spot, and immune belts were created along the northern and western international borders. From October 1954 to 31 March 1973, 449.65 million animals had been vaccinated. This campaign was followed up by 60 million vaccinations annually. As a result of this mass-scale vaccination, the incidence of rinderpest was drastically reduced and large tracts of land were rendered free from the disease. In 1965, only 306 outbreaks occurred, killing about 2,214 animals as against 8,000 outbreaks causing the deaths of about 200,000 animals before the programme. After an upsurge of the incidence of the disease during the succeeding three years due to the re-entry of the disease in Karnataka, Tamil Nadu and Kerala, which had been free from it during the preceding 20 years, the incidence had been brought down to 403 outbreaks, killing 2,685 bovines in 1968. In 1974, only 231 outbreaks were recorded, as a result of which 1,559 animals died. In 1979-80, 120 outbreaks were reported, killing 2,619 animals in pockets in Tamil Nadu, Madhya Pradesh, Karnataka, Maharashtra, Orissa and West Bengal.

Funds and Staff

From the beginning of the Programme in October 1954 up to 31 March 1980, it had cost India 261.3 million rupees (the share of the Government of India being Rs 114.3 million and that of the States being Rs 147 million). Besides the normal veterinary staff employed in the districts undertake the follow-up rinderpest vaccination as a routine, about 3,500 are employed exclusively for this scheme under vigilance units, check-posts, vaccination stations and the immune-belt teams.

Lapinized Vaccine

Experiments at Mukteswar during 1942-46 revealed that the virulent virus on successive passage through rabbits got progressively attenuated. The 55th-passage virus was used to immunize buffaloes in a small-scale trial in Punjab and the results were encouraging. The strain, however, lost its invasiveness at the 150th passage. The work on the lapinized virus was resumed after importing the Nakamura strain III from Japan with a view to finding out its suitability for immunizing cattle, buffaloes, sheep and goats in India. The strain was found to be stable even after 1,411 passages, the last 616 passages carried out at Mukteswar retaining its virulent character. This trial indicated its great potential for use in the field.

The lapinized vaccine was given extensive trials in Punjab, Uttar Pradesh, Bengal, Hyderabad, Rajasthan and Madras, immunizing about

30,000 animals (cattle, buffaloes, sheep and goats), mostly on organized farms. The vaccine proved to be safe even for animals in advanced pregnancy, and did *not* cause any appreciable reduction in the yield of milk. It conferred immunity on the animals for at least four years. The freeze-dried virus stored at —10°C was fully viable for more than six months.

The development of the lapinized vaccine made possible the formulation of a 10-year plan for the eradication of rinderpest from the country. The FAO/UN contributed to the execution of the plan by deputing experts and by supplying the necessary machinery for manufacturing the vaccine in India on a large scale.

The leadership for the Rinderpest-Eradication Programme was provided by Dr Laxmi Sahai, who was the Director of the Indian Veterinary Research Institute, Izatnagar, from 1954 to 1957, and Animal Husbandry Commissioner, Ministry of Food and Agriculture, Government of India, from 1957 to 1964.

Whereas the follow-up vaccinations are being undertaken in all the districts of the country, the needs of the vulnerable areas are being met through special institutions, viz. 114 vigilance units, 199 check-posts, 32 immune-belt teams and 22 vaccination stations. All these institutions, on an average, vaccinate about one-fifth of the bovine population of the country

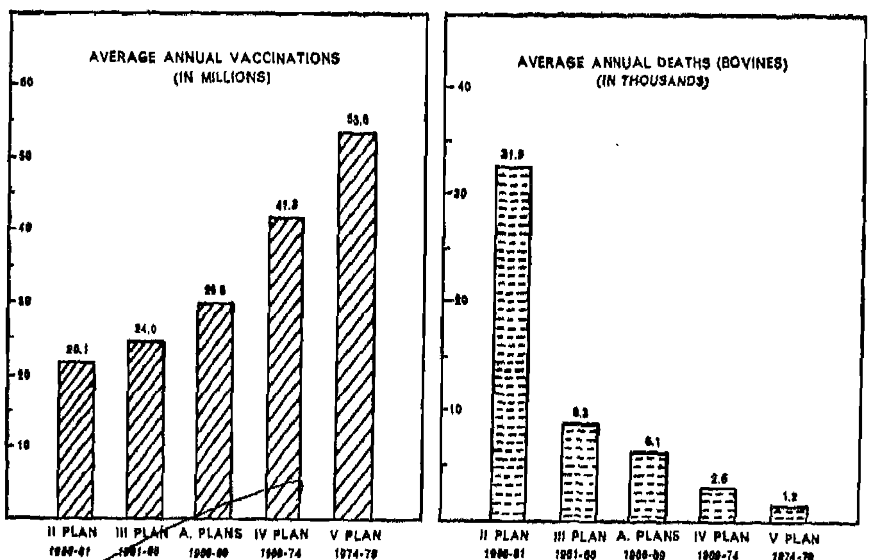


FIG. 192. The control of rinderpest in India from 1956 to 1979. During the Second Five-Year Plan, when the scheme was started, 20.1 million vaccinations were performed. In 1974-79 the average annual vaccinations were 53.6 million. The average annual deaths due to rinderpest were 31,900 in the Second Five-Year Plan. This number got reduced to about 1,000 only in 1974-79.

every year. The total number of vaccinations carried out and the decrease in the incidence of the disease in bovines from the First Five-Year Plan to 1980 are evident from Fig. 192. The disease-eradication campaign was made more effective during the Fifth Plan, when a new strategy of surveillance and containment vaccinations was adopted. Under this strategy, systematic searches to locate the endemic foci of infection were undertaken and wherever the disease was detected, containment measures such as ring vaccinations, quarantining, and scientific disposal of fomites and carcases were taken up.

The Foot-and-Mouth Disease

The foot-and-mouth disease is a global problem. It affects cattle, buffaloes, sheep, goats and pigs. Exotic cattle and their cross-breds are more susceptible than the local breeds.

The disease is ushered in by fever, followed by the appearance of vasicles in the mouth, or on feet, or at both the places. The vasicles quickly rupture, resulting in raw ulcerated areas, and cause drooling and lameness. Sometimes the lesions appear on teats also. In severe cases, the hooves are shed. The yield of milk decreases, and in an outbreak the decrease could be as much as 53 per cent in cross-bred cows and 32.2 per cent in indigenous hill-bred ones. The malignant phase of the disease stops the secretion of milk entirely. The recovered cattle may develop 'panting', i.e. the intolerance of high atmospheric temperature. At several military farms, 8.4 per cent of the cross-breds and 2.4 per cent of the animals among the local breeds were known to have become panters because of the involvement of the heart. The mortality among the exotic and cross-bred cattle may vary from 10 to 70 per cent, particularly among the unvaccinated calves, whose entire crop may be lost.

The foot-and-mouth disease is highly contagious. Its outbreaks keep on occurring throughout the year. High-cattle-density areas are most affected. The movement of cattle, particularly due to cattle fairs, facilitates the spread of the disease. Some 5,000 outbreaks, involving about 2,75,000 animals, were recorded each year from 1962 to 1973, causing an annual loss of about 40 million rupees.

The FMD virus has seven known types, and each type has several subtypes. In India, four types have been recorded so far. Vaccination against one type does not confer protection against other types. In fact, protection is maximum against a homologous subtype, i.e. the subtype used in vaccine production. The FMD virus is antigenically very labile, as aberrant types develop consequent upon its continued passage through animals. This plurality of types and subtypes has made the task of controlling the disease extremely difficult and expensive.

In view of the great economic importance of this disease in the context of the cross-breeding programme, an increase in the number of cross-bred cattle increases the frequency of the outbreaks, particularly in areas where cattle population is high.

The only way to control the disease is by regular periodical vaccination. In view of the plurality of the types and their immunological distinctness, the knowledge of the prevalent type(s) is essential while manufacturing an effective vaccine.

Researches on the FMD done at Mukteswar furnished not only the background information on the disease in India, but also created indigenous professional competence, leading to the quick adoption of modern technology for manufacturing the vaccine in the country on a large scale.

An ICAR-sponsored scheme started research on this disease at Mukteswar in 1943. The typing of the strains of the FMD virus up to the end of 1954[1] revealed the presence of O, A, C and some variants or a typical types in the country, and that the O type was the commonest. Subsequent work added Asia 1 as the fourth type, first reported in 1954 from Pakistan.

Work on evolving the FMD vaccine at Mukteswar began in the early 1940s. The crystal-violet vaccine, consisting of the emulsified epithelium of cattle tongues, the source of the virus, inactivated with crystal violet, was shown to confer immunity on animals for several months.[2] The efficacy of the vaccine in the field was proved by very small number of the protected animals infected during the outbreaks, and thereafter the disease occurred in a mild form, against the involvement of as many as 52.5 to 83 per cent of the unvaccinated cattle.

Early attempts at producing the gel-vaccine, i.e. the virus adsorbed on alumina gel and inactivated with formalin, gave variable results. But the subsequent development of the cell-culture technique for growing the virus in bulk led to the present-day version of the gel-vaccine in use in many countries of the world.

Research on this disease has been strengthened with the operation of an All-India Co-ordinated Researh Project since 1 July 1971, with the prime objective of collecting information on the occurrence of the types and subtypes in the country, so that the prevalent ones be incorporated into the process of vaccine manufacture, and the epidemiology of the outbreaks may be studied. Under this scheme, a central type laboratory was set up at Mukteswar and three regional centres at Hyderabad, Hissar and Calcutta. Subsequently, the units for studying the epidemiology of the disease were established in several States for intensifying the collecting of the strains and for typing them. The ultimate objective is the manufacture of the monovalent vaccine immediately after typing the strain of the virus involved in

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[1] *IVRI Report*, 1953-54

[2] *IVRI Reports*, 1942-1951

an outbreak. This procedure will reduce the cost of producing the vaccine.

At present, only the polyvalent vaccine, into which are incorporated O, A, C, and Asia 1 types, is being produced in bulk at Bombay by the Hoechst, at Vagholi by Bharatiya Agro-Industries Foundation, and at Izatnagar by the IVRI. The reported licensed capacity at these places is 10, 8.2 and 3 million doses of quadrivalent vaccine respectively. In addition, another unit at Hyderabad, with the licensed capacity of 25 million doses, is being put up by the Indian Dairy Corporation with assistance from Wellcome Foundation of the U.K.

In order to intensify the vaccination programme in the country, a scheme sponsored by the Government of India was started in 1975-76. Under this scheme, the sale of the vaccine to the farmers was subsidized, the government paying half the cost of the vaccine. From 1 April 1975 to 31 March 1980, the Government spent Rs 12.656 million as subsidy. The cost of the vaccine has now been brought down by the manufacturers from Rs 14 per dose—the price when the vaccine was first put on the market—to Rs 4-5 per dose. The vaccination programme has become popular. Some 3.75 million vaccinations were done from 1 April 1975 to 31 March 1979.

The indigenous development of the technology for typing the virus and for producing the vaccine in bulk is an outstanding achievement. Without this development, a large-scale cross-breeding of cattle would not have been possible.

Haemorrhagic Septicaemia

Haemorrhagic septicaemia (HS) affects cattle and buffaloes. The disease occurs sporadically, but might be followed by an outbreak. The death of the animal may occur within a few hours after it contracts the disease. The common symptom is asphyxia (hence the local name *galghottu*), caused by the oedematous swelling under the skin of the head and the neck. Some animals may suffer from the haemorrhagic inflammation of the intestine or from pneumonia. The death-rate may go up to 80 per cent or more.

This disease was considered to be second only to rinderpest in importance in India. The magnitude of the losses can be assessed from the statistics for the period 1949-53 On an average, 1,825 outbreaks occurred in a year, involving 11,000 bovines, killing 8,425 of them.

No satisfactory vaccine against this disease was available till the advent of the adjuvant vaccine in 1954, developed at Mukteswar. The use of the vaccine brought down the number of outbreaks by 69 per cent, the number of animals affected by 89 per cent, and the number of deaths by 80 per cent for the period 1962-73.

Losses from this disease can be eliminated with vaccination before the advent of the monsooon.[3]

BLACK-QUARTER

Black-quarter, a bacterial disease, has been known to exist in India since long. Its outbreaks have remained restricted to low-lying and poorly drained tracts and have been occurring during the rainy season. The main symptoms of the disease are high fever, a hot, tense and painful swelling, usually on the fore quarters and the hind quarters. Mortality is high. During 1948-52, 23,525 animals, on the average, were affected annually. Out of them, 20,230 died (86 per cent mortality). During 1962-1973, this disease killed 10,430 cattle and buffaloes every year. Before the production of the vaccine in 1951, it killed, on an average, 21,500 animals every year.[4]

Nearly 85 per cent of the outbreaks in the country occurred in Tamil Nadu, Karnataka and the Hyderabad region of Andhra Pradesh. In Tamil Nadu the disease struck throughout the year and it ranked in importance next only to rinderpest.

An examination at Mukteswar of 217 anaerobes collected from the outbreaks in the country during 1952 to 1955 revealed the comparative bacteriology of black-quarter. Extensive investigation established that *Clostridium chauvoei* was the real cause of the disease in India. This finding is of importance in the production of the vaccine. Studies at Mukteswar conducted between 1942 and 1946 and between 1952 and 1955 on the growth requirements of this pathogen made available a culture medium supporting the maximum growth. This medium was adopted for the large-scale manufacturing of the vaccine. Moreover, a better technique, involving the neutralization of the pH and the precipitation of the bacterial growth with alum, improved the quality of the vaccine which maintained its potency for 11 months.

The Bharatiya Agro-Industries Foundation, Uruli-Kanchan (BAIF), is manufacturing a vaccine adjuvanted with alumina hydrogel and is reported to be 4-6 times more potent than the vaccine in the form of a powder. Moreover, a combined HS and black-quarter vaccine, adjuvanted with hydrogel, is available. It eliminates the bother of two separate vaccinations.

VETERINARY DISEASE INVESTIGATION AND SURVEILLANCE

Scientific veterinary investigation in India started in 1930s, when the ICAR appointed veterinary disease-investigation officers in the provinces.

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[3]Dhanda, M. R., Das, M. S., Lall, J. M. and Seth, R. N. 1956, *Indian J. vet. Sci.* **26**, 273

[4]Ministry of Food & Agriculture, *Animal Health Information Service: Contagious Diseases Bulletins* for the years 1962-1973, Govt of India, New Delhi

They did yeoman's service by investigating and documenting important diseases among livestock and poultry. The investigation schemes were taken over as a regular activity by the States after 1947. The result is that now each State has its own veterinary disease-investigation unit which is a sort of 'fire-brigade' and immediately moves to the site of the outbreak of a disease.

Veterinary Hospitals and Dispensaries

Along with preventive measures taken to protect the animals against virulent diseases, steps were taken to protect them against diseases by augmenting veterinary facilities. When the Royal Commission on Agriculture submitted its report in 1928, there were 904 veterinary hospitals and dispensaries in India. The Commission observed that 'in no sphere had scientific research conferred greater benefits on agriculture than by providing the means of controlling livestock diseases'. It recommended that there should be at least one veterinarian for every 25,000 animals. By 1956, as many as 2,656 veterinary hospitals or dispensaries were functioning in the country. Their number arose to 5,923 by 1966 and to 9,495 by 1972. By 1974, one veterinarian was available for 26,000 cattle 'units' in the country. This is not a satisfactory situation as owing to the recent emphasis on animal and poultry production, both the public and private sectors are adding highly productive livestock and poultry at a fast rate to the animal wealth of the country. Such stock is known to be more susceptible to diseases. Moreover, the increased density of population of such stock facilitates the spread of diseases within a herd of a flock.

A farmer now has no time, at least not in the agriculturally advanced regions, to take his sick animals to a veterinary hospital. He demands service at his doorstep. This service, even if paid for, is cheaper to him and is also more beneficial to the ailing animal. The State departments of animal husbandry are partly meeting this demand by operating mobile veterinary clinics.

CHAPTER 47

ANIMAL HUSBANDRY

CROSS-BREEDING OF CATTLE

SPORADIC attempts to cross-breed indigenous zebu cattle (*Bos indicus*) with European breeds (*Bos taurus*) were initiated during the latter part of the nineteenth century. The European tea-planters and missionaries in northern Bengal, Assam and the Nilgiris (south India) imported animals of the exotic breeds and used them for cross-breeding with the local cows. A large number of cross-bred cows were produced and further bred through *inter-se* mating. These cattle can still be seen in cities such as Bangalore and Madras. Their yield is reported to be around 1,000 kg per lactation—more than twice that of the local cows.

A notable example of the fruits of early cross-breeding is the development of the Taylor breed of Patna. This breed is reported to have been developed after 1857 by cross-breeding the animals of an exotic herd of cattle left by Mr Taylor, the Divisional Commissioner of Patna, with the local zebu cattle. Although originally high-yielding, the Taylor breed considerably deteriorated with the lapse of time owing to the lack of selection and non-introduction of fresh exotic germplasm.

CROSS-BREEDING AT THE MILITARY FARMS

Military dairy-farms were the first to undertake large-scale organized cross-breeding with European breeds of cattle. These farms were established towards the end of the nineteenth century (the first Military Farm at Allahabad in 1889) to supply milk to the British troops in India. It was soon recognized that cross-breeding was necessary for a rapid increase in milk production. Several Ayrshire, 2 or 3 Shorthorn and one Holstein-Friesian bulls were imported and put into service in 1908. A few Jersey bulls were also used. From 1912 to 1920, only the Ayrshire bulls were used. However, when the subsequent generations of the Ayrshire offspring were found to show a low level of sturdiness and serious constitutional weakness, the use of the Ayrshire bulls was discontinued. From 1924 onwards, only the Holstein-Friesian bulls were imported for cross-breeding. Imports were made from the USA, Britain and South Africa.

The cross-breeding programmes at the military farms were continued till 1952 when, on the recommendation of an expert committee, it was decided to revert to back-crossing with bulls of the indigenous Sahiwal, Sindhi, Tharparkar, Hariana and Gir. This decision was taken to avoid dependence on recurring imports. Fortunately, in pursuance of the recommendation in 1958 of the Reorganization Committee, cross-breeding was restarted with the Holstein-Friesian bulls at all the military dairy-farms in 1960. For this purpose, 15 Holstein-Friesian bulls were imported from Holland. More bulls were later obtained from Sri Lanka, Australia and New Zealand. For a few years, Red Dane bulls were also used for cross-breeding at the Bangalore Military Dairy Farm but their use was later discontinued in favour of the Holstein-Friesian bulls.

The military farms have been following a policy of criss-cross breeding with the local and exotic bulls, so that cross-bred stocks with exotic germplasm varying from almost zero to hundred per cent have been generated. The cross-bred cows give the 300-day average lactation yield of 2,500 litres at the age of 28-30 months at the first calving.

Cross-breeding during the Early 1900s

Outside the military dairy-farms, one of the earliest organized cross-breeding programmes was taken up at the National Dairy Research Institute, Bangalore, in 1910. Initially, the programme of cross-breeding was started with the Ayrshire bulls and the Hariana cows, but it was later extended to include other indigenous (Sahiwal, Sindhi and Tharparkar) and exotic (Jersey and Holstein-Friesian) breeds.

In 1919, the Madras Government undertook a cross-breeding scheme at the Hosur Farm. The Programme envisaged the use of Ayrshire bulls to cover Sindhi and Sahiwal cows. The cross-breds showed their distinct superiority in milk production and in the shortness of the dry period. The results of this project were published by R.W. Littlewood in 1933.

The Agricultural Institute, Allahabad, procured Holstein-Friesian, Brown Swiss, Guernsey and Jersey breeds from 1924 to 1934 and used them for cross-breeding with Sindhi, Sahiwal, Kankrej, Gir and Hariana breeds. From 1934 onwards, only Jersey was used on Red Sindhi cows, followed by repeated back-crossing with Red Sindhi bulls till 1952. The result showed that the Jersey × Red Sindhi halfbreds were superior to other grades.

Cross-breeding during the 1950s

In addition to the ICAR-sponsored Project on Cross-breeding in Hilly and Heavy-Rainfall Areas taken up at 12 locations in 10 States, isolated attempts to carry out cross-breeding in the field were made in some other areas during the 1950s. Cross-breeding in Himachal Pradesh was undertaken in 1953 with Jersey-Sindhi cross-bred bulls obtained from the Agricultural Research Institute, Allahabad. Later, Jersey bulls were obtained from Australia and a cattle-breeding farm was established at Katuala in the Mandi District. The Himachal Pradesh Government also obtained some Dexter cattle from Jammu and Kashmir in 1956 and used them for cross-breeding. The Mysore Government took up cross-breeding to increase milk production in the urban areas of Bangalore and Mysore during 1955-56.

FIG. 193. Three-breed cross-bred heifers (produced by mating Red Dane × Sahiwal half-breds with Holstein-Friesian bulls) at the Punjab Agricultural University Dairy Farm, Ludhiana.

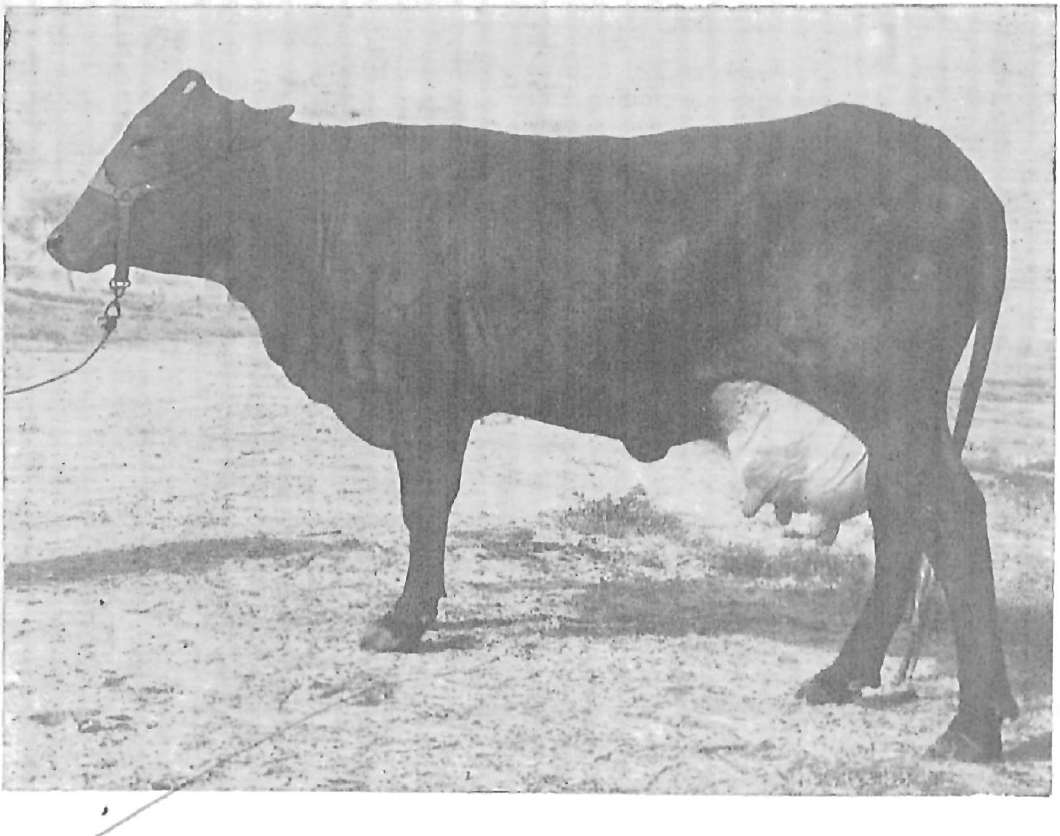

FIG. 194. The most outstanding Red Dane × Sahiwal cow at the Punjab Agricultural University Dairy Farm which attained a daily peak yield of 50.9 kg and produced 7,309 kg of milk in 305 days of her second lactation.

FIG. 195A. Portrait of Manibhai Bhimbhai Desai (b. 1920), Director of Bharatiya Agro-Industries Foundation, Pune, and Integrated Rural Development Programme, Uruli Kanchan. He has done outstanding work in improving the milk yield of local cows in Maharashtra by cross-breeding.

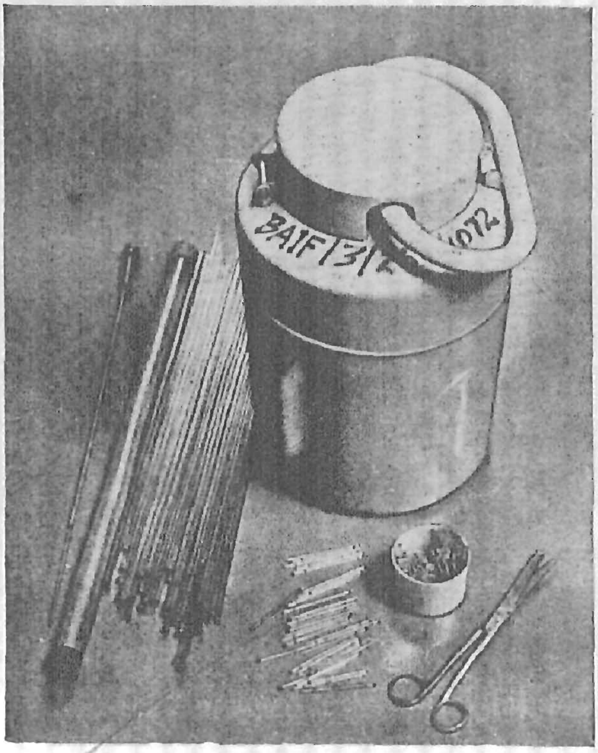

FIG. 195B. Equipment used for artificial insemination by Dr Mani Bhai Desai.

The semen of the Jersey bulls for this purpose was obtained from the National Dairy Research Institute, Bangalore.

CROSS-BREEDING WITH FOREIGN BREED, 1953

The Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry of the Government of India in the meeting, held at Poona in 1953, decided that a pilot project on cross-breeding should be taken up on a field scale in selected hilly and heavy-rainfall areas of the country. Accordingly, 12 ICAR-sponsored cross-breeding units were set up between 1955 and 1957 at Palampur (Punjab), Darjeeling (Bengal), Choharpur (Uttar Pradesh), Ranchi (Bihar), Shillong (Assam), Imphal (Manipur), Vishakhapatnam and Hyderabad (Andhra Pradesh), Coorg (Karnataka), Ootacamund (Tamil Nadu) and Noyattinkara and Chalakudy (Kerala). The Jersey cross-breds produced under this programme yielded 1,200–1,800 litres of milk per lactation. The Poona meeting of the Animal Husbandry Wing also recommended that cross-breeding might be taken up for research.

NILS LAGERLOF AND TRAINING TO INDIAN VETERINARIANS IN ANIMAL REPRODUCTION, 1953

The year 1953 marked the beginning of a new chapter in the field of Animal Reproduction. The FAO/UN at the request of Government of India, sent Professor Nils Lagerlof of the Royal College of Veterinary Science, Stockholm, Sweden, along with his two colleagues to India to vet the Key-Village Scheme and suggest modifications, if any, required. Professor Lagerlof, after touring the country, learnt of the complete absence of animal reproduction specialists. He, therefore, suggested to the Government of India to depute a few veterinarians specially interested in animal reproduction for training in the subject in Sweden.

This programme from 1957 onward made available each year a number of specialists in Animal Reproduction, some of whom were appointed Professors of Animal Gynaecology and Obstetrics in Veterinary Colleges, and others as Sterility Officers in States under ICAR sponsored schemes (1954-1969). They investigated the incidence of reproductive disorders of milch animals and took measures to overcome them. These specialists are playing an important role in ensuring the optimum sexual health of the milch animals and consequently enhanced milk production as a female must reproduce to produce.

CROSS-BREEDING OF EXOTIC BREEDS WITH NON-DESCRIPT CATTLE

The fourteenth meeting of the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry, held at Bangalore in 1961, reiterated that cross-breeding with non-descript cattle should be done in areas where feeding and management conditions were suitable for the maintenance of cross-bred cows. The meeting further recommended that only a few selected exotic breeds found suitable for cross-breeding in India and under similar environments elsewhere should be imported and not more than one exotic breed should be used in any one area. This meeting also recommended the release of foreign exchange to import and build up the foundation stock of the selected exotic breeds.

During March 1961, the Central Council of Gosamvardhana decided that there was no objection to taking up cross-breeding schemes on an experimental basis. The Committee took this decision after considering a note by Raja Bajrang Bahadur Singh of Bhadri in which he had stressed the initiation of intensive cross-breeding programmes.

A subsequent meeting of the Central Council of Gosamvardhana in 1961 set up a subcommittee under the Chairmanship of Raja Bajrang Bahadur Singh of Bhadri to consider the entire cattle breeding policy, including cross-breeding with exotic breeds. The Committee generally favoured the cross-breeding approach for cattle improvement and recommended that intensive cross-breeding should be taken up in three selected areas, one each in the plateau, the plains and the hills. It also supported the proposal for taking up research oriented cross-breeding projects at Haringhata (West Bengal) and at the National Dairy Research Institute, Karnal. The Committee suggested that a thorough analysis be undertaken of the data on cross-bred cattle generated at the military dairy farms.

In 1965, the Scientific Panel on Animal Husbandry constituted by the Ministry of Agriculture and Irrigation reviewed the cattle breeding policy in the country and suggested the undertaking of an intensive co-ordinated cross-breeding programme. The Panel recommended that Jersey should be the main breed for cross-breeding in India and Holstein-Friesian, Brown Swiss and Red Dane may be used to a limited extent. The Panel also suggested that exotic germplasm be maintained at 50 per cent level through *inter se* mating of the halfbreds, except that cross-breds with higher levels of exotic germplasm may be produced in areas with particularly favourable conditions of feeding and management. Ayrshire animals were imported by Maharaja Dr Karan Singh, and a number of cross-bred cattle were produced around Srinagar.

The cross-breeding project at Haringhata was started in 1956 and was considerably expanded in 1963 and 1968, with financial support from the ICAR, the United Nations Development Programme and PL-480. Initially, the programme was confined to crossing Jersey bulls with Hariana cows but was later extended to include the crossing of Hariana cows with Holstein-Friesian as well as with Brown Swiss. The enlarged Haringhata cross-breeding project was the first large scale organized research scheme on cross-breeding in the country. The results of this project provided further convincing evidence of the superiority of cross-breds in their production potential.

The National Dairy Research Institute, Karnal, took up cross-breeding with the American Brown Swiss semen, using Sahiwal and Red Sindhi cows. The project was later expanded to include Holstein-Friesian and Jersey breeds on the male side and the Tharparkar breed on the female side. Sahiwal× Brown Swiss cross-bred cattle have been officially baptized as Karan Swiss.

CROSS-BREEDING PROJECT UNDER INTERNATIONAL ASSISTANCE, 1970

Starting in the early 1970s, five cross-breeding programmes receiving assistance under the bilateral international agreements were taken up in the field. These were: the Indo-Swiss Projects in Kerala (Madupetty) and Punjab (Patiala), the Indo-German Agricultural Development Projects in Himachal Pradesh (Mandi) and Uttar Pradesh (Almora) and the Indo-Danish Dairy Project in Karnataka (Hessaraghatta). The Kerala Indo-Swiss Project, started in 1963, envisaged the production of Brown Swiss× Local cross-breds, with 62.5 per cent Brown Swiss germplasm. The Patiala project taken up in 1971 aimed at cross-breeding the population of local cows with the Brown Swiss semen, followed by repeated matings with Sahiwal ×Brown Swiss half-bred bulls so as to ultimately generate a breed with 50 per cent Brown Swiss germplasm and 50 per cent Sahiwal germplasm. The Indo-Swiss Project, Patiala, was discontinued in 1979, because the farmers preferred to have cross-breds of the Holstein-Friesian breed.

The Indo-Danish project gave assistance to import and build up a foundation herd of Red Dane breed at Hessaraghatta.

The cross-breeding programme under the Indo-German Agricultural Development Programme involved the crossing of local cattle with the bulls of German Highland Spotted breed in Mandi and with Brown Swiss in Kumaon.

Two ICAR sponsored programmes involving the cross-breeding of Hariana cows with Holstein-Friesian, Brown Swiss and Jersey bulls were undertaken during the mid-1960s at the Punjab Agricultural University, Hissar and at the Indian Veterinary Research Institute, Izatnagar. Later, these two centres and the Haringhata projects became part of the All-India Cattle Improvement Project sponsored by the ICAR with effect from 1969. The additional centres of the project were set up in Madhya Pradesh (Jabalpur), Maharashtra (Rahuri) and Andhra Pradesh (Lam, Guntur). In addition to Hariana breed, Gir and Ongole breeds of local cattle are being used under this programme.

From the Fourth Five Year Plan onwards, cross-breeding has been the key-programme of animal husbandry development in the country. Extensive cross-breeding programmes have been undertaken under the Intensified Cattle Development and the Key-Village programmes all over the country, excluding the areas which are known to be the breeding tracts of the famous indigenous breeds.

IMPORT OF EXOTIC BREEDS

Although some European breeds of cattle have been imported from almost the middle of the nineteenth century, organized imports have mostly been done since 1960s. As many as 8,066 exotic cattle were imported during 1961-1979, of which 4,274 were obtained during 1961-75 and 3,792 during the last four years, viz. 1975-76 to 1978-79. The 8,066 imported animals comprise 4,674 Jersey, 2,312 Holstein-Friesian and 1,080 of Red Dane and Brown Swiss breeds. By 1978, the country had 55 exotic cattle herds, with their strength varying from 15 to 350. During 1978, 965 bulls were reported to be located at various centres in the country. These include 710 Jersey, 120 Holstein-Friesian, 90 Brown Swiss and 45 Red Dane breeds. To liberalize imports of exotic germplasm for cross-breeding in India, the Government of India have exempted breeding animals, frozen semen and artificial-insemination equipment from customs' duty.

PIONEERS IN ARTIFICIAL INSEMINATION

Lazzaro Spallanzani (b. 1729, d. 1799) was Professor of Physics at the University of Modena in Italy in 1760. He became interested in microscopic organisms including spermatozoa and in 1769 he carried on work in them at the University of Pavia. In 1780 he carried on research in artificial insemination in dogs. The same experiment was successfully repeated by another Italian, P. Rossi, in 1782.

Artificial insemination was first used in horse breeding in Europe in 1890, when the French veterinarian Repiquet advised its use as a means of overcoming sterility. A leading pioneer in artificial insemination in Russia was E. I. Ivanov. In 1899 he was requested by the Chief of the Royal Russian Stud to determine the possibilities of the use of this method in horse breeding. He established the first artificial insemination centre in 1907. Ivanov was the first to undertake artificial insemination of cattle and sheep.

F.F. McKenzie initiated artificial insemination in pigs in the USA in 1931. Edward Sorensen and Jens Gylling Ham organized the first Co-operative Artificial Breeding Association in 1936 in Denmark. The first large-scale Artificial Insemination Association was organized in Clinton, New Jersey, USA, in 1938 by E.I. Perry. It is thus that the commercial use of artificial insemination began.

P. BHATTACHARYA, A PIONEER IN ARTIFICIAL INSEMINATION IN INDIA

Artificial insemination was first done in India in 1939, when some cows of Hallikar breed were successfully inseminated with the semen of Holstein-Friesian bulls by Sampath Kumaran, who brought the artificial insemination equipment as well as the semen diluent from Israel.

Systematic studies on artificial insemination in India were first undertaken at Izatnagar in 1942 by Dr P. Bhattacharya (b. 1910) who was Head, Division of Animal Genetics, at the Indian Veterinary Research Institute. This work was later extended to four regional centres at Montgomery, Calcutta, Patna and Bangalore under an IVRI project. Based on the results of these studies, the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry in their 7th and 8th meetings held in 1946 and 1949 recommended an extensive application of artificial insemination for cattle improvement in the country. Accordingly, the creation of the infrastructure to provide extensive artificial insemination facilities has been a major development programme in the Five Year Plans. Much credit for this work is due to Bhattacharya, who was later Livestock Development Adviser to the Government of India from 1960 to 1964 and Animal Husbandry Commissioner with the Government of India from 1964 to 1969. He was awarded Spallanzani Medal in recognition of his outstanding contribution in the field of artificial insemination and animal husbandry.

Training in artificial insemination was initiated by Bhattacharya at the IVRI in 1946. The course, which was originally of 15 days' duration, was increased to 3 months in 1948. It was subsequently extended to 6 months so as to cover both Artificial Insemination and Physio-Pathology of Reproduction in its curriculum. Similar training programmes in artificial insemination have been introduced by other States. The artificial insemination services in India have largely been provided by the Government Animal Husbandry departments. Starting in early 1970s, the Kaira District Co-operative Milk Producers' Union in Gujarat and the Indo-Swiss Cattle-Development Project, Kerala, have introduced a system under which the artificial insemination services are provided in the villages by literate rural persons who are trained in the technique of artificial insemination for 4-6 weeks.

Frozen Semen Banks, 1969

The development of frozen semen technology in the West in the early 'fifties was a distinct advancement in the field of animal reproduction. On account of this technology, it is no longer necessary to import costly bulls from foreign countries, as the frozen semen can be speedily and more economically transported by air. Frozen semen of proven bulls and bovine embryos have been air flown for use in other countries. It has made possible extensive progeny testing of bulls. Large quantities of semen of prospective bulls are frozen and the bulls either laid off or slaughtered. The semen is put to extensive progeny test. When results of the test after a few years become available, the semen of super-bulls is retrieved for use. The refrigerant now universally employed is liquid nitrogen. Industrial plants for manufacture of liquid nitrogen have been installed in laboratories processing semen.

Under an Indo-Swiss agreement the first frozen semen bank was established in Kerala in 1969 and later in Patiala. Five banks for collection, processing, storage and transport of semen of foreign breeds were established at Hessaraghatta, Amritsar, Gurgaon, Bhopal and Bangalore with Danish Government's assistance. Later, one frozen semen bank each at Gauhati and Palampur (Himachal Pradesh) was established with the assistance of Australian and New Zealand Governments, respectively. In addition, the BAIF has a frozen semen bank at Uruli Kanchan for large-scale field use in Maharashtra—now extended to five other States, though on a limited scale. The Indian Dairy Development Corporation has also set up frozen semen banks in several States.

At present 42 frozen semen banks are functioning in India. They process the semen of three exotic breeds (Holstein Friesian, Jersey and Red Dane) three indigenous breeds (Tharparkar, Gir and Sahiwal) and their cross-breeds, and also the semen of buffalo. Because of the prospect of immediate increase in milk production, the cross-breeding programme was further strengthened in the Fifth Plan and 14 more exotic cattle farms and 50 more ICDPs were established in milkshed areas and a target was fixed at 5.7 million inseminations per year.

Cross-breeding Programme of Bharatiya Agro-Industries Foundation

While the State Governments have started numerous projects for improvement of the milk yield in cattle by cross-breeding, initiative on the part of private organizations has not been lacking, particularly in Maharashtra, whereas the Bharatiya Agro-Industries Foundation, Pune, had been set up under the leadership of Manibhai Bhimbhai Desai (b. 1920). Dedicated disciple of Mahatma Gandhi, Desai had settled at Uruli Kanchan, a village near Pune and carried on work in cattle development since 1946. To start with, he concentrated his efforts on improving the milk yield of Gir breed. The Central Council of Gosamvardhana, recognizing this work, conferred the award of Gopal Ratna on him. In 1950, when the BAIF was registered as a public trust, Manibhai took over as the Director of Integrated Rural Development Programme through cross-breeding of cattle at Uruli Kanchan. The BAIF realized that the local cow with low milk yield should be considered a seed bed, and through an intelligent breeding programme—using exotic germplasm in a scientifically designed manner — this cow, once considered useless, could provide new cross-bred dairy animal with much higher potential for milk production and reproductive efficiency.

The operational mechanics of the programme is as follows:

The BAIF Centre has 2,000 breedable cows, owned normally by about 1,000 rural families. The centre operates in an area having a radius of about 15 km, covering about 15-20 villages. The BAIF Centre is managed by a trained veterinary graduate assisted by one attendant. Each centre is provided with a motor-cycle, so as to make services available at the door-step of the farmers. A set of liquid nitrogen containers is kept at each centre to facilitate establishing a mini semen bank. The bank contains semen straws of pre-selected bulls of exotic breed at a given blood level and the allocation of these semen straws is as per the progeny-testing programme designed and operated by experts working at BAIF's Central Research Station, Uruli Kanchan, which also housed the country's biggest exotic bull mother farm.

As soon as the Cattle Development Officer receives a call from a farmer to inseminate his cow, he rushes along with instruments and a handy liquid-nitrogen container containing bull semen. The cow is checked as regards to the heat symptoms and insemination is done. There is a periodic follow-up to examine the inseminated cows to detect the success or failure of the insemination.

Total health cover is provided by the BAIF for the cattle and buffaloes in the project area. The BAIF prepares vaccines for rinderpest, haemorrhagic septicaemia, brucellosis and black quarter. These vaccines are in wide use.

The programme operated from 1971 to 1976 as a pilot project with 12 centres to assess its utility in bringing about socio-economic upliftment. Encouraged by concrete results in terms of higher milk productivity of the cross-breds, the BAIF expanded its programme since 1976. Now it is operating about 370 Integrated Rural Development Centres engaged in cross-breeding of local cattle involving over 200,000 rural families and more than 450,000 local cows, spread over 3,500 villages. Much credit for the success of this project is due to Manibhai, who is totally dedicated to the cause of rural development through improvement of milk yield of local cows once regarded as useless. In 1982 Manibhai was given the Ramon Magsaysay award for his work among the rural poor. He is assisted by Dr S.S. Gorhe, a scientist of high ability. The BAIF programme of cattle development is in operation in Maharashtra, Karnataka, Rajasthan, Gujarat, Uttar Pradesh and Orissa. This project has provided employment to a number of educated unemployed persons as inseminators. To those who have land, it offered gainful employment in their very homes by keeping cross-bred cows with high milk yield.

Fodder Crops

Increasing demand for milk and keeping of high-yielding buffaloes and hybrid cows with exotic blood has stimulated interest in the growing of fodder crops. For normal production of milk, a good dairy animal requires 40-50 kg of green fodder per day. A variety of fodder crops are now available for supplying green fodder the year round. The most popular fodders are berseem (*Trifolium alexandrinum*), lucerne or alfalfa (*Medicago sativa*), hybrids of Napier grass (*Pennisetum purpureum*), maize, sorghum and pearl millet.

Berseem

Berseem was introduced in Sind in the beginning of the current century from Egypt. It is also known as Egyptian clover because it is extensively grown in Egypt. From Sind it was introduced into Punjab, where after trials for several years it was recommended to cultivators. It established its worth very soon and it replaced white clover (*senji*) which was then a popular fodder crop. From Punjab its cultivation spread to other regions.

Berseem is a legume that enriches the soil. It has tender succulent leaves rich in protein and is highly relished by milch animals (Fig. 196). Its yield also is about three times as high as that of white clover.

Berseem grows even on alkaline soils, though it thrives best in well-drained heavy loams. Before sowing, the seed is inoculated with rhizobium culture which is applied with jaggery (*gur*) solution as a sticker. It yields 3 to 5 cuttings and provides a regular supply of green fodder from December to May. In large dairy farms berseem harvestors powered by tractors have been introduced (Fig. 197).

Lucerne or Alfalfa

Lucerne, or Alfalfa as it is known in USA, is a perennial leguminous fodder crop which continues to give good yields for 6 or 7 years if kept properly manured and intercultured. Its plant produces the highest amount of protein per unit area and time, and is rich in calcium and vitamins. It fixes 150 kg of nitrogen per hectare in a year and as such it is an excellent soil-restorative. Seven or eight cuttings can be attained during a year. All kinds of livestock take it with avidity but it is specially valued as a green fodder for horses and is, therefore, grown largely near cantonments and remount depots.

Cowpea

Cowpea (*lobia, Vigna unguiculata*) is usually grown mixed with maize from March to July, and is harvested as green fodder 50 days after sowing. It yields 90-120 quintals per hectare. 'Cowpea 74' is dual purpose variety, also used as a pulse.

Cluster-bean

Cluster bean (*Cyamopsis tetragonoloba*) is grown as a green fodder, and also for grain, green manuring and as a vegetable. It adds 37-50 kg of nitrogen per hectare. Its seed is used as a concentrate for animals and for extracting gum. It is sown from first week of June to August.

Napier Grass

Napier grass (*Pennisetum purpureum*), also called elephant-grass, is a perennial fodder, introduced into India in 1912 from South Africa. To

FIG. 196. Berseem (or Egyptian clover) is the most popular fodder for milch cattle in northern India.

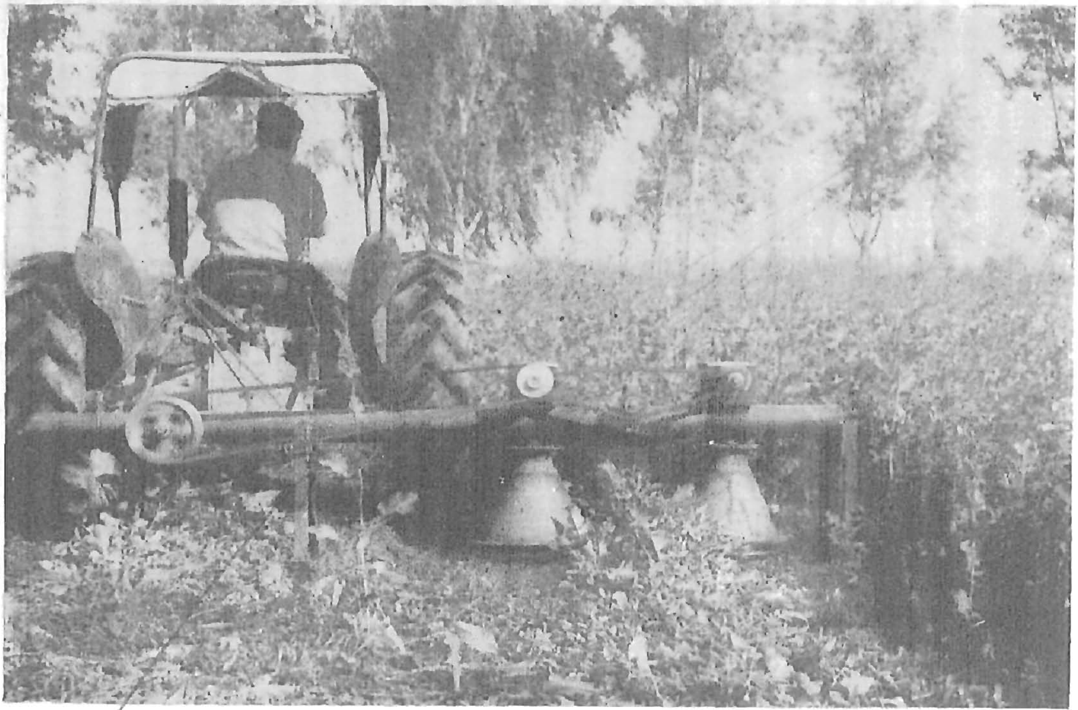

FIG. 197. A berseem harvestor at work in the farm of the National Dairy Research Institute, Karnal.

FIG. 198. Napier grass provides green fodder during May and June, when there is no other fodder crop in the fields.

obtain a multi-cut fodder crop, interspecific hybrids between Napier grass and pearl-millet have been evolved (Fig. 198). They are quick-growing, heavy yielders and have a more nutritive value than Napier grass and give 4-6 cuttings annually. Once planted, hybrid Napier continues to give good fodder for two to three years.

Sorghum

Sorghum (*chari; Sorghum bicolor*) is a most popular fodder, grown with the onset of the monsoon and is harvested in October-November. A number of varieties are now available, some of which are sweet, juicy and thin-stemmed.

Pearl-millet

Pearl-millet (*Pennisetum typhoides*) is a grain crop, but it is also grown for fodder. It can be cut before flowering, for unlike in sorghum there is no risk of poisoning with prussic acid (HCN). It also tillers profusely.

Maize

Maize (*Zea mays*) is a grain crop also grown for fodder. It can be cut within two months after sowing and is palatable and nutritious.

Forage Mixture

A number of forage mixtures have become popular with the farmers who keep dairy cattle. These are maize and cowpea, pearl-millet and cowpeas, maize, pearl-millet and cowpea, berseem and oats, berseem and mustard, and berseem and lucerne. These mixtures give higher yield of fodder if sunlight is more efficiently used and growth of weeds is checked.

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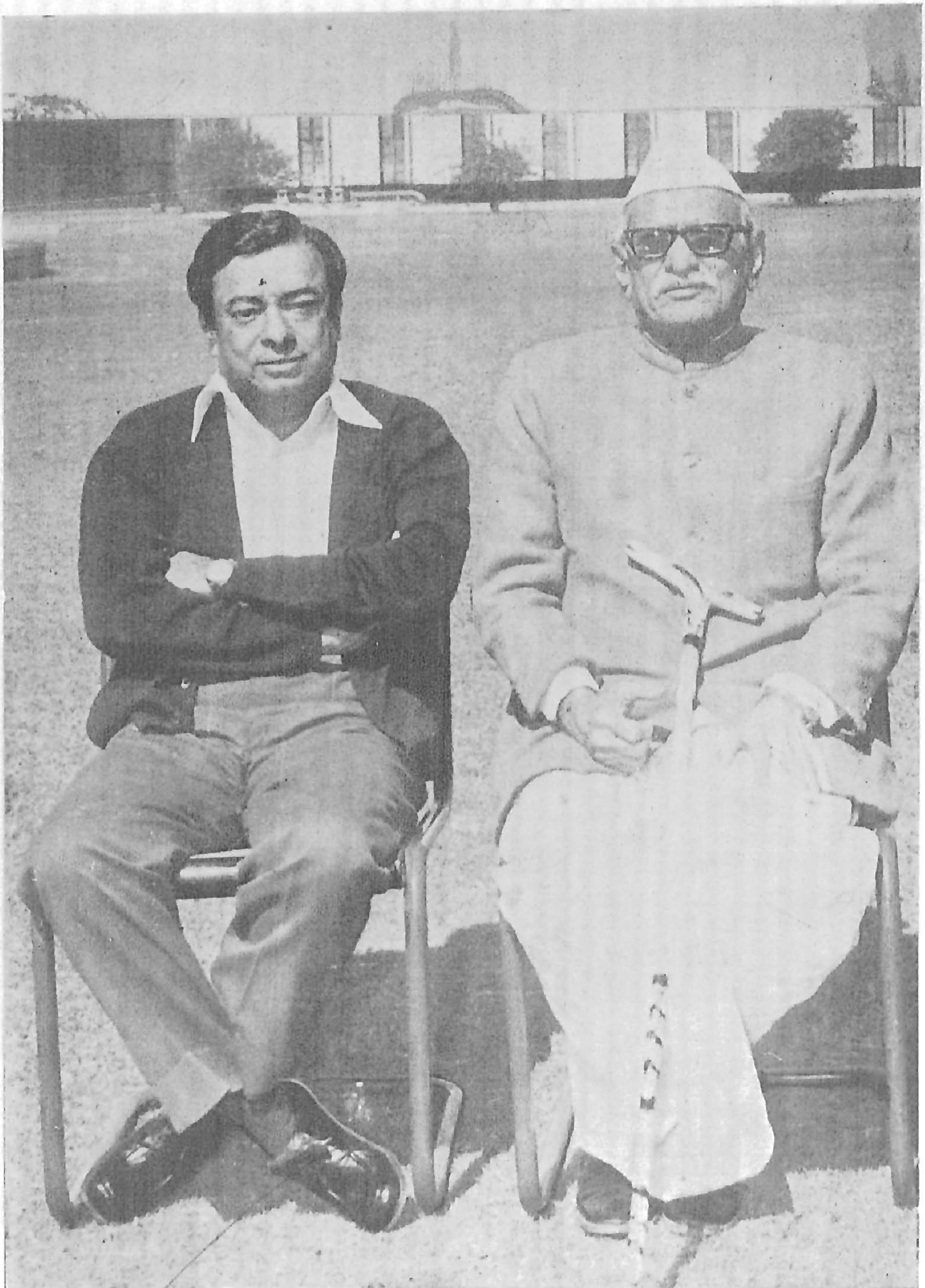

FIG. 199. Tribhuvandas K. Patel, Chairman of the Anand Milk Union Ltd (*right*), and Verghese Kurien, Chairman of the National Dairy Development Board (*left*). They provided leadership to the AMUL scheme and both of them were awarded Ramon Magsaysay Award for community leadership in 1963.

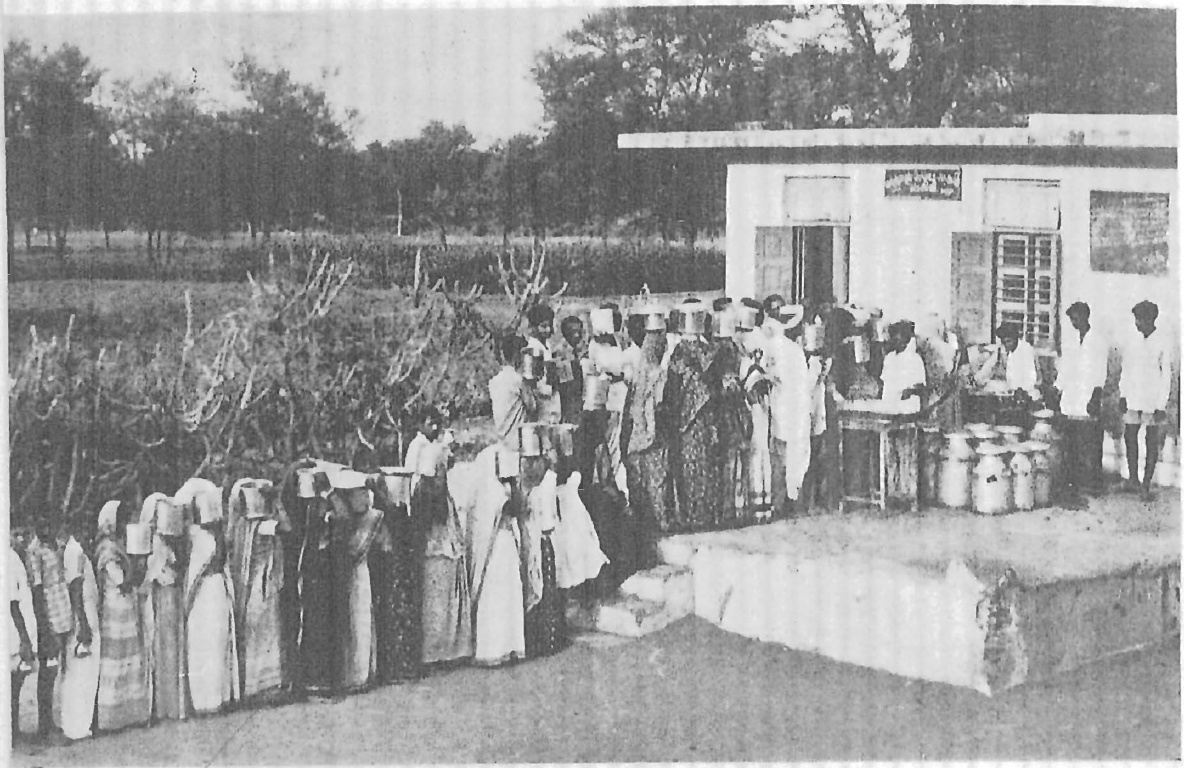

FIG. 200. *Above:* Villagers bringing milk to the sale centre of the village milk co-operative in a village in Anand District, Gujarat. Among the sellers, women predominate. Milk is brought for sale twice a day, morning and evening. *Below:* The milk brought by a member of the Milk Co-operative Society is measured, tested and paid for on the spot. A round-the-year market and remunerative price for milk has encouraged the producers.

FIG. 201. The cattle-feed plant of AMUL at Anand.

FIG. 202. AMUL also supplies cattle-feed to its members. Packaging of cattle-feed at AMUL's Kanjari plant.

CHAPTER 48

DAIRY DEVELOPMENT

AAREY-PATTERN OF MILK COLONIES IN CITIES
CO-OPERATIVE MILK-COLLECTING SCHEMES OF ANAND PATTERN
NATIONAL DAIRY DEVELOPMENT BOARD, OPERATION FLOOD AND INDIAN DAIRY CORPORATION

BEFORE Independence, apart from military dairies and a few private dairies, no attention was paid to the promotion of dairy-farming. The usual pattern was that cattle-keepers bought high-yielding buffaloes from Punjab and Gujarat and kept them in primitive insanitary sheds in the vacant sites in the metropolitan cities of Bombay, Calcutta and Madras. A familiar site in Bombay was that of railway wagons carrying buffalo-dung to the sub-urban rural areas and green fodder from the rural area to the cities. It was indeed a strange type of traffic! The worst part of this situation was that when buffaloes became dry they were sent to slaughter houses. The cities became dirty, and valuable high-yielding buffaloes were destroyed.

AAREY MILK-COLONY SCHEME, BOMBAY

To meet this situation, the Bombay Government provided a large area in the hilly area of Aarey to buffalo-keepers and also set up a dairy plant. The man in charge of the scheme was Dara Nusserwanjit Khirodi, who was appointed Milk Commissioner. About 15,000 buffaloes with their owners and attendants were removed from Bombay to the Aarey milk colony. For a while, this scheme caught the attention of the planners. During the Second Plan, colonies of milch cattle on the Aarey pattern were set up in metropolitan cities. However, it was by no means a satisfactory solution of urban milk problem.

ANAND MILK UNION LIMITED (AMUL)

While Aarey was fascinating the people concerned with milk-supply to the cities, another experiment being carried on in Gujarat went unnoticed. In 1946, the foundation was laid in India of a new system of milk-marketing and dairy development based on milk producers' co-operatives. The system originated in Anand, a *taluka* of the Kaira District in Gujarat. Most of the farmers in this District have small landholdings and own one or two buffaloes for producing milk. Most of the milk produced by the buffaloes was used by the farmers for home consumption and the left-over quantity was sold for supplementing their income. The purchasers were small vendors and merchants who used it for making *khoa*, butter and cream. The City of Bombay situated about 440 km south of Anand was the major market for milk and milk products. In addition to the small merchants, an organized private dairy, which sold milk to the authorities of the Bombay Milk Scheme, set up a network of milk-purchase centres in the villages in the Kaira District. The milk-vendors as well as the dairy exploited the rural milk-producers on the one hand, and the urban consumers on the other. The milk-producers were given low price for their milk, and the urban consumers were often supplied with diluted milk of unsatisfactory quality. When exploitation by the middle agencies reached its climax in the 1940s, the farmers started agitating and approached political leaders for help. Sardar Vallabhbhai Patel who belonged to a farming family of the Village of Karamsad near Anand, advised the farmers to take up milk-marketing themselves by organizing co-operatives. The farmers promptly responded. The first meeting of the farmers for this purpose was held on 4 January 1946 in the tiny Village of Samarkha. The first Milk Producers' Co-operative Society was organized on 26 October in the village of Hadgud. The district-level Union of Milk Producers was registered on 14 December 1946.

The dairy co-operatives were established with a two-tier structure, comprising the Village-Level Milk-Producers' Co-operative Societies and the District Milk-Producer Co-operative Union. Later, the district-level union federated into a State-Level Co-operative Milk Marketing Federation. The system thus developed into a three-tier structure. The village-level societies collected the surplus milk from the producers every morning and evening, measured the fat content of the sample collected from each milk producer of milk, made payment to the producers based on the fat content of their milk, and also provided the village with technical inputs. Any milk producer could become a member of the village society by paying a small membership and admission fee. Each society had an executive, headed by a chairman, elected by the members. For milk collection and other work, each village society engaged a team of employees, including a secretary, a fat tester, an accountant and an inseminator.

The District Level Milk Producers Union was represented by all the village societies of the district. Its affairs were looked after by a board of directors, most of whom were elected from among the representatives of the village societies and the remaining were nominated from different organizations, such as the financing institutions, the Co-operative Department, the Milk Marketing Federation, etc. The Board elected a chairman and a vice-chairman. For the day to day work, the Union engaged a professionally trained General Manager assisted by a team of other employees. The District Union was responsible for collecting milk from each society, its transportation, processing and marketing, supplying technical inputs to each village, and organizing, directing and supervising the functioning of the village co-operatives.

The Co-operative Milk Marketing Federation of Gujarat, which included all the district unions as its members, enabled the member unions to co-ordinate production and make joint marketing programmes.

LEADERSHIP OF TRIBHUVANDAS K. PATEL AND VERGHESE KURIEN

Apart from the national political leaders who provided the initial motivation and guidance in the formation of Milk Producers' Co-operatives in the Kaira District, two persons—Tribhuvandas K. Patel and Verghese Kurien—played a key role in the development and success of this new system of dairy development. T. K. Patel (b. 1903) remained Chairman of the Anand Milk Union Limited (AMUL) for the first 25 years. He was given the Ramon Magsaysay Award in 1963 for community leadership. The Government of India gave him the Padma Bhushan Award in 1964. The respect and love he commanded among the farmers of the Kaira District was evident from the fact that on his retirement in 1973, the farmers presented him with a purse of Rs 650,000. Patel used this amount to establish Tribhuvandas Foundation for launching a programme of human health care in Anand.

Kurien (b. 1926) belongs to Calicut in Kerala He is a science graduate who turned an engineer. In 1944, he got the degree of Bachelor in Engineering from the Tata Iron and Steel Company Technological Institute, and M.Sc. from the Michigan State University, USA. He specialized in dairying from the Indian Dairy Research Institute, Bangalore. In January 1950, he became the General Manager of the Kaira District Co-operative Milk-Producers' Union. A dynamic man, unconventional in his approach to problems, he is capable of taking bold decisions. He spearheaded the growth of the Kaira Milk Producers' Union and made it one of the most powerful instruments of service to the farmers. He particularly emphasized the application of scientific and professional management in the working of the co-operatives and was effective in obtaining considerable national and international support for the development of the dairy co-operative organization. He was given the Ramon Magsaysay Award for Community Leadership in 1963 along with T.K. Patel. The Michigan State University honoured him with a D.Sc. (*Honoris Causa*) in 1965. The Government of India recognized his work and honoured him with the award of Padma Bhushan in 1966. Much more than these awards, he is held in high esteem by the farmers of Gujarat, who regard him as their benefactor.

The success of the Anand Scheme is due to wise leadership—a political leader with a rural base working in combination with a dynamic and imaginative manager whom he trusted and honoured. Also, the Gujarati Patel farmers have a business sense and they co-operate more easily. The daily payment of their dues without harassment was another factor which ensured the success of the scheme.

The main features of the Anand pattern of dairying are as follows:

The milk-marketing facilities and technical inputs were made available to the milk-producers at their doorsteps through their own co-operative at the village and district levels. A veterinary doctor visited each village once a week and treated sick animals of the member-producers free of charge. Emergency cases were treated promptly. For that service, a reasonable fee was charged. Inputs such as cattle feed and the seeds of fodder crops were sold in each village by the village society. Artificial insemination service was provided every day by one of the employees of the Village Society trained in this technique. The milk-producers received payment for their milk every morning and evening when they supplied milk.

The District Union conducted regular programmes of training, research and extension education in different aspects of dairying. The training curricula covered dairy husbandry, co-operative management, secretarial practices, account-keeping, artificial insemination, and veterinary first-aid.

Most of the expenditure on milk-marketing and technical inputs was met out of the funds created by earmarking a small fraction of the profits from milk sales, about 2 paise per litre. The Union was, therefore, essentially self-supporting.

By 1980, the Milk Producers' Co-operative Societies were functioning in 895 out of 957 villages in the Kaira District. The total membership of the co-operatives had risen to 308,000 families by 1980.

Fluctuation in Milk Supply in Winter and Summer

A problem which the AMUL had to face was the fluctuation in milk supply. Milk production increases in winter and sharply decreases in the dry summer months. Since the estimated production of milk in winter was double than that in summer, the farmers were not able to sell the entire milk produced. To meet this situation, Kurien, the General Manager, planned a plant to convert the surplus milk into milk powder. The milk powder was used during summer to enlarge the milk supply. This device further promoted milk production. To meet this situation, Kurien enlarged the dairy plant and made provision for the production of baby foods, cheese and butter.

In 1948, the Union made the first collection of 250 litres of milk from two villages. By 1970s, it owned and operated a milk factory which collected more than 500,000 litres of milk daily. The milk products manufactured by the Union including butter, cheese, milk powder, baby food and ghee, were being sold under the brand name of AMUL, which has become a household word. The value of milk and milk products sold was Rs 7.4 million in 1955-56 and Rs 446.6 million in 1974-75. The Union owns and operates a feed factory daily producing more than 300 tonnes of compounded feed, named amuldan.

BENEFITS OF THE SCHEME

A number of studies of the Anand Pattern of dairying in the Kaira District have shown that it brought to the farmers several direct and indirect benefits. Income per milch animal was estimated to have increased by about 62 per cent. The overall income of the member-families went up by about 69 per cent. A farmer, on an average, received 4 to 5 rupees daily from the sale of milk. The daily flow of income was particularly helpful to the farmers in meeting their daily expenditure for domestic needs. Most of the beneficiaries belonged to the weaker sections, comprising landless labourers and small farmers.

A study showed that a buffalo in the area served by AMUL produced on an average 48 per cent more milk than a buffalo in a village not covered by the Co-operative Milk Producers' Union. Crop husbandry also improved at the same time.

The development in dairying brought about through the co-operative system led to the establishment of a number of industries, viz. the manufacturing of dairy equipment, biological products, and agricultural implements and tools, thus leading to a large demand for stainless steel. The Government of India built a plant to produce stainless steel. The roads and transportation facilities markedly improved and a communication system with telephones also developed, showing that small beginnings on proper lines ultimately produced multiple effects.

The democratic way of functioning of the Village Co-operatives and the District Union helped to identify and develop local leadership. The principle of equality practised in elections of the co-operatives and in the procedures of milk-marketing and distribution of technical inputs greatly weakened the social barriers of race and caste. The scientific management introduced under the Anand Pattern inculcated a systematic and rational outlook in the villagers. The special programmes launched for the training and education of farm-women brought about enlightenment and made them increasingly important participants in dairying and agriculture. Awareness was aroused even on matters of health, hygiene and family-planning.

The lesson from Anand was soon learnt by the planners. In the Third Five-Year Plan, the objective was to develop the dairy industry with emphasis on milk production in the rural areas and to link it up with dairy plants in urban centres for processing and marketing milk. The collection of milk was to be undertaken by producers' co-operatives in the villages where fodder grew and where dung could be used as a manure.

NATIONAL DAIRY DEVELOPMENT BOARD, 1965

The remarkable success of the 'Anand Pattern' of Dairy Development and Marketing in the Kaira District aroused interest in the scheme at the high level in the Government. Lal Bahadur Shastri, then Prime Minister of India, while visiting Anand in October 1964 to perform the opening ceremony of the Feed Factory of AMUL, chose to stay overnight in the village of Ajarpura near Anand. He dined with the villagers, had intimate talks with them and personally watched the entire process of milk collection, fat-testing, payment to the producers and feed sale by the Village Co-operative Society early in the morning. He was greatly impressed by the working of the dairy co-operatives and immediately proposed that a national-level institution should be established to help the milk-producers all over India to organize their dairy co-operatives on the Anand pattern. Out of this suggestion grew the Organization known as the National Dairy Development Board (NDDB), which was registered as a non-profit charitable trust in 1965, with its headquarters at Anand. Its Board of Directors comprised leading dairy experts and top officials connected with dairying and animal husbandry. Kurien was appointed the first Chairman of the Board.

A notable feature of the NDDB was that it developed into a self-supporting institution. From 1967 onwards, it did not receive any Government assistance, all its expenses were met out of the fees charged for the services rendered by it. By 1970, the NDDB had built and moved into its own campus, comprising offices, hostels and residences built on about 6 hectares at Anand. Starting with two divisions (Engineering and Management-cum-Manpower Development) and eight professional members of the staff, it grew by 1978 into a complex consisting of four functional divisions of Planning, Engineering, Technical and Manpower Development, and Farmers' Organization and Animal Husbandry, supported by four other divisions and sections covering Administration, Accounts, Audit, and Monitoring, Management and Edible-oil Production and Marketing on the pattern of Operation Flood.

This Board provides technical assistance for co-operative unions and for the State governments who want to set up modern dairy plants. The Board makes a feasibility study and prepares a project report. When sanctioned by the State governments, the Board can also implement the projects to the stage of operation and after that hand them over to the State governments or to a dairy organization.

OPERATION FLOOD

In 1970, the NDDB launched a massive dairy development project, which popularly came to be known as Operation Flood (because it was designed to create a flood of rurally produced milk in India). This was said to be the largest dairy-development project undertaken anywhere in the world. The idea of taking up this Project arose from the fact that by the late 1960s the European Economic Community (EEC) had accumulated huge surplus stocks of dairy products, commonly referred to as 'mountains of milk-powder and butter'. These surplus stocks of dairy commodities constituted a threat to the domestic markets in Europe. The NDDB proposed and submitted to the Government of India in 1968 a proposal which was designed to import the donated milk-powder and butter oil from the EEC and use the funds generated through the sale of the reconstituted milk for promoting dairy development in the country. The import of dairy commodities and their utilization was proposed to be done in a manner which would help dairy development rather than hinder it. After a detailed consideration by the Government of India and the World Food Programme (WFP) of the UN-FAO, the proposal was approved and a plan of operation was signed between the Government of India and UN-FAO-WFP on 4 March 1970. The first shipment of donated commodities was received in June 1970 and the Project was officially launched on 1 July 1970. The total outlay for the first phase of the Project designated as Operation Flood I (initially for 1970-75 and later extended up to 1978) was estimated at 954 million rupees. The whole of this amount was to be generated from the sale of milk constituted by recombining the skimmed-milk powder and butter oil (126,000 and 42,000 tonnes respectively) donated by the EEC through the FAO-WFP. The Project was thus designed to be self-supporting in its financial requirements. The main objectives of the Operation Flood I were to expand the milk-processing and marketing facilities in 4 major cities, viz. Calcutta, Bombay, Delhi and Madras, and to establish 18 Anand-type dairy co-operatives in the rural areas, which were ultimately to supply all the milk requirements of the four cities. The programme of the Project was spelled out under eleven action items, which included the resettlement of about 100,000 city-kept cattle, the establishment of a National Milk Grid and manpower development.

Indian Dairy Corporation, 1970

Being a charitable trust, the NDDB could not receive and sell the imported milk commodities. The Government of India, therefore, established a new company named the Indian Dairy Corporation (IDC), which was designed as an implementing agency for the project. The NDDB was designed as the IDC's main source of technical expertise. The IDC was registered in early 1970 with Kurien as the first Chairman of its Board of Directors comprising senior officials and dairy experts of the country. Kurien was thus the common Chairman of both the NDDB and the IDCs. Over time, the IDC grew into what is described as a 'finance-cum-promotion house' with a wider sphere of responsibilities for the country's dairy development.

Most of the targets of the first phase of the Operation Flood having been achieved by 1978, the NDDB designed and launched a much bigger and elaborate national dairy development programme designated as the Operation Flood II which was about five times the size of the Operation Flood I. Designed to be completed over seven years (1978-85), the Operation Flood II involved an outlay of 4,850 million rupees. About half of this amount was to be generated through the sale of the dairy commodities donated by the EEC (144,000 tonnes of skimmed-milk powder and 76,000 tonnes of butter oil/butter). The rest of the funds were to come from the World Bank Aid, resources of the Indian Dairy Corporation and, if necessary, even through budgetary support from the Government of India. With its major thrust on multiplying the Anand-type dairy co-operatives, the programme was designed to benefit some ten million rural families in 155 milkshed districts of 17 States. A significant part of the programme was to develop and link into a National Milk Grid all the 148 major urban city centres, with rural milksheds. The project aimed at helping the milk producers to rear about 16 million cows and buffaloes, constituting what was referred to as the National Milk Herd.

Milk schemes have shown great progress onwards from 1972-73, the peak year of the Green Revolution. After achieving success in crop production, a majority of the farmers having small holdings turned to mixed farming to augment their income. In 1972-73, the number of dairy plants in the country was 132. In 1978-79 it rose to 186 (Table 1). With rising standard of living, now there is much talk of a White Revolution.

TABLE. 1. PROGRESSIVE ACHIEVEMENTS IN MILK HANDLING

	1972-73	*1973-74*	*1974-75*	*1975-76*	*1976-77*	*1977-78*	*1978-79*
(i) Number of Dairy Plants	132	141	147	161	178	186	186
(ii) Daily average of milk in Public, Co-operative Sector Dairy Plants (million litres)	2.90	2.88	2.72	3.82	4.44	5.53	5.30

SOURCE: Dairy Division (Ministry of Agriculture), Government of India

The impact of the 'Anand Pattern' of dairy development has created interest in other spheres of rural development. For example, a project was undertaken in the late 1970s to apply the principles of Anand Pattern for handling the production, processing and marketing of cotton and oilseeds in parts of the Gujarat. Other countries also evinced interest in adopting this institutional structure for rural development.

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CHAPTER 49

MILK SCHEMES IN WEST BENGAL, DELHI AND PUNJAB

WHILE Dara Nusserwanji Khurody and Verghese Kurien had done outstanding work in planning and implementing milk schemes in Maharashtra, it fell to the lot of Lal Chand Sikka to tackle the milk production problems of West Bengal. Sikka graduated from the Punjab Agricultural College, Lyallpur, in 1927. He got his Ph.D. from the University of Glasgow. The subject of his thesis was 'Milk production as affected by heredity and environment'. On return to India in 1940 he became the Livestock Expert of Bengal Province where he established the Central Livestock Research-cum-Breeding Station, at Haringhata. In 1949, he was appointed the first Milk Commissioner and the Head of the Directorate of Dairy Development of West Bengal, and Haringhata became the hub of the Greater Calcutta Milk Supply Scheme. During a study tour in New Zealand and Australia, Sikka obtained from these countries pedigree bulls and heifers of Jersey breed to improve the State's livestock. It is because of his foresight that West Bengal today can boast of having perhaps the largest population of cross-bred cattle.

In 1956, Sikka was appointed Dairy Development Adviser to the Ministry of Agriculture, Government of India. Apart from assisting the States in planning their dairy development programmes under the Plans, he planned and executed the Delhi Milk Scheme. He was appointed the first Chairman of the Delhi Milk Scheme from which post he retired in 1965. As is inevitable for a person of his energy, Sikka did not retire from dairying. He was appointed Milk Commissioner by the Punjab Government. When the Punjab was partitioned, he became the Milk Commissioner of Haryana and planned and implemented several dairy development schemes.

DAIRY DEVELOPMENT IN PUNJAB—ROLE OF PARTAP SINGH KAIRON AND G.B.S. KAHLON

In dairy development also, Sardar Partap Singh Kairon provided leadership, firstly as Development Minister, and later on as Chief Minister of Punjab. In 1957, when I was Vice-President of the Indian Council of Agricultural Research, I paid a visit to Anand and saw the benefit which the milk scheme had conferred on the Gujarat farmers. I wrote a letter to Kairon explaining the impact of the scheme, and suggested that he should take up a similar scheme in Punjab. Kairon responded positively and as a small beginning he created a dairy development cell in the Animal Husbandry

Department. He appointed Gurbhagwant Singh Kahlon (b.1919), Assistant Dairy Development Officer, to head the cell. Kahlon is a tall and well-built Sikh from a farming family of Sikh Jats of Gurdaspur District (Village Wasoukot, Tahsil Shakargarh, now in Pakistan). He is a graduate in Veterinary Science from the Veterinary College, Lahore, and an associate of the Indian Dairy Research Institute, Bangalore. In 1956, he attended the First FAO Course in Milk Production, Processing and Distribution in Denmark, and had taken an educational tour in Sweden, Holland, West Germany, France, USSR, Japan, UK, USA and Canada. Thus he was well-equipped to handle a challenging job.

During the period 1958 to 1960, Kahlon succeeded in getting Technical Co-operation Mission (TCM) aid for the establishment of the first composite milk plant at Verka, in Amritsar District. He also invited private dairy concerns—Messrs Nestle & Co. and Messrs Horlicks—to establish their milk factories at Moga and Nabha respectively. He prepared project reports for the establishment of milk projects at Chandigarh, Hissar and Ambala and a milk powder plant at Jind.

By 1962 the progress made in the field of dairy industry became discernible and Punjab ranked in the forefront of dairying in the country. Kairon, realizing the potentialities for dairy development and the magnitude of the work involved, took a decision to have a separate and independent department of Dairy Development headed by a Milk Commissioner, and also a Dairy Development Corporation for running the milk plants already established in the public sector.

Kahlon established a Research and Dairy Development Wing in the Punjab Dairy Development Corporation for diversification in the manufacture of milk products. Thus, for the first time in the country milk products like sterilized flavoured milk, *lassi*, *lassi* powder, ice cream powder, *paneer*, instant coffee milk, milk cake and indigenous milk sweets were commercially introduced. The equipment designed by the Punjab Dairy Development Corporation for the manufacture of these products and the techniques perfected in this regard were adapted by other organizations in the country.

Kahlon established the first cattle feed factory in Punjab for the preparation of balanced cattle feeds at Khanna. He also established a bull mother farm, an exotic cattle farm, a dairy extension unit, an artificial insemination centre, a training centre for lay artificial inseminators and a fodder demonstration centre at Khanna complex. This complex was adjudged to be one of the best in the country.

Kahlon gave new dimensions to the dairy extension work by establishing dairy extension-cum-demonstration farms with attached milk chilling centres and milk bars at Bija in Ludhiana and Dasuya in Hoshiarpur districts. At these centres practical demonstration was given of producing at least 6,000 litres of milk by keeping 3 to 5 quality milch animals on less than half a hectare of land by maximising the fodder production.

Milk Bars

Another innovation for which credit is due to Kahlon is the establishment of a chain of milk bars in the Punjab. These milk bars, apart from sale of milk and *lassi*, also serve as sale points for *ghee*, cheese and other products manufactured in the milk plants. They are situated in attractive sylvan surroundings on the highways and have been landscaped with profuse use of ornamental flowering trees, shrubs, and climbers (Fig. 206). They are patronized by tourists and others. Now there are 40 such milk bars in Punjab.

After the resignation and death of Kairon, all the pending milk schemes suffered. The schemes for the establishemnt of milk projects at Jullundur, Bhatinda and Ludhiana were shelved.

Tide turned again in 1968. A ministry came into power which had interest in agricultural development. Kahlon was appointed Milk Commissioner-cum-Managing Director, Punjab Dairy Development Corporation. The project for the milk plant at Ludhiana was revived. At that time I was Vice-Chancellor of the Punjab Agricultural University, Ludhiana, and had a full engineering unit with an architectural cell at my command. I made an offer to Sardar Parkash Singh Badal, then Chief Minister of Punjab, that the engineering unit of the University would construct the milk plant. The offer was accepted, and the plant was formally inaugurated by Prime Minister Indira Gandhi in 1974. It is attractively designed and is beautifully landscaped (Fig. 203). This competition from an unconventional source activated the sluggish Public Works Department of the State Government, and milk plants were also built at Bhatinda, Jullundur and Hoshiarpur.

Punjab has now 13 milk plants in the public, private and co-operative sectors and 40 milk chilling centres. Details are given in Table 1. The total milk handling capacity of these plants comes to about 1.15 million litres, which is 16 per cent of the total milk produced.

Price Formula

To encourage rearing of crossbred cows, the Punjab Government adopted 2-axis milk pricing formula. At present, a price of Rs 1.85 per litre for 4.2 per cent fat and 8.5 per cent SNF of crossbred cow milk is offered. The corresponding price for 6.2 per cent fat and 8.8 per cent SNF of buffalo milk is Rs 2.25 per litre.

Artificial Insemination Services

Six semen banks with facilities for freezing and storage of semen of cows and buffalo bulls have been established in Punjab. The State

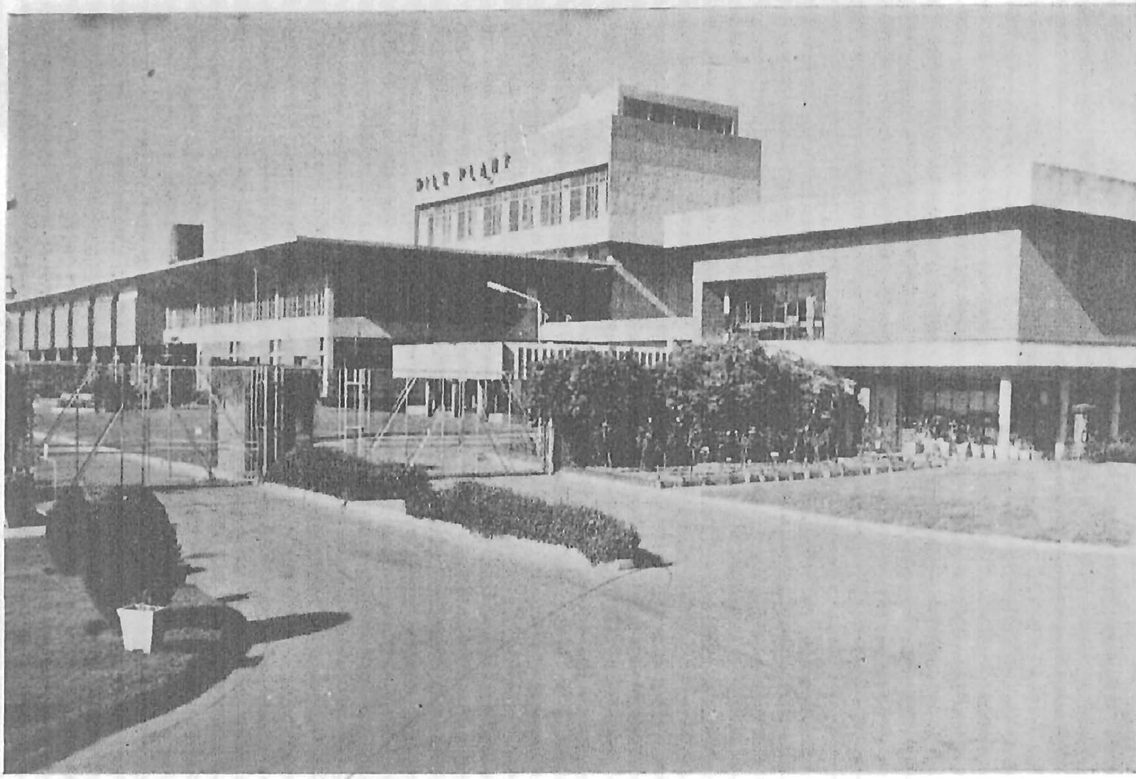


FIG. 203. Punjab has a number of modern milk plants. This one at Ludhiana has a capacity to handle 1 million litres of milk a day. It was constructed by the Engineering Organization of the Punjab Agricultural University for the Punjab Dairy Development Corporation.

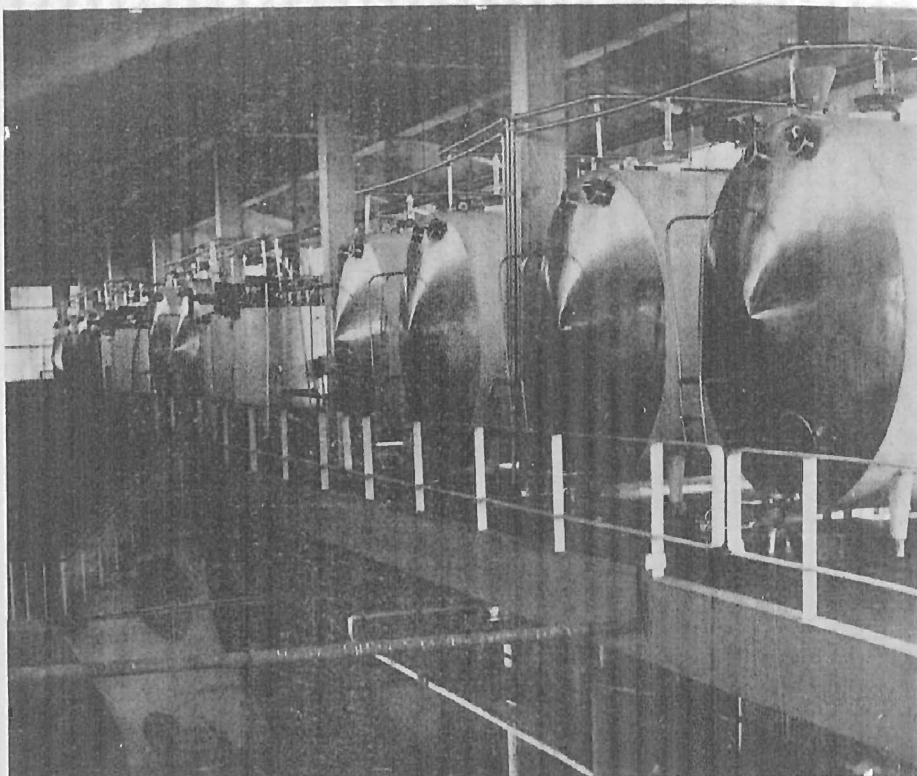
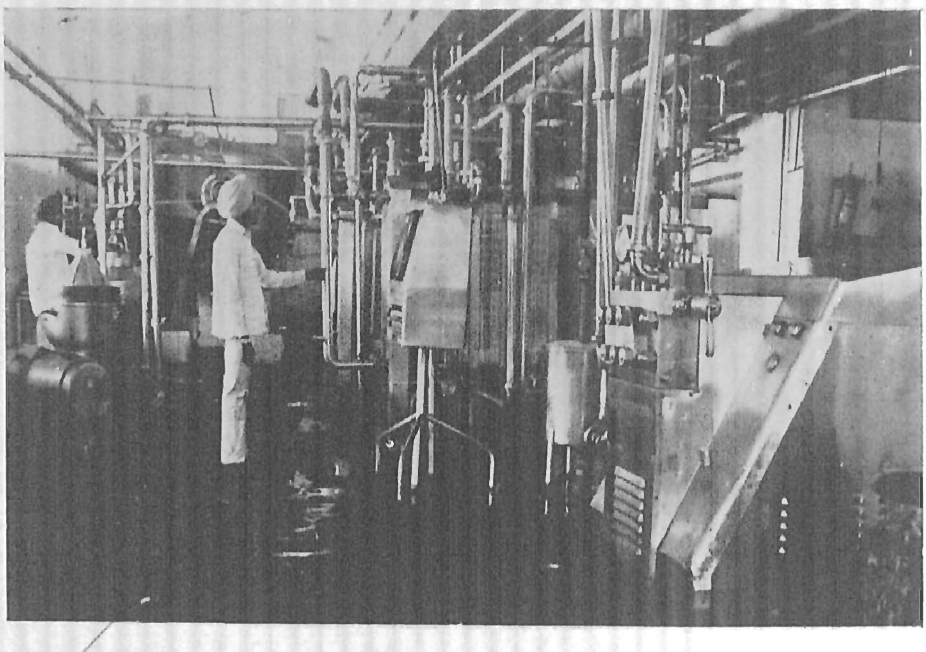


FIG. 204. The milk plant at Ludhiana is equipped with modern machinery. *Above*: Milk-storage tanks. *Below*: Milk-pasteurization plant.



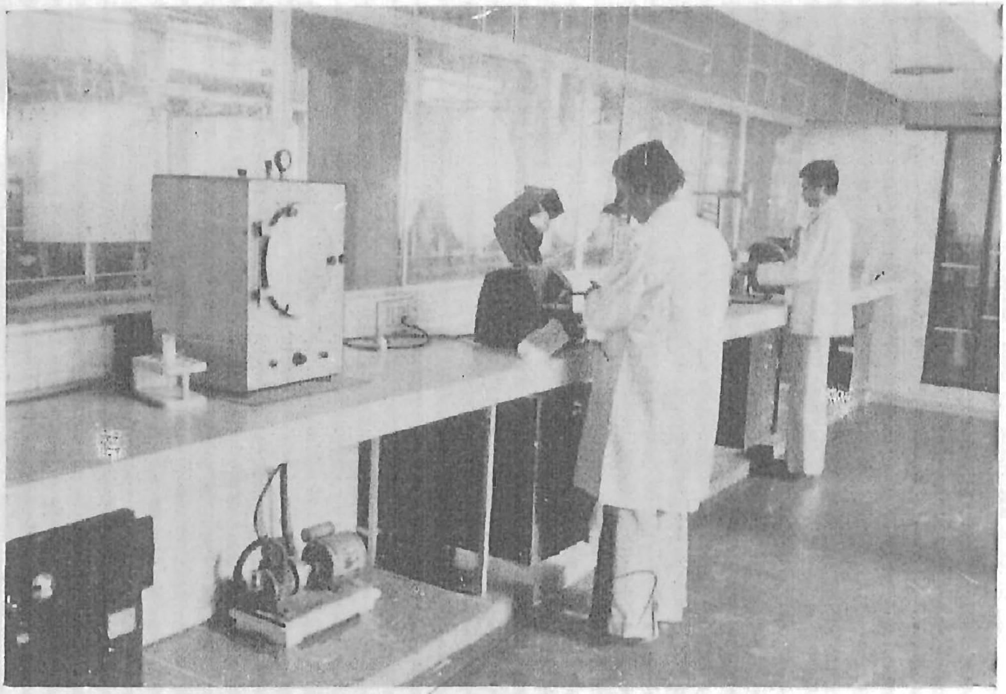


FIG. 205. *Above*: A view of the quality-control laboratory of the milk plant at Mohali (Chandigarh). *Below*: Packing of butter by automatic machines at the Mohali milk plant.

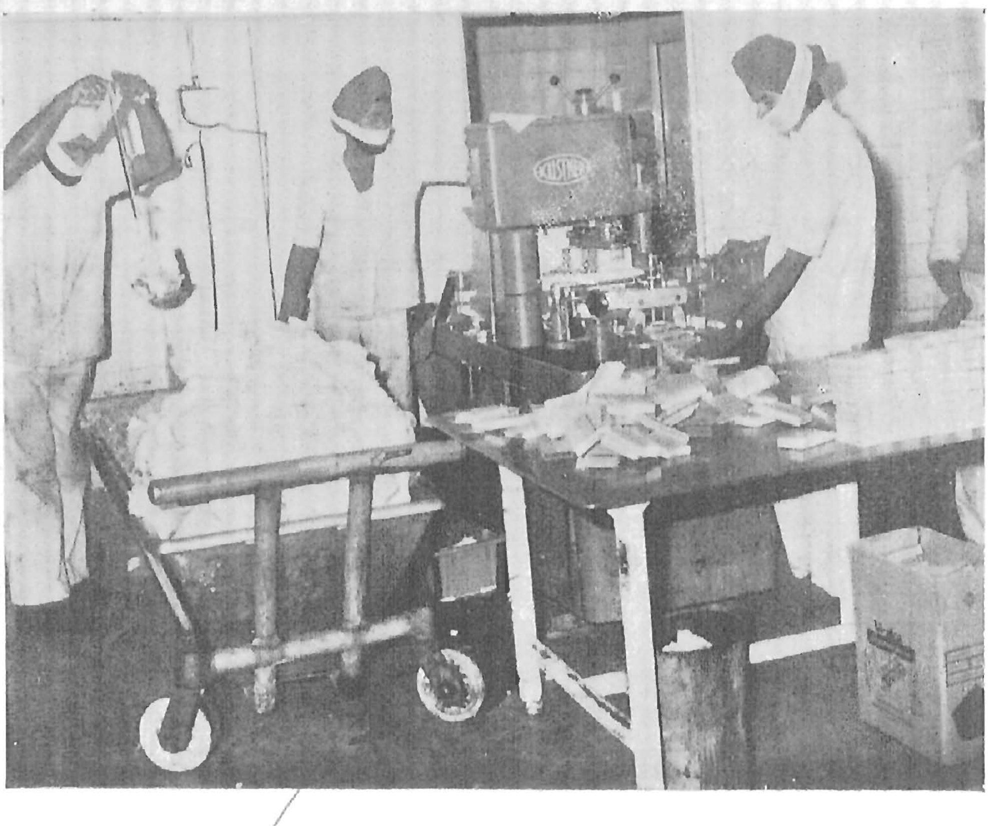


FIG. 206. A large number of milk booths were set up in attractive surroundings in Punjab by the Milk Commissioner, Gurbhagwant Singh Kahlon. Apart from milk, other dairy products like *ghee* and cheese are also sold at these booths.

Plants	Capacity (litres/day)	Purpose
Public Sector (Punjab Dairy Development Corporation)		
1 Verka (Amritsar)	60,000	Products and liquid milk
2 Chandigarh	40,000	Products only
3 Ludhiana	1,00,000	Products and liquid milk
4 Mohali (Ropar)	1,00,000	Liquid milk
Co-operative Sector		
1 Bhatinda	1,00,000	Products and liquid milk
2 Hoshiarpur	60,000	—do—
3 Jullundur	50,000	—do—
4 Sangrur	50,000	—do—
5 Gurdaspur	1,00,000	—do—
Private Sector		
1 Food Specialities Ltd, Moga	1,75,000	Products only
2 Hindustan Milkfood Manufacturers, Nabha	1,00,000	—do—
3 Jagatjit Industries, Hamira	50,000	—do—
4 Milkfood, Bahadurgarh	1,70,000	—do—

SOURCE: Dr S.S. Gill, Animal Science Department, Punjab Agricultural University, Ludhiana.

Animal Husbandry Department has set up a network of 50 artificial insemination centres and 650 insemination units all over Punjab. A few lay inseminators have also set up their private artificial insemination centres in the State. According to the latest estimates, 100,000 crossbred cows/heifers have been produced in Punjab.

Maintenance of Exotic Herds and Cross-breeding Policy

To produce quality bulls, exotic herds of Brown Swiss are maintained at Patiala and Nabha, Holstein-Friesians at Matewara (Ludhiana) and Rupar, and Jerseys at Rupar. Two bull mother farms, one at Nabha and the other at the Punjab Agricultural University, Ludhiana, have also been established.

Three major exotic breeds, viz. Jersey, Brown Swiss and Holstein-Friesian, are being used for cross breeding in Punjab. The State has been divided accordingly into three regions. Jersey breed is being used in the sub-montane areas comprising the districts of Hoshiarpur, Rupar and Gurdaspur. Brown Swiss are popularized in Patiala and Sangrur districts. The agriculturally productive zone comprising Bhatinda, Ferozepur, Faridkot, Ludhiana, Amritsar, Jullundur and Kapurthala has been earmarked for cross breeding with Holstein-Friesians. Red Dane has also been used in Ludhiana and Amritsar districts.

Under the Canadian Hunger Foundation Programme the Punjab Dairy Development Corporation imported 300 female calves of Canadian Holstein-Friesian breed along with bulls and frozen semen. This stock is maintained in an 87-hectare farm at Rupar. The bull calves of this breed are supplied to farmers at concessional rates.

Development of a new Breed

The Punjab Agricultural University has developed a herd of Red Dane × Sahiwal crossbreds. The herd of these cross-breds has yielded an average of 3,000 litres in its first lactation (305 days) and 3,500 litres during the subsequent lactations. One cow of this herd yielded as much as 50.9 litres in one day and created a national record of 7,309 litres in the second lactation (Fig. 193). Red Dane × Sahiwal cows are being further crossed with Holstein-Friesian bulls with a view to producing three breed crosses for developing a new breed by *inter-se* mating (Fig. 194). Every year about 30 thousand doses of liquid and frozen semen obtained from high quality exotic and cross-bred bulls are supplied to the farmers of the State through various agencies for insemination of cows.

Buffalo Improvement

The main factor in improving buffalo breeds is the use of high-quality bulls. Such bulls should be from high-yielding dames sired by progeny-tested bulls. To produce such bulls the Punjab Agricultural University in July 1970 established a centre under the Co-ordinated Project of Indian Council of Agricultural Research on Buffalo Improvement. A herd of 300 high-yielding buffaloes with 305-day lactation yield of 2,100 to 2,200 litres has been established.

Health Cover

The Punjab Veterinary and Animal Husbandry Department has the main responsibility for providing animal health cover for the entire live-stock population in the State. This service is being provided through a net-work of 348 veterinary hospitals and 460 dispensaries and a Disease Investigating Centre at Jullundur. The Punjab Agricultural University also operates three clinics, including a mobile one at its Ludhiana Campus.

Punjab Dairy Farmers' Association

The Department of Animal Science of the Punjab Agricultural University in 1970 started a project on 'Intensified Cropping and Milk Production' sponsored by the Ford Foundation. Through this project 24 farmers were helped to introduce dairy farming with high-yielding buffaloes and cross-bred cows in their traditional crop farming pattern. The mixed farming pattern adopted by these enterprising farmers has become a demonstration for the other farmers. The packages of management practices for efficient dairy farming developed under the project are extended to the farmer throughout the State. The technology of mixed farming with dairying is fast catching up with the Punjab farmer. These enterprising dairy farmers established the Punjab Dairy Farmers' Association with a membership of 300 dairy farmers in 1974, with headquarters in the Department of Animal Sciences, Punjab Agricultural University, Ludhiana. This association provides a forum for discussion on dairy problems with experts. It also takes up problems of the dairy farmers with the authorities in the State Government.

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CHAPTER 50

POULTRY FARMING

POULTRY KEEPING IN THE COLONIAL PERIOD
CONQUEST OF POULTRY DISEASES
DEVELOPMENT OF POULTRY FARMING DURING THE FIVE-YEAR PLANS

DOMESTICATED fowl was known to exist in India around 2300 B.C. From India, it moved towards north and east, reaching Greece about 525 B.C. The Iranian invaders took it to Persia, from where it reached Palestine and from there, through the Palestinian Jews, into England. From England it went to various parts of Europe, South Africa, Australia, Japan, Russia and the USA.

For a long time, the domesticated fowl was kept mainly for cock-fighting and as a fancy pet animal. It was, therefore, bred for the fighting qualities and for the beauty of plumage, which gave rise to a number of breeds, including the famous Aseel breed.

INDIAN POULTRY CLUB, LUCKNOW, 1860

The first important step towards poultry development was taken in 1860 when the Indian Poultry Club was organized at Lucknow by the British officers. The Club started publishing a quarterly journal, the *Indian Poultry Gazette*, which continues till today. The Indian Poultry Club organized regular poultry shows which generated considerable competition in breeding chickens for fancy and body conformation. Taking a cue from the Indian Poultry Club, various States set up poultry associations, including the well-known Delhi State Poultry Breeders' Co-operative, which started a monthly journal, the *Poultry Guide*.

POULTRY FARMS OF MISSIONARIES

During the early 1900s, some foreign missionaries in the United Provinces of Agra and Oudh and the Madras Presidency started importing pure-bred foreign stocks from England, the USA and Australia with a view to promoting poultry production for improving the economic conditions of the people. One of the mission's poultry-farms was set up at Etah (UP) in 1912. The farm maintained the Rhode Island Red, White Leghorn and Black Minorca breeds.

A very important event took place during 1919, when, on the advice of Sir Harcourt Butler, the Governor of UP, the provincial government took the first step for poultry improvement and engaged a British poultry expert, Mrs Fawkes. She organized the UP Poultry Association and set up a State Poultry Farm at Lucknow. Poultry-training programmes were initiated. Mrs Fawkes also wrote a book, *Poultry-Farming in the East* (1933).

The first major organized effort on poultry research and training in India started with the establishment in 1939 of a poultry research section, later known as the Poultry Research Division, at the IVRI, Izatnagar. The Division recruited a poultry expert from the UK and deputed an Indian veterinarian to the UK for training in Poultry Pathology.

Military Poultry Farms

During World War II, a large number of military poultry farms were set up in different parts of India. Even though the military farms were disbanded immediately after the War, these farms helped to multiply and spread the exotic poultry stocks and also served as models of organized commercial poultry-farming.

Ranikhet Disease (New Castle Disease), 1948

Ranikhet Disease (New Castle Disease) was first reported in India in 1927 by Cooper, who recorded an outbreak at Ranikhet, in Kumaon. By 1930, the disease had spread throughout the country. It caused enormous loss to the country till a successful vaccine was developed at Mukteswar.

Work on evolving a vaccine strain began around 1941 with three strains of the virus and culminated in 'fixing' their characters in 1948. One of the strains at the 110th passage was found to be sufficiently attenuated. After laboratory trials, the vaccine prepared from this strain was successfully tested on one million birds mostly at military poultry farms. The vaccine proved safe and conferred full protection against the disease. It was issued for use in the field in 1945. The immunity lasted for four years, the full utility period of a bird.

A further improvement was effected by freeze-drying the vaccine, which enhanced its keeping quality and made transport easy. This vaccine (R_2B strain) was shown to be more effective when used on 8-week-old or older chicks. For protection of younger chicks a milder strain (F_1) was evolved. The Bharatiya Agro-Industries Foundation (BAIF), Pune, markets La Sota/F strain for use on day-old chicks, and R_2B Mukteswar strain vaccine for 6-8-week-old chicks. The vaccine has been in use throughout the country. This vaccine proved to be very efficacious, and has removed the single greatest threat to the poultry industry of the country by controlling a deadly disease which used to sweep away large flocks year after year.

Fowl Pox, 1949

Fowl pox used to occur throughout the country causing 17-15 per cent mortality but now it is completely in check with the use of vaccine developed at the Indian Veterinary Research Institute, Izatnagar, in 1949 by passage of the virus in developing chick embryos. It confers protection for one year, and is recommended for immunising chicks. For laying-birds, the pigeon-pox vaccine has been developed.

Fowl Spirochaetosis, 1954

It is one of the most important diseases of poultry in India which causes high mortality. A vaccine evolved at the IVRI in 1954 by adapting the causative organism on developing chick embryos confers protection for one year.

Other Poultry Diseases

Marek's disease, chronic respiratory disease, infectious laryngotracheitis, infectious bronchitis and Gumboro disease—all viral infections– recorded during the last two decades are now widely prevalent in the country. These viruses have possibly been imported along with the birds. Gumboro disease is immuno-suppressive, the implication of which is the impaired response of the infected birds to vaccinations and heightened susceptibility to pathogens.

So far vaccines against Marek's disease were imported but recently there has been a welcome development that two organizations have started indigenous manufacture: Babcock, in collaboration with their principals in the USA, and Bharatiya Agro-Industries Foundation (HVT vaccine), with indigenous technology.

Poultry-keeping during the First Five-Year Plan

Before the planning era no organized efforts were made to develop poultry industry in the country. The average indigenous hen produced about 50 eggs a year.

The introduction and popularization of poultry-keeping formed an important developmental programme under the Community Development Scheme. During the First Five-Year Plan (1951-56), the programme on poultry was largely limited to the distribution of the imported pure-bred varieties and the upgrading of the indigenous poultry stocks. Pilot poultry extension centres were established during the latter half of the Plan.

Imports of High-yielding Pure-bred Stocks

During the Second Five-Year Plan (1956-61), more of the pure-bred exotic stocks, including 30,000 White Leghorn and Rhode Island Red chicks from the USA, were received under Technical Co-operation Mission (TCM) aid along with poultry-farming equipment. A network of poultry-extension centres was established for the multiplication and distribution of the exotic varieties of chickens. In 1959-60, five large regional poultry-farms were set up at Bangalore, Bombay, Bhubaneshwar, Delhi and Simla.

The real breakthrough in poultry production occurred during the Third

Five-Year Plan (1961-65). For the first time, poultry-farming was taken up on a commercial scale in various parts of the country. A notable feature of this plan was the adoption of an area-development approach, under which 77 centres for intensive production and marketing of eggs and poultry were set up. These provided the farmers with a complete package of inputs and extension services, including improved chicks, balanced feeds, services of vaccination, debeaking, disease control and the marketing of eggs and birds.

Hatcheries

Another very significant development during the Third Plan was that the Government of India approved and helped to set up 5 large franchise hatcheries in the private sector. These hatcheries imported and multiplied the internationally famous brands of hybrid chicks, having the potential of very high production. The introduction of hybrid chicks laid a firm foundation for the further development of poultry in the country.

Poultry-dressing Plants

To help the marketing on broilers and old hens, the Government of India assisted to establish in 1969 two large poultry-dressing plants at Chandigarh and Pune. The plants had the capacity of processing 600 and 1,000 birds per hour respectively.

New Poultry Rations

Another major factor which made poultry-farming a commercially profitable proposition was the development during the early 1960s of several economic and efficient poultry rations as a result of the work carried out under the leadership of Dr Gurcharan Singh Sidhu, Professor of Biochemistry, at the College of Agriculture, Ludhiana. Similar work was done in the Poultry Research Division of the IVRI. The new poultry rations were mostly based on cheap and easily available agro-industrial by-products, such as rice bran, groundnut-cake and maize by-products. Extension of rice cultivation in Punjab and Haryana also stimulated poultry-keeping, as rice bran is an important constituent of poultry feed.

Poultry-farming in Punjab

Poultry production made a particularly rapid progress in Punjab, when Sardar Partap Singh Kairon, paid personal attention and provided all the encouragement needed for its development. Dr Harbhajan Singh, who had headed the Poultry-development Section in Punjab since the early 1950s, planned and diligently carried out various poultry-development programmes in the State. Two poultry experts from the USA, Dr Pran Vohra and Dr P.C. Clayton, also played a very useful role and organized a large number of small poultry units around the Gurdaspur and Ludhiana cities, which became the nuclei of poultry in northern India. Dr A.R. Winter, another US poultry expert, for the first time organized a postgraduate poultry-training programme at the Punjab Agricultural University, Ludhiana, in which 25 persons from Punjab and the adjoining States received training. Dr Earl Moore, also from the USA, did a lot of work to promote poultry around Hyderabad.

Pure-line Poultry Breeding

In the Fourth Plan (1969-74) several significant advances were made under the overall leadership of a very able poultry expert, Dr J. N. Panda, who remained the Head of the Poultry Section in the Animal Husbandry Department of the Ministry of Food and Agriculture of the Government of India for many years. Three more franchise hatcheries with foreign collaboration were established. They initiated the era of "pure-line" poultry-breeding so as to avoid the need for recurring imports of grand parental poultry stocks for producing hybrid chicks. Four hatcheries, each of 50,000-egg capacity, were set up in the public sector at Bombay, Bangalore, Bhubaneshwar and Chandigarh. A High-Level In-service Poultry-Training Institute, now named the Central Training Institute for Poultry Production and Management, was set up at Bangalore with the assistance of the FAO/UN. Dr Allan Mcardle, a poultry expert from Australia, who was known for his total commitment to the cause of poultry development in Asia, played a key role in organizing these programmes. Dr Mcardle also made a notable contribution to poultry-farming by guiding and providing help for the setting up of small workshops for manufacturing incubators and other poultry appliances in India. This industry has developed to such an extent that the country has not only become self-sufficient but is exporting poultry equipment to many other countries.

To make the country self-sufficient in the requirements of high-quality poultry stocks, the ICAR launched in 1970 an All-India Co-ordinated Research Project on Poultry Improvement. The project was started at 8 centres spread all over the country.

Another important development in the field of poultry-breeding was the setting up of a Random Sample Poultry-Testing Centre at Bangalore in 1970. The earlier Random Sample Testing Schemes initiated at the IVRI in 1955 had not made an impact. The 1970 scheme of Random Sample Testing was later expanded and two additional Test Units were set up at Bombay and Bhubaneshwar.

During the Fourth and Fifth Five-Year Plans, the agricultural universities and the Indian Veterinary Research Institute considerably expanded their teaching and research programmes in Poultry Science. Several institutions set up separate departments dealing with Poultry Science and

FIG. 207. Poultry sheds like the one shown here have mushroomed in the suburbs of all towns in India.

FIG. 208. The most popular poultry birds are White Leghorn hybrids. They yield about 250 eggs a year. Control over Ranikhet disease and rise of commercial hatcheries which imported high-yielding birds from the USA have given impetus to the industry, which creates large amount of self-employment.

started offering postgraduate courses in this subject. A major step forward in this area was the establishment in 1978 of a national institute on poultry under the name of Central Avian Research Institute, at Izatnagar, which takes the place of the Poultry Research Division.

The status of the Head of the Poultry Section in the Animal Husbandry Wing of the Government of India was raised from Deputy Commissioner to Joint Commissioner. Dr J.N. Panda was the first person to hold this position.

The import of poultry stocks in the form of grand parental lines has continually expanded since the early 1960s. Towards the end of 1970s, as many as 10 franchise hatcheries of international fame were operating in the country. The Government has, however, continually reviewed the import policy and a major policy decision was taken in 1976 which greatly restricted the further import of poultry stocks. Another regulation by the Government of India in 1980 almost completely bans the import of the grand-parental lines, but permits the import of pureline stocks for further breeding in the country.

In the mean time, the country has developed its own capability to breed high-yielding poultry stocks. The highest hen-housed average production recorded is 232.8 eggs over a laying period of 11 months. A poultry stock named HH-260, developed at the Central Poultry Farm, Bangalore, was officially released in 1977. Since then, other institutions, notably the Punjab Agricultural University, Ludhiana, the Indian Veterinary Research Institute and the University of Agricultural Sciences, Bangalore, have evolved new poultry stocks with a performance level equal to, or better than, that of the imported stocks.

Co-operative Marketing of Eggs and Supply of Poultry Feed

The arrangements which the State Governments made for co-operative marketing of eggs and supply of poultry-feed at the door of the poultry farmer through autonomous corporations have greatly helped in promoting poultry-keeping. Now farmers do not spend any time in making arrangements for sale of eggs. The eggs are transported by the Corporations in their trucks to the consuming centres, and they also supply feeds to the poultry-keepers.

The largest concentration of fowls in India in 1961 was in Kerala, West Bengal, East Bihar and Punjab. Ducks are mainly kept in West Bengal and Assam (Fig. 209). The number of layer-hens rose from 35 million in 1961 to 88 million in 1980. The number of improved layers (hens) was 2 million in 1961 and 58 million in 1980. The number of *desi* hens declined from 33 million in 1961 to 30 million in 1980. The annual egg output in the country has risen from 2,340 million in 1961 to 5,340 million in 1971, 8,204 million in 1975 and 10,300 million in 1977, and 12,500 million in

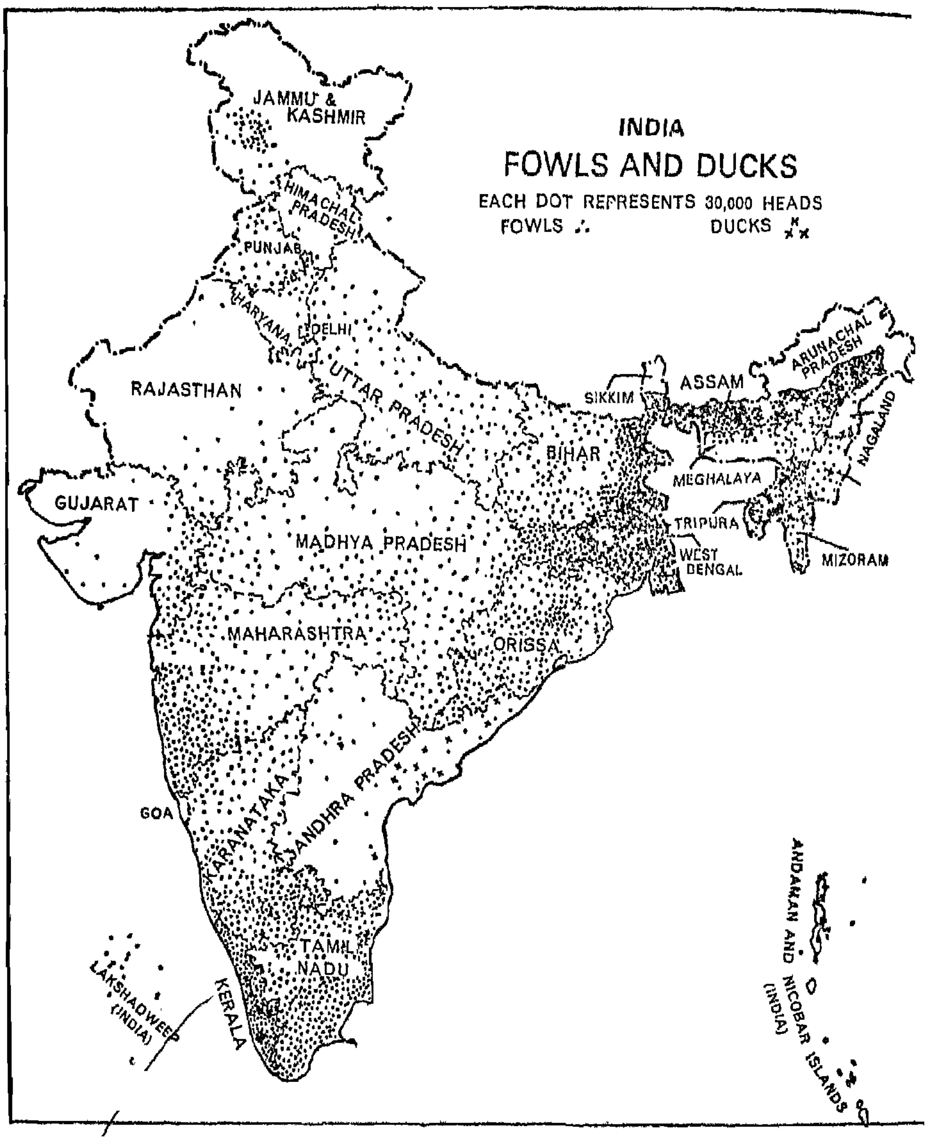

Fig. 209. A map of India showing distribution of fowls and ducks. There is a large concentration of poultry in Kerala, Tamil Nadu as well as in West Bengal and East Bihar. Ducks are mainly kept in West Bengal and Assam.

1980. Broiler production rose from 4 million in 1971 to 30 million in 1980. The remarkable progress made by the Indian poultry industry in a short span is reflected in the fact that already more than 80 per cent of our total egg production comes from genetically improved birds kept under intensive system of rearing. Another indicator of the rapid pace of development of the Indian Poultry Industry is the value of the annual production of poultry products. From a mere Rs 600 million in 1960 this figure has shot to an estimated Rs 6,600 million in 1980. India is now an exporter of day-old chicks, and our poultry equipment manufacturers have won foreign orders in the face of stiff international competition.

Poultry sheds have mushroomed in the suburbs of all the towns in India (Figs 207, 208). The most popular poultry birds are White Leghorn hybrids which yield about 250 eggs per annum. For broilers Rhode Island Reds are preferred. The outlay on poultry development in the Second Five-Year Plan (1956-61) was Rs 28 million and it rose to Rs 365 million in the Fifth Plan (1974-78). Poultry industry has created a large amount of self-employment. It has proved to be a boon to military officers, a large number of whom take it up after retirement from service. Spectacular progress of poultry production in two decades from backyard to modern industry occurred because all the essential inputs—equipment, training of poultry farmers, high quality exotic birds, effective health cover, finance and marketing—were provided.

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CHAPTER 51

FISHERIES

INDIA has considerable fishery resources, but these have not been properly assessed so far. An extensive coastline of about 6,000 km, a continental shelf of nearly 260,000 square kilometres in the Arabian Sea and the Bay of Bengal, and a large number of small oceanic islands form an extensive source of marine fish. Similarly, numerous rivers, streams, lakes, *jheels*, artificial reservoirs and innumerable ponds and tanks and other water areas constitute a rich potential source of inland fish. But, on account of primitive fishing methods and inadequate facilities for storage, transport and marketing, the fishery resources are not being fully exploited or developed at present. Fishing in the seas is generally confined to a narrow belt of 8 to 11 kilometres only, and the rich off-shore and deep-sea waters are left practically unexploited. Vast stretches of inland waters remain completely or partially fallow, and destructive fishing practices are often indulged in for lack of adequate conservation measures.

The population of adult fishermen in the country is over 500,000 and the number of fishing craft, mostly primitive sailing-boats, was about 75,000 in 1958. The total annual production has been estimated at 1.1 million tonnes — 71 per cent sea-fish, and 29 per cent freshwater fish. On the basis of nutritional requirements of 75 grams of fish per day, the fish-eating population of India needs 4.55 million tonnes of fish. The annual consumption of fish per person is estimated at only 1.8 kg.

The consumption of fish varies in different parts of the country on account of (a) disparities in fishery resources, (b) differences in the food habits of the people, and (c) economic factors. In Saurashtra, a strong religious prejudice exists against the eating of fish. In Punjab, fish is not very popular, though there is no such religious taboo. In western Uttar Pradesh, Rajasthan and Madhya Pradesh, fish-eating is generally confined to riverine areas. In Bihar, West Bengal, Kerala and Assam, on the other hand, fish is an important item of diet, whereas in Orissa, Andhra Pradesh, Madras, Karnataka and Maharashtra (excepting Saurashtra), a good proportion of the people would eat fish if they could afford it. Kerala leads in the consumption of fish per person, followed by West Bengal. The lowest consumption is in Punjab.

In the non-maritime States, fresh fish is in demand. In the maritime States, both fresh and dry fish is consumed. Organized trade exists near the centres of production and in the urban areas, where people are comparatively well off. In the vast tracts of the rural areas, however, no regular supplies are available. Only 43 per cent of the total production is consumed as fresh fish. Nearly half of the total production is dried and cured, the bulk being of sea-fish. India exports annually nearly 193,040 tonnes of dried fish, valued at Rs 36 million mostly to Ceylon and Burma. The exports of frozen prawns to the USA are now being actively promoted. About 7 per cent of the fish produced in the country is converted into by-products, such as fish manure, fish guano, fish oil and isinglass.

Principal Fisheries of India

In the order of importance, the *principal freshwater* fisheries are those of (1) major carps, (2) catfishes, (3) live fishes, (4) prawns, (5) mullets, (6) feather-backs, (7) miscellaneous, including minor carps, perches, loaches, etc., (8) eels, and (9) herrings and anchovies.

The marine and estuarine fisheries comprise the following major types in the order of importance: (1) mackerels and perches, (2) herrings and anchovies, (3) miscellaneous, (4) catfishes, (5) jewfishes, (6) silver bellies, (7) flat fishes, (8) Bombay duck, (9) mullets, (10) pomfrets, (11) Indian salmon, (12) dorab, (13) shellfishes, and (14) eels.

The production of marine and inland fisheries increased slowly from 1951 to 1976 (Table 1).

Table 1. Production of Fish in India (thousand tonnes)

Year	*Marine*	*Inland*	*Total*
1951	534	218	752
1956	718	294	1,012
1961	684	277	961
1966	890	477	1,367
1971	1,162	690	1,852
1976	1,525	875	2,400

Source: Ministry of Agriculture and Irrigation

Development of Fisheries

The development of fisheries in India started on an *ad-hoc* basis under the post-war Grow-More-Food Schemes. It was, however, under the First Five-Year Plan that the work was undertaken on a comprehensive scale. Steps were taken to increase the production and utilization of fish by establishing fisheries research station and initiating schemes for training fishery-workers and fishermen, development and conservation of fresh water fisheries for stepping up the exploitation of sea fisheries, and for improving fish-marketing and fish utilization. These activities were further expanded during the Second Five-Year Plan. An increase of 10 per cent in fish production was estimated to have taken place by the end of the First Plan, and it had been expected that under the Second Plan the production would go up by 33 per cent.

The development of inland fisheries entails the surveys of culturable waters, increasing the extent of such waters by repairing and reclaiming derelict tanks and marshy areas, increasing the availability of fish seed of suitable species, stocking them to the maximum possible extent and the rational exploitation of fisheries. Activities on these lines have been undertaken in almost every State. The development of reservoirs in the multipurpose river-valley projects is also being initiated. The Central Inland Fisheries Research Station, Calcutta, and its substations are undertaking investigations on various developmental problems.

For increasing the production of sea fisheries, efforts are being directed towards providing the fishermen with the necessary fishery requisites and improving their economic condition, and popularizing the mechanization of fishing operations. Mechanized fishing with powered craft is being introduced along two lines: (1) increasing the operational range of the existing craft by installing engines and mechanical devices; (2) introducing off-shore fishing by undertaking exploratory fishing with powered vessels that have proved successful elsewhere.

Exploratory fishing has been taken up at the Central Deep-Sea Fishing Stations at Bombay and Cochin, by West Bengal, Maharashtra, Kerala and Tamil Nadu. Modern fishing methods, such as otter-trawling, bull-trawling, shrimp-trawling, seining, ring-netting, long-lining, gill-netting, and drift-netting are being tried. It is proposed to establish more exploratory fishing-centres on both the eastern and western coasts. With the integrated programme for the development of in-shore and off-shore fishing, a firm foundation is being laid for modern powered fishing industry in India.

The Central Marine Fisheries Research Station, Mandapam, and its substations, and the Central Fisheries Technological Research Station, Cochin, are undertaking investigations on various problems connected with the development of marine fisheries. The Central and maritime State governments have established half-a-dozen centres for training fishermen in the methods of mechanized fishing. Measures are also being undertaken to improve fish-marketing and fish utilization.

Marine Capture Fisheries

The major achievements in marine capture fisheries are the development of a survey system for the accurate estimation of marine fish-landings, and the assessment of fish resources by the continual monitoring of ecological, biological and population parameters of fish stocks essential to the proper exploitation and management. These measures have indicated that increased production for several fish resources is possible from the traditional as well as from the new fishing-grounds recently discovered as a result of the exploratory and experimental fishing-surveys.

MARICULTURE

In the field of mariculture, emphasis is laid on the development of low-cost technologies for the culture of milkfish, mullets, pearl spat, prawns, spiny lobster *(Panulirus homarus)*, green crab *(Scylla serrata)*, edible and pearl oysters, and agar-yielding seaweeds under various culture systems to obtain maximum yields. As a result of these studies, considerable advancement, leading to the establishment of modern coastal activities of aquaculture, including sea-farming, has been made. A major breakthrough in the field of prawn culture is the development of the brood stock of *Penaeus monodon*, *P. indicus* and *Metapenaeus dobsoni* through induced maturation, breeding and larval production and rearing under captivity. Field experiments on the intensive culture of *P. monodon* and *P. indicus* have established that they grow fast and reach marketable size in 3 to 4 months after stocking. The possibility of producing 1,000 to 1,500 kg/ha/year has been demonstrated in the commercial prawn culture undertaken in several of the farmers' fields. In the open sea, raft culture for green mussel *(Perna viridis)* and brown mussel *(P. indica)* resulted in a production of 750 tonnes/ha/5 months. In the 'rack culture' for edible oysters, a production rate of 150 tonnes/ha/year was obtained. Indigenous techniques developed for farming pearl oysters and the production of cultured pearls have opened up possibilities for establishing a pearl-culture industry in the country.

Research on inland and marine fisheries and on fisheries technology is being done at the CIFRI, Barrackpore (West Bengal), the CMFRI and the CIFT, both at Cochin (Kerala). The technique of composite culture, involving both Indian and exotic species, developed by the CIFRI, has established that fish production in small and medium inland water bodies can be enhanced to at least five times the present yield by using suitable combination of species and some supplementary inputs. Successful induced breeding of most of these carps has overcome a major constraint in the availability of quality stocking material in these fish-culture operations. A technique for preserving and ampouling pituitary extract needed for this purpose is also an important factor in promoting fish-culture and in setting up 'pituitary banks' to serve as a ready sources of injection material. Also, the Institute developed efficient devices for hatching the spawn and later for rearing the fry to develop into fingerlings with the maximum survival.

A major breakthrough in the production of fish seed can be achieved by injecting the pituitary-gland extract of matured fish into both Indian and exotic carps and inducing them to breed in confined waters. This technology has opened up a new line of research on selective breeding and hybridization in carps, which will help researchers to evolve new high-yielding and disease-resistant varieties. Methods of preservation and ampouling the pituitary extract for use in future have also been developed.

COMPOSITE FISH CULTURE

In research on freshwater aquaculture and development, great strides have been made through the successful development of hatchery systems by increasing the production of quality seed and by adopting different systems of aquaculture for carps at the experimental farms and in the farmers' fields, resulting in high rates of production. The emerging new technology of composite fish-culture lays stress on the stepping up of quality seed production through the establishment of hatchery complexes in the country. The achievements of 900 fish-farmers in West Bengal who took up composite fish-culture during 1975-79 showed that the highest production rates obtained varied from 7,124 to 8,150 kg/ha/year, against the highest experimental yield of 10,000 kg/ha/year. An average gross profit of about Rs 16,000/ha/year (1975-77 prices) was obtained by the fish-farmers by employing the new technology.

The intensive culture of air-breathing fishes has shown great promise for developing a system of high production. This system will also enable the utilization of swamps, derelict waters and sewage-fed waters for productive purposes.

Integrated fish-livestock farming has a great potential and holds out great promise for increasing the production of protein. The system of fish-culture is combined with the rearing of pigs and ducks and green cattle fodder, with the result that no other supplementary feeds or manure are to be applied. Fish productions of 7,300 kg/ha/year and 4,323 kg/ha/year were achieved in fish-pig and fish-duck farming respectively. The cost of fish production worked out at Re 0.83/kg in fish-pig combination and Rs 1.38/kg in fish-duck combination. The raising of animals contributed to the additional income.[1]

With the declaration of 322-kilometre 'Exclusive Economic Zone' in the Indian Ocean, the exploitation of additional resources, such as the oceanic tuna, tuna-like fishes, squids and meso-pelagic fishes, opens up new frontiers of production and offers a challenging future for the programmes of research and development. When sea-farming projects involving the culture of prawns, mussels, oysters, lobsters and eels are introduced under rural development projects, the opportunities for providing employment along the vast sea-coast will increase considerably. In the sector of capture fisheries, the development is mainly concerned with the improving of the efficiency of fishing-craft and fishing-gear and the introduction of the modern fishing-gear for diversified fishing and fishing-vessels for long-range operations for increasing fish production.

[1]Silas, E.G. 1980, *Major Achievements through Fisheries Research in India*, ICAR, New Delhi

CHAPTER 52

INTEGRATED RURAL DEVELOPMENT SCHEME

ABOLISHING POVERTY IN RURAL INDIA

A study made by the Planning Commission in 1976 showed that 100 districts out of a total of 400 had a negative growth in the preceding 10 years. This situation was in contrast to that in the intensive agricultural areas, which had been stirred by the new technology of high-yielding varieties and the use of chemical fertilizers and ground-water. It was felt that time had come to tackle poverty in rural areas that had remained stagnant. The author of the concept of the Integrated Rural Development is C. Subramaniam. He was born and brought up in a village in the Coimbatore District in Tamil Nadu and belonged to an agricultural family. As Minister for Food and Agriculture of the Government of India from 1964 to 1967, he had seen the impact made by the programme of high-yielding varieties in the Intensive Agricultural Areas in alleviating poverty. From 1971 to 1974, he was the Deputy Chairman, Planning Commission, and Minister for Science and Technology. The Department of Science and Technology was created in the Government of India in 1971 at his initiative. He was instrumental in setting up a National Committee on Science and Technology comprising leading scientists of the country. They were entrusted with the task of formulating a Science and Technology Plan for the country for 10 years. The Committee was asked to find an answer with respect to the role of science and technology in dealing with rural problems more efficiently and effectively to bring about rural transformation.

PILOT PROJECT IN THE KARIMNAGAR DISTRICT

Dr Nayudamma, Director-General of the Council of Scientific and Industrial Research, who belonged to a farming family, and was conversant with rural conditions, on the request of Subramaniam, agreed to formulate an action plan. He selected Karimnagar, a backward district in Andhra Pradesh, for launching pilot project. It was soon realized that no worthwhile plan could be formulated without the knowledge of the available natural resources. The traditional method of surveying is time-consuming. Hence it was decided to make use of the satellite technology, and to get suitable photographs from the NASA in the USA, whose earth-resource satellite was photographing every area of the earth. Fortunately, some Indian scientists who were trained in the USA for the interpretation of such photographs volunteered to do this job. It was thus that the National Remote-Sensing Agency was founded. Its job was to interpret photographs and to identify natural resources. These pictures revealed the surface resources as well as the underground ones—hydrological and mineral. The satellite pictures gave a complete description of the underground water resource. It enabled the study not only of the availability of water but even of its quantity. This capacity greatly enhanced the planning of the locations of new wells. Data on soil conditions were also available in much greater detail from these pictures than possible by using traditional method of soil-testing, thus giving a new dimension to soil and water management.[1]

Finance

After the assessment of natural resources, the question of finance arose. Fortunately for this scheme, Subramaniam became the Finance Minister of the Government of India in 1974 and remained as such till 1977. The Government of India decided to push banks into the rural area. Banks were asked to give loans for improving land, sinking tube-wells and for setting up rural industries. The Government agreed to grant subsidies, where justified. Where the borrowers could not meet the commercial rates of interest (14-15 per cent), the Government of India sanctioned differential rates—6-8 per cent—and subsidized the balance.

From the Karimnagar Pilot evolved the Integrated Rural Development Plan for the regeneration of the rural area. It encompassed agriculture, animal husbandry, industry, health and education— an integrated approach to serve the rural area.

Role of M.S. Swaminathan

The innovation of a scientific model of integrated rural development as a means for wiping out rural poverty in India was given content and meaning in concrete terms by Dr M.S. Swaminathan, who at that time was the Director-General of the Indian Council of Agricultural Research. In his presidential address to the 63rd session of the Indian Science Congress, held at Waltair in January 1976, he stressed the need for organized complementarity between the scientific-cum-engineering technical talent on the one hand, and the commensurate financial and socio-economic institutional structure on the other, to undertake an effective and balanced utilization of natural resources in the country. He felt that the strategy would increase farm and non-farm production and also create more opportunities for the employment of labour. He was also of the view that the purchasing power generated in this manner would have a multiplier effect upon the promotion of self-employment activities in the secondary and tertiary sectors of the village economy. Among the measures which he proposed for the integrated rural and urban development to promote the interdependent growth of the village and the city, he recommended the reservation of specific indus-

[1]Subramaniam, C. *The New Strategy in Indian Agriculture*, p. 81

tries, credit and energy for the rural sector. As the first step, he recommended the preparation of an inventory of land, water, and mineral resources, area by area, and the development of plans for the judicious use of land and water.

PRIME MINISTER INDIRA GANDHI'S SUPPORT TO THE PROGRAMME

In the inaugural address to the Indian Science Congress, Prime Minister Indira Gandhi stated, 'The relationship between villages and towns has been one of the earliest problems of civilization. Etymologically, the very word civilization connotes urbanization and thus carries in it a bias against villages. Science has, by and large, been an ally of industrialization and urbanization and has not given adequate attention to a comprehensive study of rural problems. The drain of talent from village to town is the oldest form of brain drain, except in ancient India, where the great *ashrams* were located in villages, and a wise-institutionalized attempt was made to take city youth to learn in rural and sylvan environments. No less notable is the economic drain from rural to urban areas. Much initial capital for industrial growth, whether in the capitalist or the socialist system, has been accumulated through a conscious policy of denying the villages their due share of social investment. In the Indian pattern of development, it was our deliberate effort to avoid this wrong.' She concluded that rural life should be so enriched as to prevent the migration of people and resources from the villages to towns.

C. Subramaniam, who was Finance Minister of the Government of India, wrote a paper on the strategy for Integrated Rural Development, and emphasized the need for making a special budgetary allocation for this purpose in the 1976-77 budget. An *ad-hoc* provision of Rs 150 million was made.

The work on the programme was seriously undertaken in June 1976. The programme involved the following steps, viz. precise definition of the concept of Integrated Rural Development (IRD); preparation of resource inventories of 20 backward districts in the country; preparation of integrated action plans; and reorganization of the administrative set-up.

The IRD was defined as that form of 'development which can help to increase the purchasing power of the rural poor through the generation of greater opportunities for gainful employment.' The rural poor are mainly landless labourers and marginal farmers. The preparation of a resource inventory was considered necessary, and the specific natural, technical and financial constraints were to be identified. The designing of an action plan involved the dovetailing of the existing development programmes with fresh proposals by an on-the-spot progress verification.

A major policy decision taken in this connection in 1977 was to go in for decentralized micro-level planning at the block level. The preparation of guidelines for such a planning was entrusted to a Committee headed by the economist M.L. Dantwala. The strategy evolved was to intensify efforts for the integrated development in 2,000 blocks out of a toal of 5,004 in the country in combination with the on-going programmes of various categories.

In order to ensure the maximum participation of the people, a committee headed by B. Sivaraman was appointed to work out the details. From 1979 onwards, another 300 blocks were proposed to be taken up each year from areas not covered by the special programmes. The 'Food for Work' programme was initiated in 1978 for benefiting the rural labour classes, through employment in the construction of new durable community assets, and the State works, at wage payments in kind out of the foodgrain stocks. Large stocks of wheat were reserved for this programme.

Village Industries

Since Integrated Rural Development involves the integration of the primary, secondary and tertiary sectors of activities at the village or area level, it was felt necessary to lay parallel stress on the promotion of village industries along with the improvements in agriculture sectors. The Khadi and Village Industries Commission identified 23 types of village industries for rural development. The All-India Handloom Board, the All-India Handicraft Board, the Silk Board, and the Coir Board also offered substantial assistance in their respective spheres. In this connection, there was a shift in policy also. Instead of concentrating the centres of technical research and inventiveness in large towns, the Industries Centres were established in 1979 at the district headquarters, irrespective of the size of the town. These centres offer assistance and guidance to village entrepreneurs. Their main functions include economic-resources investigation; provision of available raw materials; supply of suitable machinery and equipment; and arrangement for credit facilities. Besides these functions, separate wings for setting up cottage and household industries were attached to them. The development of the tertiary sector was proposed to be stepped up through organized marketing, processing and trade activities, including transportation.

Antyodaya Model

Besides the above Intergrated Rural Development model, two other variants of the same were preferred in some of the northern States : (i) the Antyodaya model, and (ii) the Central village northern model. The Antyodaya model, which seeks to benefit the poorest section of the community, was selectively started in Rajasthan, Haryana and Himachal Pradesh. It envisaged the selection of five poorest families in each village and providing them with the means for gainful employment with a view to enabling them to cross the poverty line. The objective was to demonstrate such a possibility for the motivation of other households of weaker section.

PUNJAB FOCAL-POINT VILLAGE SCHEME

The central village scheme was devised and initiated by Sardar Parkash Singh Badal, former Chief Minister of Punjab, who is also a progressive farmer. A central village within a cluster of five was designated as 'Focal point' to act as a 'growth centre' for the cluster of villages and the area around. The focal point was to function as a sub-unit of the development block. The entire State was marked out into 500 sub-units each of 100 square kilometres. The rural population served varied between 20 and 30 thousand persons depending upon the density. In 117 blocks the same number of focal points was started in 1977, and the full coverage of the State was to be achieved within 5 years, i.e. by 1982. Each of the focal points was equipped with a market yard and a number of commission shops, a storage shed, a branch of the Central Co-operative Bank, a fair-price shop to supply consumer goods, a veterinary hospital, and a stock-breeding centre. In some of the focal-point villages, telephone booths, and diesel and petrol pumps were also provided.

The *panchayat* of the central village provided the land, and the town-based market committee set up the central co-operative bank. The *zila parishad* and the State Government provided funds for the construction buildings and approach roads. The primary co-operative credit societies in the villages were reorganized to meet the needs of all people. Thus credit was easily available and the farmers could sell their produce in a market close to them instead of carting their produce to far-off towns. They could also buy essential goods from shops in the focal village at reasonable prices. Thus the amenities of the town were brought within the reach of villagers in their own environment, and the integration of some of the basic amenities of urban life with rural living was achieved.

The planning and implementation of development was entrusted to an agricultural inspector, assisted by a *gramsewak* posted at the focal point under the overall control of the Block Development and *Panchyat* Officer, who was required to arrange for technical and financial assistance.

The Punjab model attracted much attention throughout the country. This was because it involved scientific planning and participatory implementation leading to phased transformation of the employment pattern within the primary sector, and further on mobility to the secondary and tertiary sectors. This required the reorganization of the co-operative credit structure, and the marketing, processing, supply and servicing functions. Private self-employment enterprises were also encouraged to form an essential part of the focal-point service complex.

In this effort, the Punjab Agricultural University was involved in planning, technical guidance and training of administrative and technical personnel. Another important assignment was the preparation of guidelines after conducting a scientific survey of the State. The Department of Economics and Sociology of the University released a report of the survey entitled *Dynamics of Integrated Rural Development : Model Programmes for Punjab,* 1981, which rationally assesses the programme performance, examines the pertinent issues, and offers guidelines to solve related problems.

The Economic and Statistical Organization of the State Government also conducted a survey of the poverty-stricken households in 1980. Fixing the poverty-line in terms of annual household earnings at Rs 3,600, as many as 824,000 of households were categorized as poor. These persons were issued yellow identity cards to enable them to purchase consumer goods from State-run fair-price shops. The provision for interest-free loans up to Rs 300 million was made in 1980-81 for the income-earning schemes for the weaker sections.

PROGRAMMING

The Integrated Rural Development action programme emphasized increased employment mainly through (i) optimal utilization of the technically feasible farm, forestry, and mineral resources; (ii) strengthening of the infrastructure to remove the techno-economic constraints; and (iii) creation of employment opportunities in possible village industries and trades by entrepreneurs. These measures were started in as many as 2,000 blocks in the country. Out of these, 1,000 blocks were put under the special category and 1,000 in the general category. The special programme category with annual allocation of one million rupees each included 546 blocks for intensive employment programme. The general category was allocated 500,000 rupees each. From 1979 onwards, the total expenditure on the Integrated Rural Development was decided to be shared by the Central and State Governments on half-and-half basis.

A sum of Rs 5,000 was estimated to be adequate for investment on a self-enterprise unit to attain full employment. Accounting for the existing pattern of subsidies, a sum of Rs 1,500 was thought to be enough for the economic upliftment of the household above the poverty line. The amount was proposed to be arranged mainly by the central co-operative banks to be routed through the village co-operative societies. In this scheme of programmes both the primary as well as secondary-cum-tertiary sectors were covered.

The rural employment programmes envisaged and started in 1979 were as under: diversified and mixed farming involving intensive labour input; food-for-work programme; and training of youth for self-employment. There are a number of young men trained in Industrial Training Institutes and they are unemployed. Similarly there are blacksmiths, carpenters, ropemakers and cobblers who were given loans for purchase of improved implements and machinery for making their occupation more efficient and productive.

The record of performance in the scheme shows positive achievements in almost all spheres of activities.

Farm Production

Foodgrain production in the country increased from 126.4 million tonnes in 1977-78 to 131.4 million tonnes in 1978-79. The major achievement was in wheat, which increased from 31.75 million tonnes to 34.98 million tonnes. Groundnut increased from 6.083 million tonnes to 6.387 million tonnes; and rape and mustard from 1.65 million tonnes to 1.877 million tonnes; cotton marked up from 7.24 million bales (each of 170 kg) to 7.927 million bales; and jute and mesta from 7.154 million bales (each of 180 kg) to 8.294 million bales. Potato increased from 8.135 million tonnes to 10.125 million tonnes. The irrigated area moved up to 58.5 million hectares in 1978-79. The consumption of fertilizers in 1979-80 increased by 20 million tonnes over the quantity consumed in 1978-79. This was mainly due to the financial help given to the farmers in IRD areas for purchasing fertilizers and agricultural machinery.

Village Industries

The performance of the khadi and village industries was as under:

Year	*Outlay (million Rs)*	*Production value (million Rs)*	*Employment (million)*
1977-78	446.5	2,508.2	2.314
1978-79	667.3	3,193.7	2.497

Employment increased by 183,000, and the value of output by Rs 685.5 million. Productivity per worker increased from Rs 1,084 in 1977-78 to Rs 1,279 in 1979-80.

In the food-for-work programme, labour employment generated in 1978-79 was 370 million mandays. The wage payment involved 1.4 million tonnes of foodgrains, besides the cash component. Employment in 1979-80 was of the order of 1,000 million mandays. Grain wages gave considerable relief to the farm workers.

The youth-training programme involved 200,000 persons in 1979. Training included the technique for skilled workers, artisans, and master-craftsmen. In 1979, there were as many as 24 khadi boards, 694 registered societies, and 27,871 co-operatives engaged in imparting training.

In 1977-78, a scheme for developing rural markets was started with an allocation of Rs 150,000 per market. As many as 414 markets were set up with the assistance of 54.99 million rupees.

The organization of focal points in 1977-78 led to a remarkable increase in foodgrain production in Punjab. The output of wheat increased from 6.648 million tonnes in 1977-78 to 7.434 million tonnes in 1978-79 (i.e. by 11.8%), and that of rice from 2.491 million tonnes to 3.092 million tonnes (i.e. by 24.1 per cent). Productivity of cotton per hectare increased by 3.47%. This was mainly because of the substantial investment made by the farmers in fertilizer, quality seed, and power inputs, which were more easily available to them. The consumption of fertilizers in nutrient elements in standards of 20%, 16%, and 60% was as under:

Year	*Nitrogen (N)*	*Phosphate (P_2O_5)*	*Potash (K_2O)*
1977-78	331,000	105,000	29,000
1978-79	419,000	155,000	29,000

Per cultivated hectare the consumption in 1978-79 works to 99.4 kg of N, 36.7 kg of P_2O_5, and 7.0 kg of K_2O.

Registered and unregistered industrial units are mostly concentrated in towns. However, out of the total 170,000 estimated workers employed in unregistered industries in 1978, hardly 13.66% are in the rural areas. Incentives such as subsidy on investment of the order of 15% was allowed in 1978 for setting up medium-scale and even large-scale industries in the backward areas, particularly of the Hoshiarpur and Rupar districts.

The well-diffused State-owned system of supplying consumer goods at a fair price is being given a character of permanence by arranging distribution through co-operatives. Wholesale co-operative supply depots are being opened to strengthen the distribution system. Co-operatives, therefore, are likely to assume an increasing role in the social welfare schemes.

Poverty is a relative term. Though it cannot be claimed that the Integrated Rural Development Programme has abolished poverty in the rural areas in which it is operating, it has most certainly alleviated it. It has shown the way. With the investment of massive resources and earmarking of specific industries and energy for these areas, much more progress can be expected. The Integrated Rural Development Scheme has certainly shown a new direction.

FIG. 210. A Focal Point in a village in Ludhiana District. In the foreground is a marketing-yard for sale of foodgrains. In the background are shops for the sale of fertilizer, plant protection chemicals and a branch of a bank.

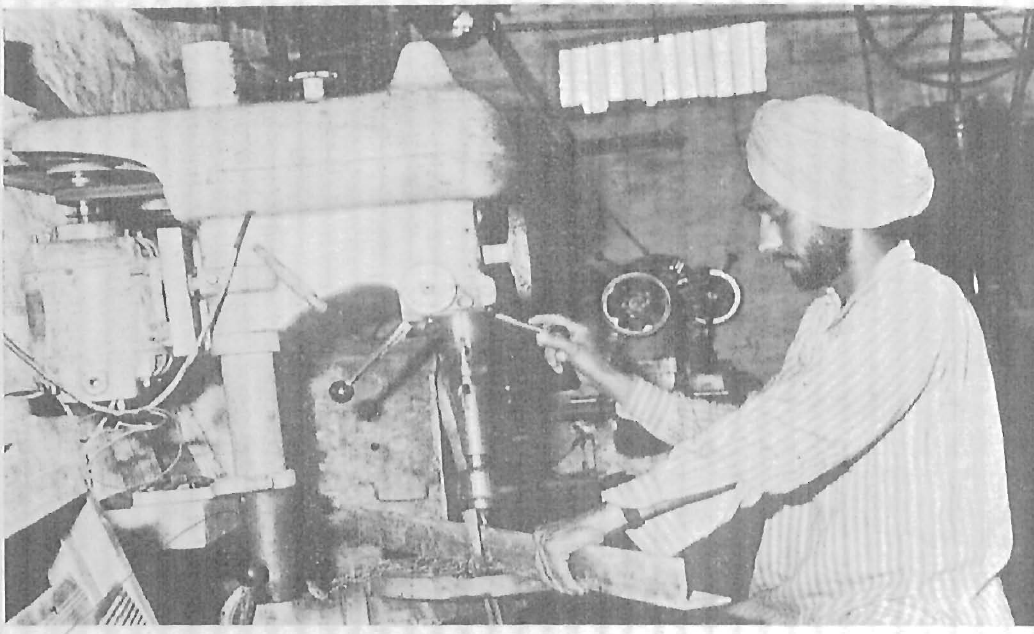
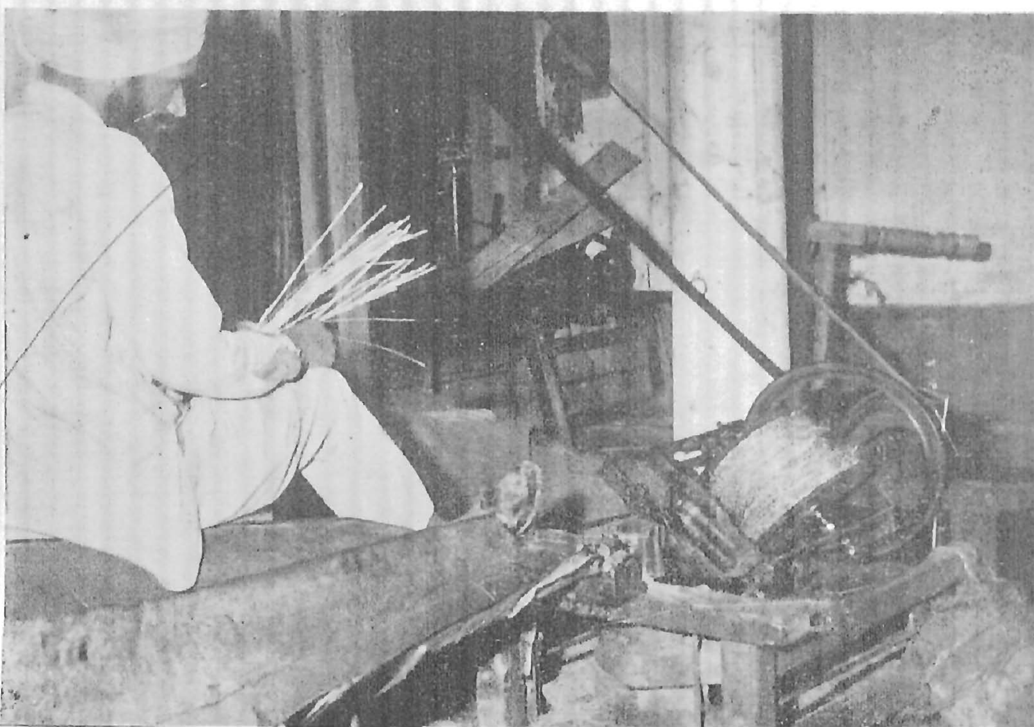


FIG. 211a. This machinist was unemployed. He got a liberal loan from a bank and set up a shop for repair of agricultural machinery and implements, which now serves the farmers of the village.

FIG. 211b. There is a colony of rope-makers at Village Kajauli in Rupar District (Punjab) who make ropes and sell them to farmers for tying bundles of harvested wheat. They used to prepare ropes manually—an arduous and inefficient method. When the Scheme of Integrated Rural Development was launched, they got loans from a bank, bought rope-making machines powered by half-horse-power electric motor. Their drudgery was lightened and their output has increased.



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CHAPTER 53

GREEN REVOLUTION IN INDIA

A CASE STUDY OF GREEN REVOLUTION IN PUNJAB

THE Green Revolution in India was sparked off by the introduction of short-statured, high-yielding varieties of wheat and rice in 1965-66. The States in which the maximum impact was made by these varieties are Punjab, Haryana, western Uttar Pradesh, coastal Andhra Pradesh, and deltaic region of Tamil Nadu. The districts in these States which have given the maximum production are those having facilities for irrigation by canals, tube-wells and tanks or have assured rainfall (Fig. 212). These districts were selected for intensive agriculture in 1964 and supplied with adequate quantities of chemical fertilizers and improved seed.

When one examines the growth in agricultural production from 1962-65 to 1971-74, it becomes abundantly clear that the leading States are Punjab and Haryana (Fig. 213). Punjab showed a growth rate of 8.35 followed by Haryana with a growth rate of 6.66. In Rajasthan it is the canal-irrigated Ganganagar District which is a Green Revolution area, and so is the Nainital Tarai in western Uttar Pradesh. The crops which have shown the maximum increase in area and production are wheat and rice (Fig. 214).

The Green Revolution was not easily achieved. It required a tremendous administrative effort backed by scientific expertise. The leader of the production team at the Centre was C. Sul ramaniam, then Minister for Food, Agriculture and Community Projects. While he had cleared almost all the hurdles, one remained that he had still to tackle. He thus describes, how he circumvented it: "I went before the Planning Commission with all the papers prepared up to that time, and with a paper on the programme for 1966-67 explaining how we envisaged the new varieties would cover 13 million hectares by the end of the Fourth Plan period. There the member for agriculture sat in judgement. We were put in the dock and were asked to explain to him all the steps we were taking and what this new technology meant. After two or three sittings he said he had not studied it enough to give his views about it. He suggested it should be postponed for a year, and should start in 1967-68 rather than 1966-67. Meanwhile demonstrations and other activities might be continued for another year. In those days I was generally considered to be very short-tempered. I retorted by saying that seasons and events cannot wait till the Planning Commission members become educated about this new programme. He might by all means take his own time to get educated and when he had studied enough

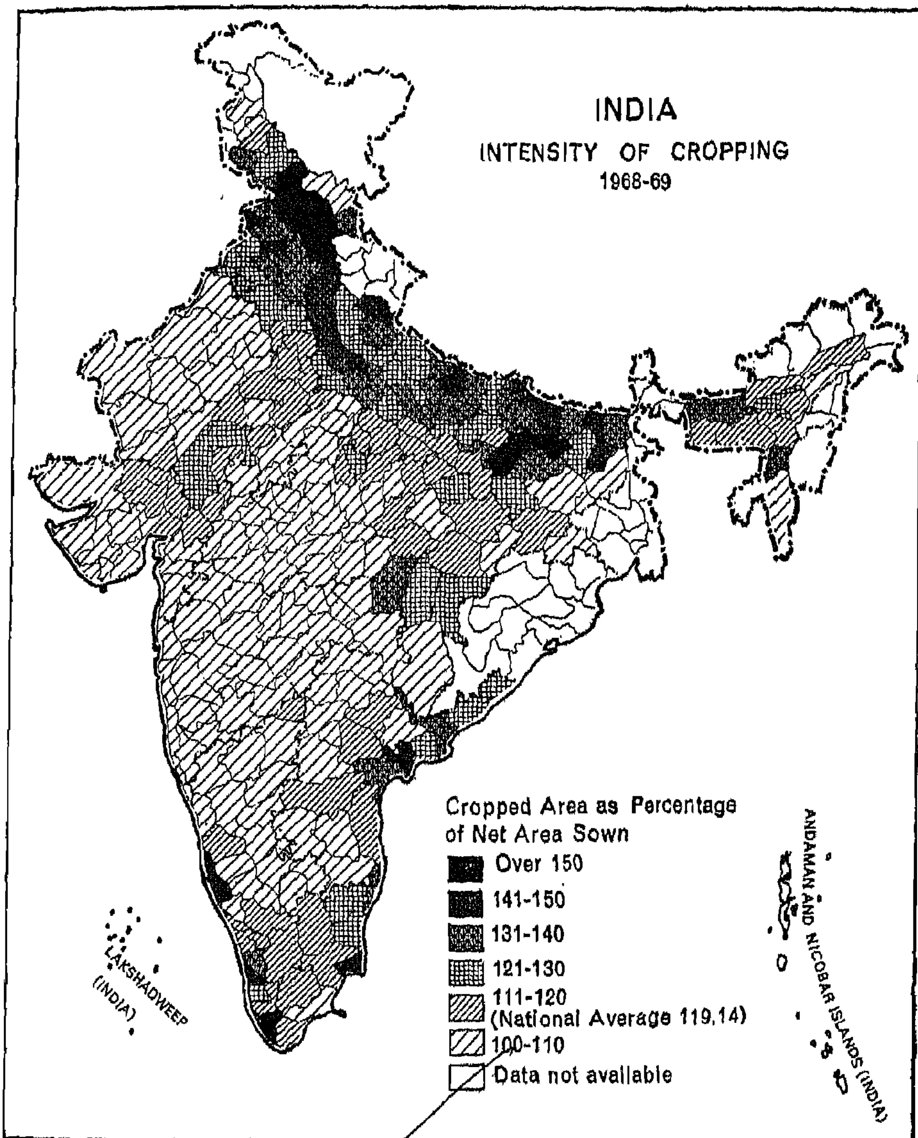

FIG. 212. A map of India, showing intensity of cropping in 1968-69. These are districts irrigated by canals, tube-wells and tanks, or have assured rainfall. These areas were selected for intensive agriculture in 1964-66. Supplied with chemical fertilizers and improved seed, they filled the empty granaries of India. (After Dr Jasbir Singh, Geography Department, Kurukshetra University).

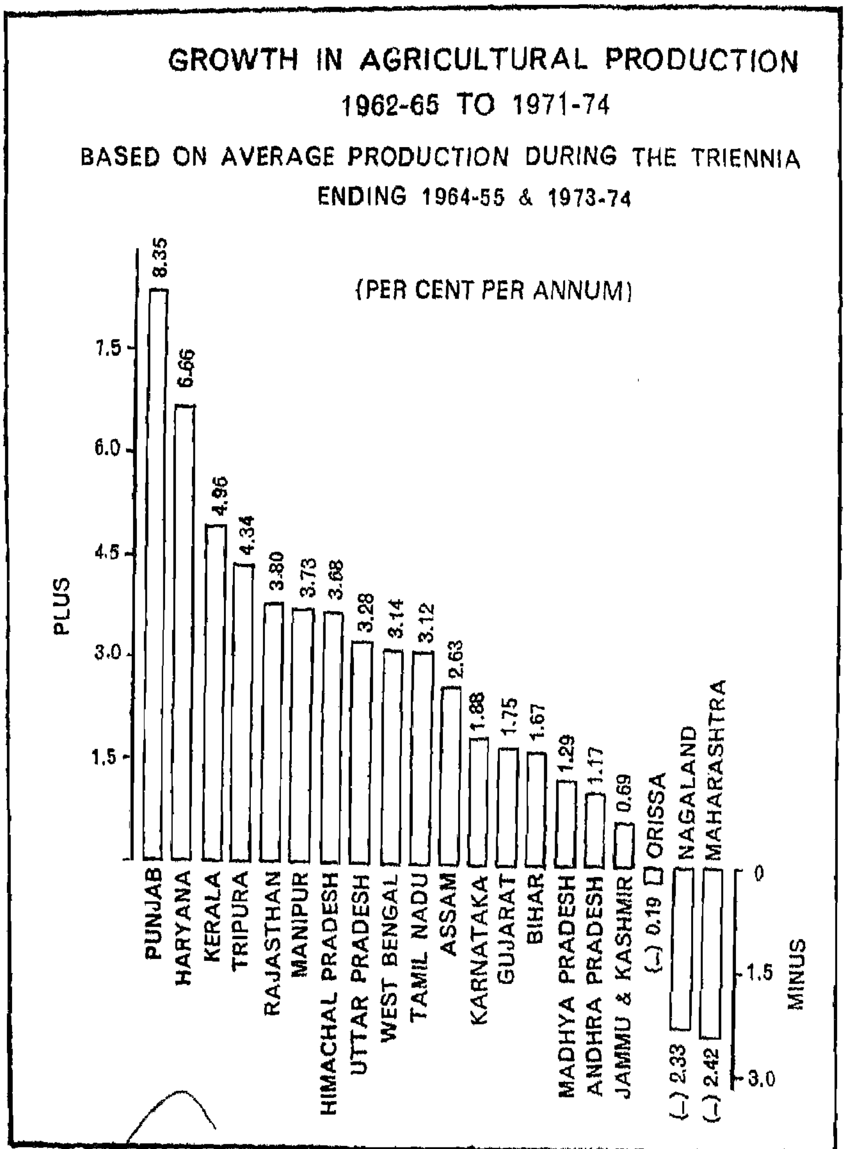

FIG. 213. Growth in agricultural production in India from 1962-65 to 1971-74.

then he could send for me; then we could discuss it. But I was going forward now with this programme.[1]

Of all the States, the Green Revolution made maximum impact in Punjab. Why is it so? Seeds of high-yielding varieties of wheat and rice were provided to all the States where these crops grow. Incentive prices for wheat and rice were given to all the growers in all the States. Co-operative and bank credit was also made available to the growers in all the States. Now every State has at least one agricultural university for imparting education in agriculture and for research and extension. There is plenty of ground water in all the States in the Indo-Gangetic plain, and there is also canal irrigation. The problem States, however, lag behind in rural electrification and provision of link roads to their villages. They have also not appreciated the usefulness of consolidation of holdings. Unless the scattered and fragmented holdings are consolidated in blocks, no worthwhile agricultural progress is possible. Besides, a hard-working peasantry liberated from the handicaps of feudalism is also necessary.

In the case study, which follows, of the Green Revolution in Punjab, all the factors which led to this phenomenon are described with the hope that the Green Revolution would spread to the States which have lagged behind.

GREEN REVOLUTION IN PUNJAB: A CASE STUDY

Punjab lies within latitudes 29°30′ to 32°30′ North and longtitudes 73°55′ to 76°50′ East in the Indo-Gangetic plain of northern India. Except for a strip of the Siwalik Hills along its eastern borders, the entire area is a flat alluvial plain with height above sea-level ranging between 180 and 290 metres.

Its population of 15.37 million constitutes nearly 2.5 per cent of the total population of India. The density of population is 305 per square kilometre as against the all-India figure of 182. The rural population of Punjab constitutes 76.3 per cent of the total as against 81.1 per cent in the country as a whole. There are 1,665,000 cultivators and 780,000 agricultural labourers. The percentage of literacy is 33.7 as compared with 29.3 for the country.

The size of operational land holdings is generally small, as 82.7 per cent of them are smaller than 5 hectares, 12.3 per cent between 5 and 10 hectares and only 5 per cent are above 10 hectares. The Punjab Land Reforms Act, 1972, imposes the following ceilings on land holdings: 7.0 hectares with assured irrigation and capable of growing two crops a year; 11.0 hectares with assured irrigation for one crop only; 20.5 hectares for *barani* (rainfed) land and orchards.

[1]Subramaniam, C. *The New Strategy in Indian Agriculture*, pp. 50-51

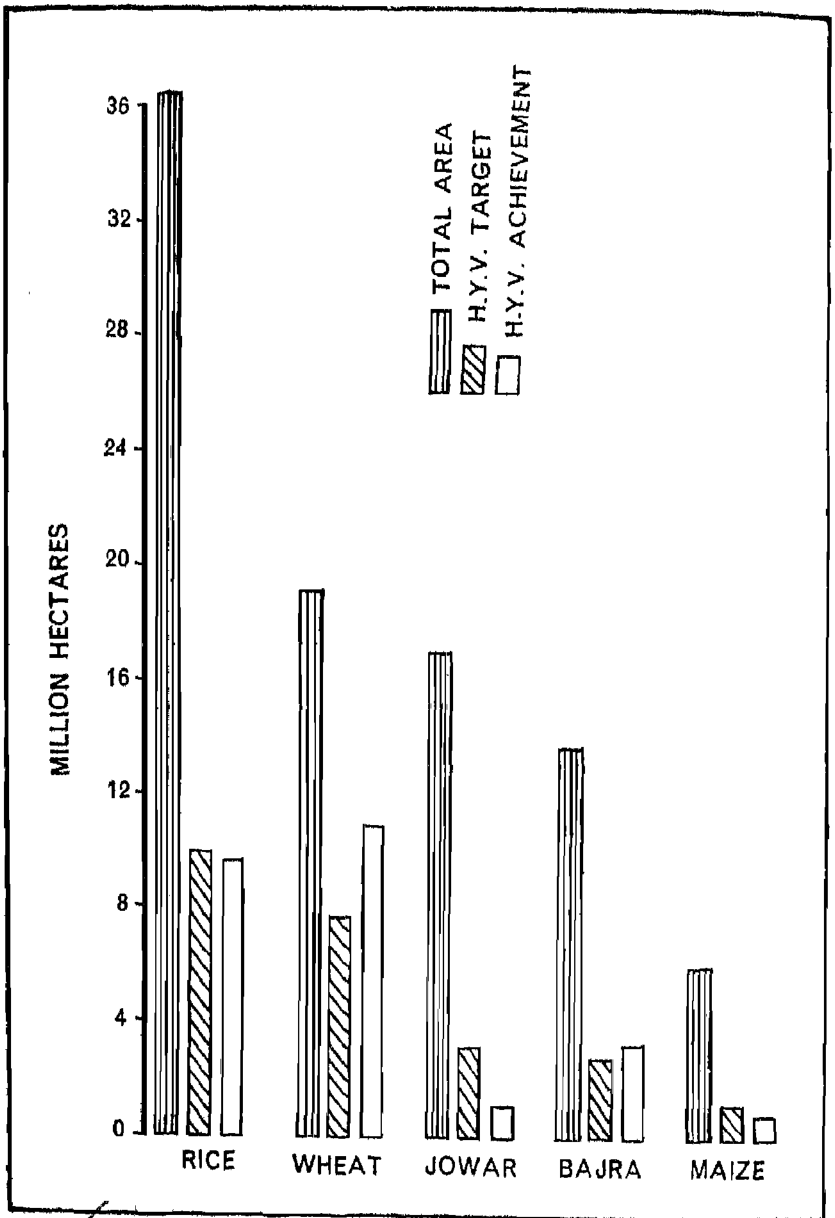

FIG. 214. Area under high-yielding varieties of the major cereals, viz. rice, wheat, sorghum, pearl-millet and maize, in India, 1973-74. (National Commission on Agriculture).

Human Element

In India, as in the rest of the world, the human element has an important role in agricultural development. Kusum Nair, a journalist, travelled all over India during 1958-1960 to assess the role of human element in rural development. In a number of States she found contentment with the existing miserable conditions. In Punjab alone she saw people who were enterprising and energetic, and she could discover no 'blossoms in the dust'. Even in 1958 she saw industries humming in the towns of Punjab where owners of small workshops were turning out sewing machines, bicycles and agricultural implements amidst a constant din of hammers and electric motors. She also noticed that the refugee farmers who had migrated from West Punjab were more progressive and superior in the techniques of cultivation to the farmers of the East Punjab.

The Sikh Farmer

There is a consensus among observers of the agricultural scene in India that the Sikh farmer is the best farmer in the country. At the time of the first census of Punjab in 1881 Sir Denzil Ibbetson, the Census Commissioner, wrote: 'The Sikh Jats of Punjab are proverbially the finest peasantry in India. Much no doubt is due to the sturdy independence and resolute industry which characterize the Jat of our eastern plains, whatever his religion. But much is also due to the freedom and boldness which the Sikh has inherited from the traditions of the Khalsa. Independent and self-willed, he asserts the freedom of the individual strongly.'[2]

Sikhism is a faith which brought about a social revolution in north India five centuries ago. It broke the fetters of the caste system and provided an equal opportunity to the oppressed and the down-trodden to attain human dignity. It liberated people from a system which looked to the past for its Golden Age. The new faith promoted dignity of labour and exhorted its followers to earn their living by manual work. Its ban on tobacco-smoking promoted physical fitness. Above all, it gave new dignity to agriculture which was declared as the best of professions. The system of the common kitchen which provided free meals also had a levelling influence. The founder of the Sikh religion, Guru Nanak (1469-1539), in his old age settled down at Kartarpur on the bank of the Ravi and adopted agriculture as his profession. The surplus production of the farm was contributed to the *langar*, the common kitchen, where the farm workers and visitors were given free food. Since then the *langar* has been an essential part of the Sikh faith and no visitor to a Sikh temple who turns up at meal-time is denied free food. This surprises westerners who visit Punjab, for not even affluent America has such a system of free meals.

[2]*Census Report*, *Punjab*, 1881, Vol. I

The cultivators are Jats, Kambohs and Sainis. Agriculture and service in the army are their main professions. They also have an aptitude for machinery and easily learn the use of tractors and pumping-sets. At the multi-purpose dam sites of India it is these people who handle heavy earth-moving machinery. In a number of States in India the drivers of trucks, lorries and taxis are Sikhs. They colonized the wastelands of the West Punjab, Bikaner and the Tarai and turned them into smiling fields of wheat and rice. In fact, when one examines the distribution of tractors all over India, their heaviest concentration is in areas colonized by the Sikh farmers.

With the spread of modern education Sikh farmers and artisans have contributed many men of distinction to the professions and the administration. Sikh doctors, engineers and agricultural scientists have made a significant contribution to the modernization of Punjab. Most of the scientists of the Punjab Agricultural University have a rural base. That is one reason why their researches are more intimately related to the felt-needs of the farmers.

Admiring the role of the Punjabi Sikh farmers in agriculture, C. Subramaniam observed, 'They set the pace for this agricultural revolution in India. The Punjab farmers showed to all the others how to utilize this new technology to bring about a revolution in our agricultural production. And if today we find wheat production rising in Punjab and Western Uttar Pradesh it is because mainly in these areas that the influence of the Punjab farmer is still prevalent'.[3]

The Artisans

Theoretically, the caste system is not accepted in Sikhism, but the division into endogamous groups based on professions persists. The artisans comprising blacksmiths, masons and carpenters are called Ramgarhias. They are born engineers and have played a vital role in the regeneration of agro-industry in Punjab. By studying foreign designs they have invented chaff-cutters, threshers, sprayers and seed-cum-fertilizer drills to suit local conditions. They are also pioneers in industry and manufacture of electric motors and diesel pumps. Their skill as carpenters, masons and machinists is in great demand and they have spread all over India. The farm machinery industry of the State owes its development substantially to the initiative and hard work of Ramgarhia Sikhs. Many of these mechanics started their one-room shops in the early part of this century, manufacturing items such as persian wheels, steel ploughs and cane-crushers. Some of them could foresee the agricultural development in the State and tried to come up with innovations to match the changing requirements of the farmers.

[3]Subramaniam, C. *The New Strategy in Indian Agriculture*, p. 50

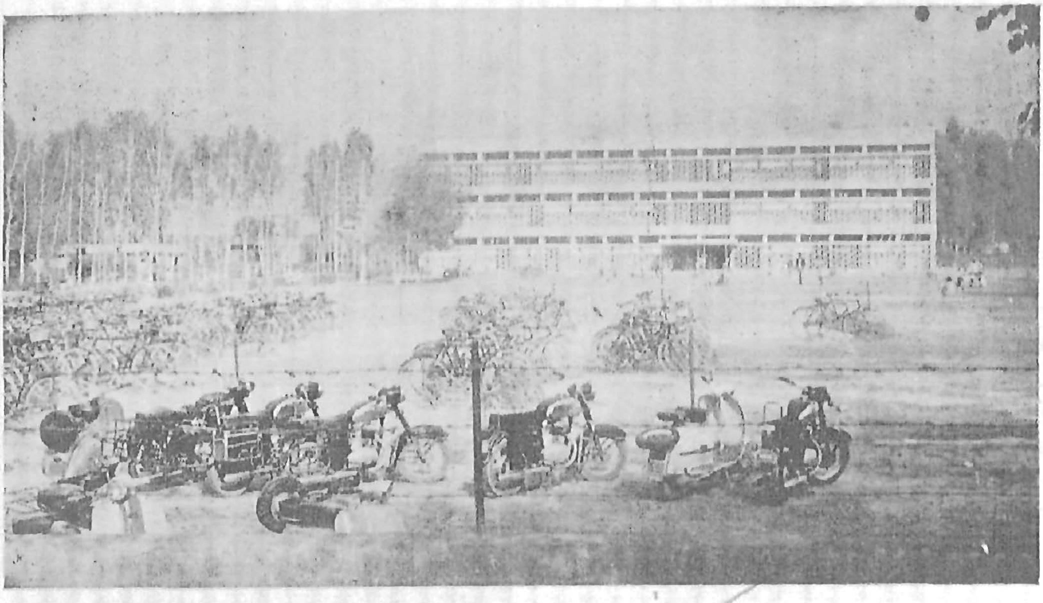

FIG. 215. A boys' college in the rural area of Punjab. Most of the students come to the college on bicycles from the villages. A few affluent ones use scooters.

FIG. 216. Farmers' wives examining improved varieties of seeds of pulses and foodgrains at a Kisan Mela (Farmers' Fair).

FIG. 217. Girls from the rural area join schools and colleges in increasing numbers. Girl students of Khalsa College for Women at Sidhwan.

FIG. 218. A great demand for textiles has arisen in the rural area on account of higher incomes which the farmers are earning.

Some of these innovations have influenced agricultural mechanization in the whole country.

Indigenization of Technology

Commenting on the nature of small industries for fabrication of agricultural implements and indigenization of technology, Partap C. Aggarwal observes, 'Most of the business enterprises are small, and they have relatively simple machines, most of them locally made. This is extremely important because the level of skills needed to work in these factories is, on the average higher than those needed in large factories with sophisticated and automatic machines. In other words, men are brought closer to basic technology in this manner than they would be if the machines are automated.

'Finally, most of the workers are from the neighbouring villages who commute to work either by bicycle or by bus. One effect of this is that knowledge of machines has come down to the village level.

'Along with industry, a variety of support facilities have become established in the district. For example, a large number of repair and service workshops have come up. They have the facilities to repair, recondition, rebuild and service machines of various sorts. All types of welding, turning, grinding, fitting and testing is done in Ludhiana. Furthermore, a large number of shops that supply spare parts, tools, lubricants, fuels and new equipment have been set up. Even in the villages such facilities are becoming available.

'The villager's knowledge of the machine is reflected in the number of new words that have been added to his vocabulary. One hears words such as bearings, nozzles, bolts and nuts, piston, pins, foundation, fan belt, fuse, and so forth. Also many words relating to the working of the machines have come into common use; play, *lag* or area of contact, over-heating, friction, short-circuit, temperature, speed, *chakkar* or revolutions per minute, *phawaara* or atomization, and quite a few more. We have noticed that these words are used by villagers with a good deal of understanding too.'[4]

Thus we find that conditions were created so that farmers could invest in machinery with confidence. In this process, artisans who run the farm machinery industry played a key role.

Role of Soldiers and Education

In *The Punjab Peasant in Prosperity and Debt,* Malcolm Darling tells us how the Punjabi soldier in France 'saw an entirely new order of rural life, and realized with surprise that the village can be as civilized as the town. The sight of the French peasant, educated, prosperous and independent, has roused in him a discontent with his own surroundings that will not be

[4]Aggarwal, Partap C. *The Green Revolution and Rural Labour—A Study in Ludhiana*, pp. 110-111

easily allayed. In other words, the secular inhibition has been dissipated by a year or two's experience, not I suggest, of the French climate, but of a human environment in which peasants are able to live a reasonable life on resources not very much greater than those available in Punjab.' The returned soldier has tried to raise his standard, his influence also extended to his neighbours, and as Darling justly observes, never has the time been more propitious for grappling with the problem of poverty and waste.'[5]

There are about half a million serving soldiers and pensioners in Punjab, and they have played a leading role in bringing about the Green Revolution. Besides, there are a large number of school teachers, minor government officials, policemen, and truck-, taxi- and lorry-drivers who have roots in the countryside. All these skilled men have played a productive role in agriculture. They have invested their savings in land development and have also the intelligence and education to grasp the intricacies of tractors, machines and plant-protection chemicals. In fact, the best agriculture is practised by families some of whose members are educated. Among the totally illiterate, agriculture is the poorest.

As was to be expected, an education explosion has followed the Green Revolution. At least one high school was opened in or near every big village and colleges were established in moderately large towns. About two decades earlier it was difficult to come across a degree holder in the rural areas, but now it is not easy to find a young Sikh who has not passed the matriculation examination. There is a great demand for English-medium schools. Boys dressed in uniforms and wearing neckties can be seen in rickshaws on the roads in Punjab. College buildings are well-designed with modern architecture, and approach roads are lined with eucalyptus trees. Students commute to the college from their villages on bicycles, and few affluent ones use scooters (Fig. 215). There are separate colleges for girls in some villages, and a famous college in Sidhwan village with hostel facilities attracts girl students from even remote villages (Fig. 217). The girls also take advantage of education in co-educational schools and colleges.

Land Reforms

In Punjab land reforms have been effectively implemented and the abolition of intermediaries, tenancy reforms and ceilings on holdings have placed a large number of cultivators in a direct relationship with the State. All *jagirs* (except war *jagirs*) were abolished and the occupancy tenants were given proprietary rights. With the fixation of an upper limit of land that can be resumed for self-cultivation, an area of 177,796 acres (71,951 hectares) was declared surplus up to 30 September 1970. As a result, 26,088 eligible tenants were settled, and many landless tenants could purchase land.

[5]Darling, M.L. Sir. *The Punjab Peasant in Prosperity and Debt*, p.289

As a result of these measures the area cultivated by owners increased from 51.4 per cent of the total in 1947 to 66.4 per cent in 1957 and 80.89 per cent in 1969-70. The area cultivated by tenants, on the other hand, decreased from 47.2 per cent in 1947 to 32.5 per cent in 1957 and to 19.11 per cent in 1969-70. The area operated by occupancy tenants declined from 9.9 per cent to 4.6 per cent in 1957 and 0 per cent by the end of the fifties. This was due to the fact that 647,740 occupancy tenants acquired proprietary rights over an area of 1,850,489 acres (748,868 hectares). Although, there were some exemptions from the ceiling for gardens and mechanized and well-managed farms, as a result of these measures Punjab emerged as a land of peasant-proprietors.

A stable and restructured rural base with an equitable tenurial system thus paved the way for the Green Revolution. It created a highly responsive agricultural and rural society which has the capacity and was willing to adopt and absorb the elements of improved production technology.

So-called Uneconomic Holdings Provide Social Insurance

There is a common misunderstanding among economists that uneconomic holdings are an evil and should be eliminated. Onwers of such holdings are not solely dependent upon such holdings for their livelihood. Most of them are growers of vegetables who raise a number of crops on their small holdings. Some of them have other sources of income, e.g. truck-driving, jobs in the police and the army or in factories. Their small holdings are their insurance against spells of unemployment due to illness or other causes. They used to let out their fields to their neighbours on the crop-sharing system, but now they get them ploughed on hire-basis by the farmers who own tractors and keep the entire produce.

Punjab Agricultural University, Ludhiana; Education, Research and Extension

The role of the Punjab Agricultural University in education, research and extension has been described in Chapter 140. The University has maintained a close link with the farmers. They are provided hostel facilities in Kairon Kisan Ghar, and they take advantage of short-term courses in the maintenance of tractors, poultry-farming and dairying (Fig. 219). The practice of holding *Kisan Melas* twice a year before the *rabi* and *kharif* crops were sown, and the sale of improved seeds in small packets which the farmers multiplied on their farms, led to the rapid dissemination of new technology (Fig. 220). By devoted service to the farming community through meaningful agricultural education, scientific research and extension education, the university has fulfilled the expectations of the people. The work in the University has brought about a real revolution in farming techniques and it has also had an impact on the attitude of the farmers and the policies of the State Government. It has been a revolution from pessimism, conservatism and age-old traditions to innovations, dashing adventurism and hope. In the short period of 20 years the University has made a significant contribution to improvements in agricultural technology which has made this small State the granary of India. Not only has agricultural production considerably increased, thus bettering the lot of the farming community, but the general economy of the State has also received a big boost. The dream of the University's founders to develop Punjab as the most progressive State in India has come true.

CROP PRODUCTION

As already mentioned, it is the introduction of high-yielding varieties of wheat and rice along with the use of inputs such as irrigation and chemical fertilizers, which generated the Green Revolution in Punjab. In the following account is described how production increased in a phenomenal manner.

The improved varieties of wheat which were available before the Green Revolution were only marginally superior to the varieties cultivated by the farmers, whereas the new varieties provide a sharp contrast by doubling or even trebling the crop yield. The impact which these Mexican varieties have made on wheat production is startling. In 1961-62 the production of wheat in Punjab was 1,763,000 tonnes; in 1971-72 it was about 5,600,000 tonnes. In 1979-80, it rose to 7,900,000 tonnes (Fig. 224).

TABLE 1. AREA, PRODUCTION AND YIELD OF WHEAT IN PUNJAB
AREA : THOUSAND HECTARES
PRODUCTION : THOUSAND TONNES
YIELD : KILOGRAMS/HECTARE

Year	*Area*	*Production*	*Yield*
1965-66	1,548	1,916	1,238
1970-71	2,299	5,145	2,238
1975-76	2,449	5,809	2,372
1976-77	2,630	6,392	2,432
1977-78	2,620	6,648	2,537
1978-79	2,734	7,423	2,715
1979-80	2,800	7,900	2,812
1981-82	—	8,553	—

SOURCE : Department of Agriculture, Punjab Government

The area incresed during the same period from 1,548,000 hectares to 2,800,000 hectares. However, the main increase in production resulted from the enhanced yield per hectare. The average yield per hectare in the State rose from 1,238 kg in 1966 to 2,812 kg in 1980. This is the highest average yield obtained in the country, the national average being only 1,500

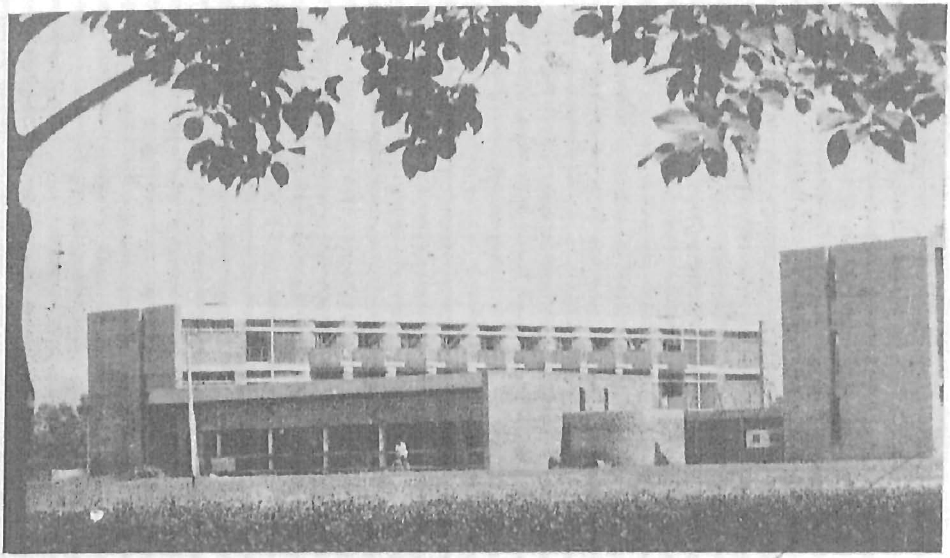

FIG. 219. Kairon Kisan Ghar, where farmers stay when they come for short courses to the Punjab Agricultural University, Ludhiana.

FIG. 220. Farmers queuing up for purchase of seeds of new strains of wheat at the Punjab Agricultural University, Ludhiana.

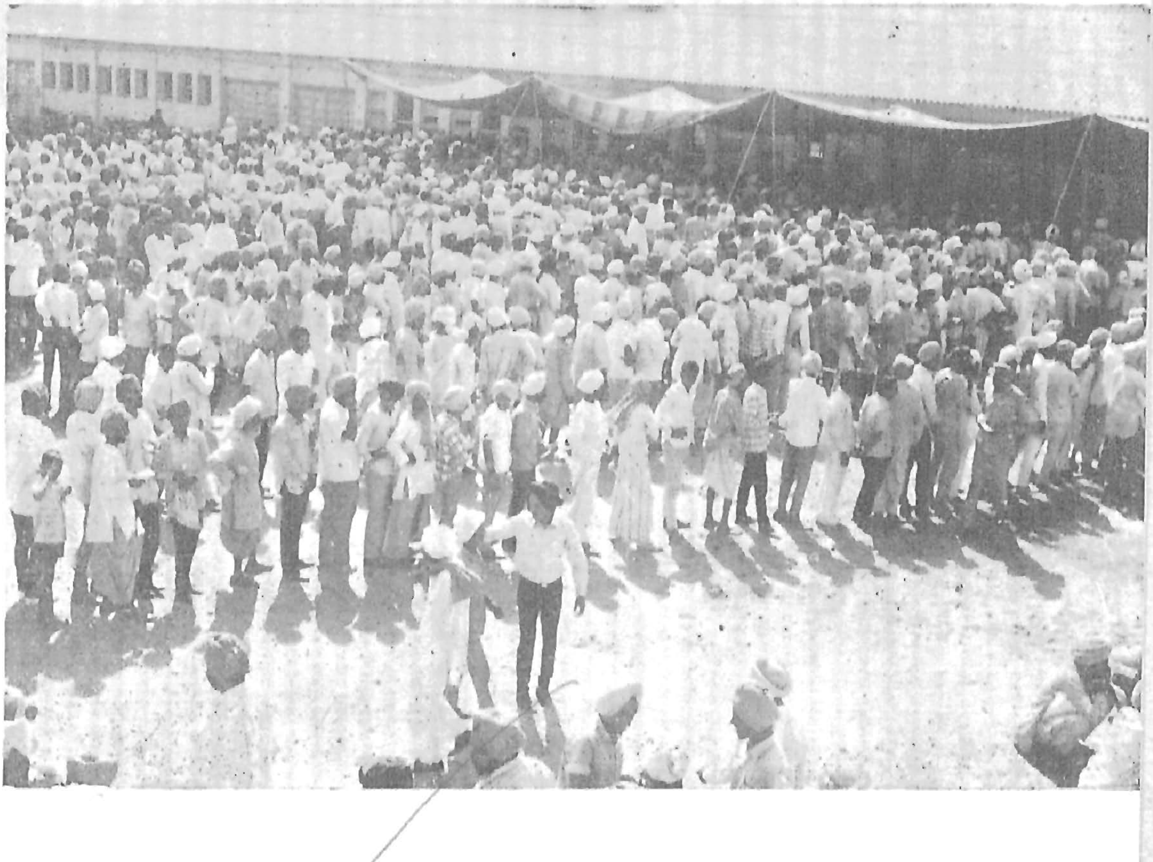

FIG. 221. Towering above the wheat crop are the stalks of *Phalaris minor*. This obnoxious weed has infested wheat fields in northern India on a large scale. Farmers have to use weedicides to eradicate this weed. This has further added to their costs on wheat cultivation.

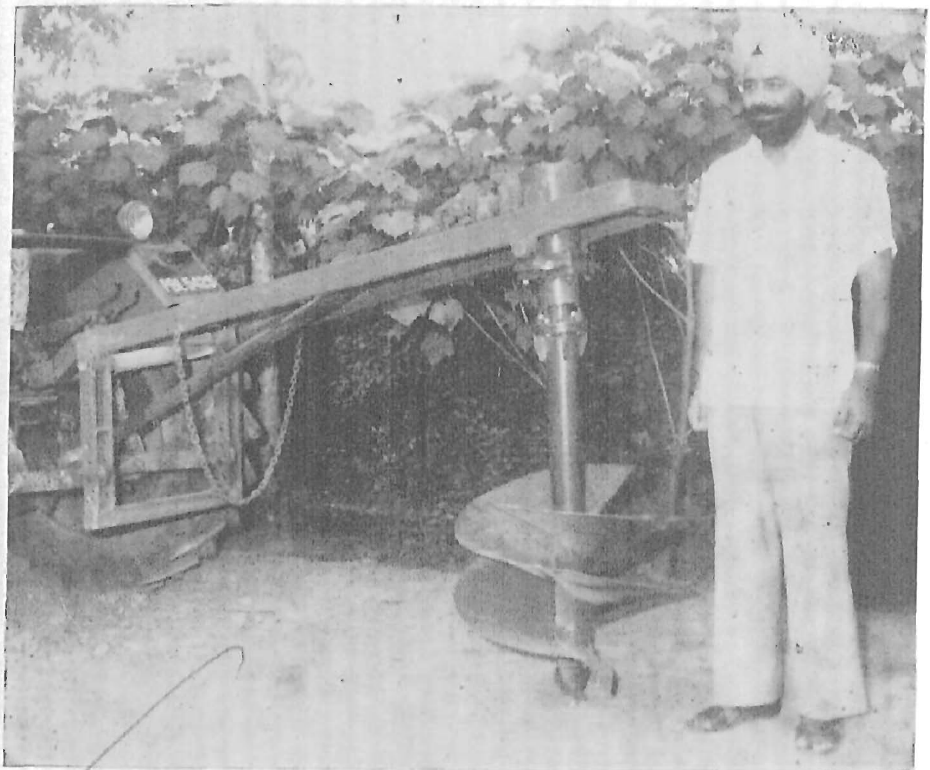

FIG. 222. A farmer-cum-industrialist, Amarjit Singh, of the Union Forgings, Ludhiana, with a tractor-drawn seed-cum-fertilizer drill and a machine, which he has manufactured, for digging pits for planting trees.

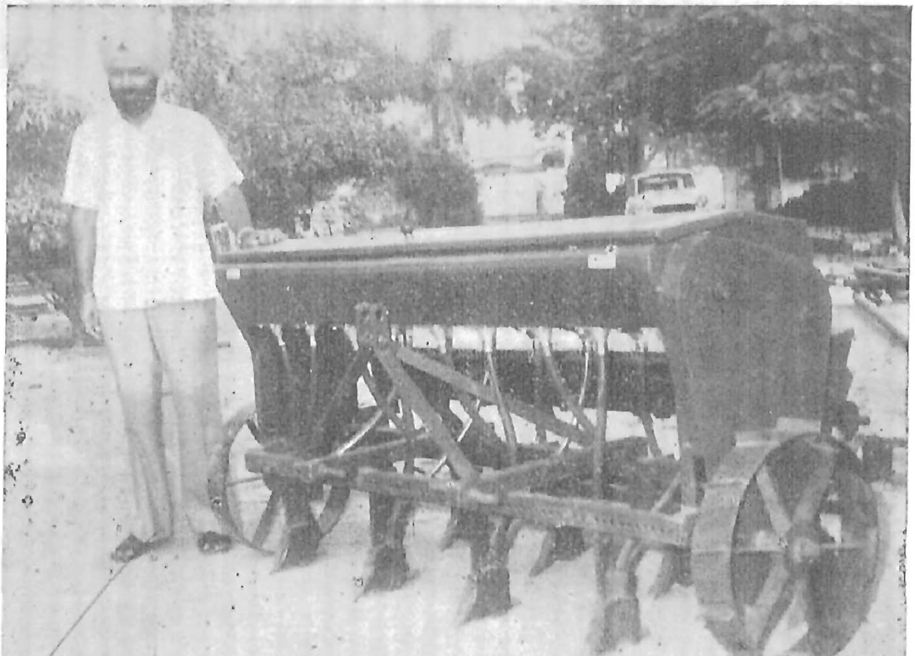

FIG. 223. Shops selling fertilizers and improved seed are now seen in all the small towns and big villages in Punjab. *Top,* A farmer buying fertilizer from a depot, *Bottom,* A farmer buying improved seed from a seed shop.

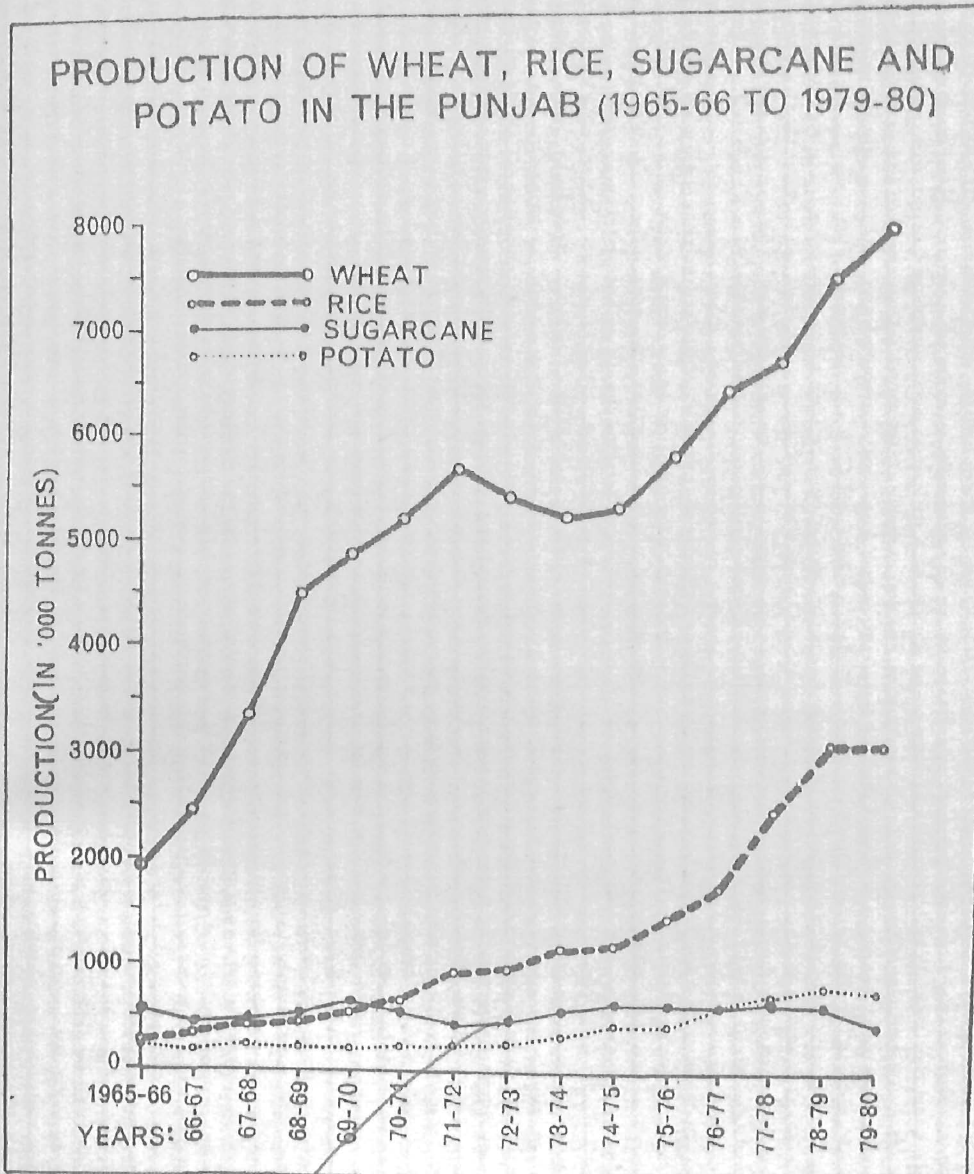

FIG. 224. Production of wheat, rice, sugarcane and potato in Punjab (1965-66 to 1979-80).

kg per hectare. The average yield in the Ludhiana District of the State, where the University is located, is over 3,500 kg per hectare, which compares favourably with any of the areas growing spring wheat in the world.

On account of the spectacular increase in wheat production, Punjab has played a major role in enabling the Central Government to maintain larger stocks of this grain. Punjab annually contributes over 60 per cent to the Central procurement pool. The major role in the increase of wheat production has been played by the new high-yielding varieties developed from time to time.

Rice

There have been significant achievements in rice production over the past five or six years. At several locations in the State the dwarf rice varieties like 'IR 8' and 'Jaya' yielded more than 10 tonnes per hectare in 140 to 145 days from seed to seed. At well-maintained farms their average yield has been well over 60 quintals per hecatre.

New dwarf rice varieties with good yield potentials and short-duration are also in advanced stages of testing at the Punjab Agricultural University. A new variety, 'Palman 579', is capable of yielding 70 quintals per hectare of good-quality rice in 112 days. Another variety, 'HM 95', takes 90 to 95 days from seed to seed and has a yield potential of about 60 quintals per hectare. These short-duration varieties fit in with situations where long-duration varieties cannot be grown.

With the availability of high-yielding rice varieties the farmers are bringing more area under rice. Even areas traditionally considered unsuitable are now being put under this crop. A flat rate for consumption of electricity for tube-wells is a major factor for increase in area under rice.

The production of rice in the State increased from 290,000 tonnes in 1965-66 to 3,091,000 tonnes in 1978-89. Details regarding area, production and yield per hectare are given in Table 2.

Punjab contributed 2.6 million tonnes of milled rice to the Central Pool (1978-79). This is 47.2 per cent of the total procurement, and is a record figure.

OTHER CROPS

The intensive cultivation of Mexican wheat varieties taught the use of fertilizers to the farmers. Having learnt this new technology, farmers are applying fertilizer to other crops like sugarcane, cotton, oilseeds, fruits and vegetables. This has led to general improvement of agriculture in the country.

It is not merely a Wheat Revolution in Punjab but a real Green Revolution which has influenced agriculture as a whole.

Cotton

The production of cotton rose from 851,000 bales in 1969-70 to an all-time record figure of 1,325,000 bales in 1978-79. The 1978-79 yield of 360 kg of lint per hectare was the highest in the country.

TABLE 2. AREA, PRODUCTION AND PRODUCTIVITY OF RICE IN PUNJAB
AREA : THOUSAND HECTARES
PRODUCTION : THOUSAND TONNES
YIELD : KILOGRAMS/HECTARE

Year	*Area*	*Av. yield*	*Production*	*increase over previous year*
1968-69	345	1,364	470	—
1969-70	359	1,490	535	13.8
1970-71	390	1,765	688	28.6
1971-72	450	2,043	919	33.6
1972-73	476	2,007	955	3.9
1973-74	498	2,291	1,141	19.5
1974-75	569	2,071	1,179	3.3
1975-76	567	2,553	1,447	22.7
1976-77	680	2,611	1,775	22.7
1977-78	856	2,910	2,491	40.3
1978-79	1,052	2,938	3,091	24.1
1981-82	—	—	3,755	—

SOURCE : Department of Agriculture, Punjab Government

SUGARCANE

Sugar production was 469,000 tonnes in 1971-72 and rose to 641,000 tonnes in 1977-78. At the Sugarcane Research Station of the Punjab Agricultural University at Jullundur, Dr R.S. Kanwar evolved a new variety, 'CoJ 64', which helped to increase the average yield of the State from 39 tonnes per hectare in 1971-72 to 56 tonnes in 1977-78. In the sugar-mill areas the yield is as high as 65 tonnes. When the new variety spreads to the whole State—at present it covers about 30 per cent of the area—the State yield should rise even further. The sugar recovery, which used to be between the range of 8-9 per cent, was 10.8 per cent in the Batala sugar-mill in 1977, and has risen further since then. Punjab has now emerged as the leading State in cane production and sugar recovery in northern India. Given an adequate price, sugar production is likely to go up.

POTATOES

The production of potatoes has risen from 216,000 tonnes in 1970-71 to 650,000 tonnes in 1977-78 and to a record figure of 800,000 tonnes in 1978-89 (Fig. 224). The yield has also risen from 12,781 kg per hectare in 1970-71 to 22,408 kg per hectare in 1978-79.

CHEMICAL FERTILIZERS

High-yielding varieties of wheat and rice require heavy doses of chemical fertilizers. There was very meagre use of chemical fertilizers in Punjab before the introduction of these varieties. There has been a progressive increase in the use of chemical fertilizers from 1966 onwards. In 1978-79, 600,000 tonnes of fertilizers were used by the Punjab farmers. Details regarding consumption of chemical fertilizers in Punjab are given in Table 3.

TABLE 3. CONSUMPTION OF FERTILIZERS IN PUNJAB ('000 NUTRIENT TONNES)

Year	*Nitrogenous (N)*	*Phosphatic (P_2O_5)*	*Postassic (K_2O)*	*Total*
1960-61	5	—	—	5
1965-66	43	3	—	46
1970-71	175	31	7	213
1975-76	232	53	10	295
1978-79	419	155	29	603

SOURCE: *Statistical Abstract, Punjab*, 1979

IRRIGATION

In 1960-61 the net area irrigated by Government canals was 1,173,000 hectares. In 1978-79 it rose to 1,429,000 hectares. The percentage of net area irrigated to net area sown was 80, the highest in the country (Table 4).

TABLE 4. NET AND GROSS IRRIGATED AREA IN PUNJAB BY SOURCES (IN THOUSAND HECTARES)

Year	*Net area irrigated by*			*Per cent of net area irrigated to net area sown*	*Gross irrigated area*
	Govt Canals	*Tubewells*	*Total*		
1960-61	1,173	829	2,020	54	2,646
1956-66	1,288	921	2,263	59	3,136
1971-72	1,364	1,554	2,955	72	4,377
1976-77	1,382	1,802	3,194	77	50,80
1978-79 (P)	1,429	1,929	3,374	80	5,505

SOURCE: *Statistical Abstract, Punjab*, 1979

RURAL ELECTRIFICATION AND TAPPING OF GROUND-WATER WITH TUBE-WELLS AND FLAT RATE SYSTEMS FOR POWER CONSUMPTION

Electric power supplies the mechanical power to tube-wells, pumping-sets, threshers and chaff-cutters. The share of agriculture in power consumption rose from 15 per cent in 1960 to 35 per cent in 1970 and 45.0 per cent in 1978-79. The industrial and commercial sector consumed 40.8 per cent in 1978-79. Thus Punjab is the only State where the agricultural sector has priority over the industrial and commercial sectors (Table 5). In 1979 all the 12,234 villages were electrified. In Punjab the per caput consumption of electricity has gone up from 0.03 kWH in 1951 to 10.86 kWH in 1968. It is higher than in other States excepting Tamil Nadu, another progressive State, where it is 27.83 kWH per caput. About 280,000 private tube-wells have been electrified in Punjab (Table 6).

To promote electrification of tube-wells, a flat rate system for electricity charges was adopted. This removed uncertainty from the minds of farmers who definitely know what they were required to pay. The State Electricity Board saved the expense of employing a horde of meter readers with consequent problems of corruption and pilferage of power. If such a system had not been adopted, Punjab could not have gone in for rice cultivation. Punjab and Haryana combined are the biggest contributors of paddy to the central food reserve. This has been possible largely due to the adoption of incentive-oriented flat-rate system for tubewells. The State Electricity Boards of these States complain about losses in their budgets. People have a tendency to look at the economics of various sectors in isolation from each other. What does it matter if one sector loses, but economy as a whole gains. If stagnant areas in Bihar, Bengal, Orissa and Assam are to be activated, the State Governments concerned should adopt flat rate system for electrified tube-wells.

TABLE 5. PERCENTAGE OF TOTAL CONSUMPTION OF ELECTRIC POWER IN PUNJAB BY SOURCE

Category of consumption	*1969–70*	*1971–72*	*1973-74*	*1975–76*	*1977–78*	*1978–79*
Domestic	10.32	9.98	12.28	11.89	12.6	10.8
Commercial	6.16	4.97	5.73	5.33	4.9	3.9
Industrial	39.86	34.02	35.54	35.35	36.6	36.9
Public lighting and bulk	10.44	10.22	4.76	4.27	4.2	3.4
Agriculture	33.22	40.75	41.69	43.16	41.7	45.0

SOURCE : *Statistical Abstract, Punjab*, 1979

TABLE 6. NUMBER OF TUBE-WELLS IN PUNJAB (THOUSANDS)

	1966	*1972-73*	*1973-74*	*1974-75*	*1975-76*	*1976-77*	*1977-78*	*1978-79*	*1980-81*
1 Electric	25	110	130	139	146	167	190	233	283
2 Diesel	—	252	270	300	304	378	380	—	378
Total		362	400	439	450	545	570		661

SOURCE : Director of Agriculture, Punjab

In 1978 the canals irrigated nearly 138,000 hectares and tube-wells owned by the farmers irrigated 181,000 hectares. Without tube-wells, which have placed water at the command of the cultivators, the agricultural revolution would not have taken place. With tube-well irrigation the intensity of cropping could even be more than 200 per cent.

MECHANIZATION, MULTI-CROPPING, AND NEED FOR MORE WORKERS

Farm mechanization is a necessity for intensive cropping. After harvesting a crop there is a race against time to prepare the land and sow the next crop in time. A delay of 15 to 20 days can convert a possible bumper crop into an average, mediocre crop. For example, to reap a bumper wheat crop the sowing of 'Kalyan Sona' and 'PV 18' wheat varieties should commence from the first week of November. If sown early, these varieties escape exposure to mid-season rusts and high temperatures near maturity. A delay beyond the optimum sowing period results in a progressive decline in the yield. Mechanization helps greatly in the utilization of scarce resources. By properly levelling the land, water is utilized effectively. Deep ploughing with discs and cultivators prepares the land better for sowing. Proper depth of the seeds and placement of fertilizer with drills optimizes the use of costly fertilizer. Multi-cropping is necessary to utilize the scarcest resource of all land. This can be accomplished most efficiently only by increasing mechanization in Indian farming. Never was the necessity of mechanized threshing realized more than at the time when the first bumper harvests of the high-yielding varieties started pouring in. The conventional method of bullock-drawn *phalas* and winnowing could not cope with the harvests. So mechanical threshers, driven by diesel engines, electric motors and tractor power came to stay. Political leaders and urban-bred economists with no practical experience of farming have deep-rooted, false ideas that mechanization will aggravate the rural unemployment problem by displacing labour. Their attention needs to be drawn to Punjab, which has many mechanized farms but no unemployed rural labour. The human labour input per cropped hectare increased from 52 man-days in 1954-55 to 57 man-days in 1967-68 and 95 man-days in 1976-77. The new technology in agriculture generated a lot of demand for labour. So much work has been created in the farms that a grave labour shortage has arisen. In fact, it is the migrant labour from Uttar Pradesh and Bihar which is now sustaining Punjab's agriculture. Thus, the Green Revolution in Punjab has substantially helped other States too by providing employment to unemployed and partially employed farm workers. Though the employment of a tractor on a farm does displace some workers in its immediate field of operation, on the whole mechanization helps by raising productivity and creation of more employment opportunities by multi-cropping and intensification of cropping. Now there is no slack season in intensively cultivated areas and farmers keep busy throughout the year. Punjab has 124,000 tractors, and their number is increasing. Every worthwhile farmer desires to have a tractor.

Shift to Non-farm Jobs

Like developed economies the world over, Punjab has experienced a perceptible shift in employment towards non-agricultural occupations and a faster growth of sectors other than agriculture and allied activities in the wake of the Green Revolution.

Another significant dimension was the growth of secondary and tertiary sectors. If these sectors started growing at a fast rate under the impulse of surpluses generated in the primary sector, the structural shift in terms of income and employment in the primary sector would manifest themselves sooner.[6]

Rural Link Roads

Punjab gave a lead in providing link roads to villages in 1968. Out of a total of 12,188 villages, nearly 12,000 have been connected by roads. This scheme has stirred up the entire countryside and is responsible for the dissemination of the Green Revolution technology all over the State. The progress of the scheme is evident from Table 7. In 1965-66 the road kilometrage in Punjab was 9,115. In 1978-79 it was 30,836 and now it is much more.

Table 7. Length of roads in Punjab

Year	*Kilometrage*
1965-66	9,115
1970-71	13,859
1975-76	25,705
1978-79	30,836

Source: *Statistical Abstract, Punjab*, 1979

CREDIT

Short-term crop loans to small farmers have enabled them to purchase chemical fertilizers and to grow high-yielding varieties of wheat and rice. With long-term loans the farmers have sunk tube-wells. In this process the credit provided by the co-operative banks has played a useful role (Table 8).

Table 8. Agricultural production and co-operative credit in Punjab (million rupees)

Year	*Co-operative services*		
	Short-term loans	*Long-term loans*	*Fertilizer distributed*
1960-61	117.6	3.1	20.7
1965-66	275.5	16.4	104.7
1968-69	619.6	132.9	354.6
1970-71	572.6	195.6	426.5
1972-73	620.2	162.6	490.0

Source: Registrar of Co-operative Societies, Punjab

Role of the Co-operative Department and the State Co-operative Marketing Federation (Markfed)

Manohar Singh Gill, who was Registrar of the Department of Co-

[6]Study by the Birla Institute of Scientific Research and the Punjab Agricultural University, Ludhiana, 1981

operation and later of Development Commissioner, Punjab, thus describes the role of the State Co-operative Marketing Federation (Markfed) in the supply of inputs and purchase of foodgrains. 'Markets, regulated, controlled and organized by the Government, were expanded rapidly from 1967 on, to cater for the rising production. The trading functions formerly undertaken by the Agricultural Department were transferred to the Markfed, the State Co-operative Marketing Federation, on a commercial basis. The Markfed raises credit from the commercial banks, thus relieving the hard-pressed State budget of this burden. Within a few years it built more than 300,000 tonnes of storage in the countryside to stock and distribute the needed inputs. It maintains 4,000 or more village depots—almost one to every 3 villages—for this purpose. The Federation buys and stocks chemical fertilizers and pumping-sets, and ensures their availability at the right place and the right time. The distribution by the Co-operative Marketing Federation also ensures productive use. The system is simple. The farmer is sanctioned loans by the co-operative banks through his village society. Against these the Markfed supplies him fertilizer or pump-sets or other inputs through the same village society. The banking and the marketing structures have their common base in the village society. The Punjab Markfed, with an annual turnover of something like Rs 3,500 million, has become one of India's great co-operative success stories. It distributes almost Rs 500 million worth of chemical fertilizers a year. It has in the years since 1967 distributed 30,000 diesel pumping-sets. It has an aerial spraying unit with helicopters. It has harvest-combines and an extensive set-up for processing of commodities like oilseeds and cotton.

'The marketing co-operatives were also involved in the procurement, storage and despatch of foodgrains to other places, procurement of approximately 3 million tonnes of wheat every year is entrusted by the Government to the Markfed, the Food Corporation of India and the State Food Corporation, in almost equal measure. The Markfed's extensive modern storage facilities are invaluable for this purpose. But at the level of the markets, the local co-operative marketing society is used as the sole buying agent for the Government. The Punjab Government for many years has given up buying through grain dealers, and has in fact abolished their functioning in the foodgrain trade. This year the entire wheat surplus is to be bought by the three agencies through the local marketing co-operatives. This was successfully done in 1971-72 but then given up for a short period.

'Thus the Punjab co-operatives underpin the entire process, from the growing of the crop to its marketing. Each crop season is jointly planned by the Director of Agriculture and the Registrar of Co-operative Societies under the control of the Development Commissioner.'[7]

[7]Gill, M.S. The Green Revolution—Success in the Indian Punjab, *Centenary Celebration of Birmingham University*, 1975

BENEFITS OF GREEN REVOLUTION SHARED BY ALL PEOPLE IN PUNJAB

The social side effects of the Green Revolution have not been entirely beneficial in countries such as Pakistan and Mexico, where the system of land ownership is such that there is wide disparity in the size of holdings, with most people working on small holdings and a few people in possession of the vast expanse of land. While the owners of large farms have unduly prospered, the condition of the peasantry has not perceptibly improved. In Mexico the real income of landless labourer decreased from $68 in 1950 to $56 in 1960. In Pakistan the wages of landless labourers remained static.

On the other hand, in Indian Punjab there is an equitable system of land distribution and as a result the benefits of the Green Revolution have reached a large mass of people. 'Wage rates have more than doubled in the past six or seven years. The total earnings of the labourers have increased nearly fourfold because employment has become steadier due to double-cropping and more supplementary employment opportunities. The greater prosperity of the agricultural labourers is visible in their new brick houses, better clothes, bicycles, radios, and other relatively expensive consumer items.'[8]

Intensive farming with the new technology has generated demand for more farm labour. As a result, an acute labour shortage has arisen. Another contributory cause is that sons of Harijans who are landless labourers, after receiving education are going into professions and skilled jobs and are no longer interested in working on farms as unskilled labourers. The gap in labour supply is being partially filled by migrant labour from the over-populated eastern Uttar Pradesh, Bihar and the dry areas of Rajasthan.

It is for the first time that time has acquired value for the Indian farmers. With the ready availability of water all the year round from tube-wells, double-cropping or even triple-cropping has become a common practice.

When the farmer prospers, the country prospers. Apart from dealers in inputs like fertilizers, agricultural machinery, pesticides, etc., leather-workers, tailors, oil-pressers, dyers, transporters and shop-keepers of various categories also prospered. The biggest gainer from this new market is the industry. Manufacturers of bicycles, sewing machines, textiles and sundry articles enjoyed an economic boom.

Increased grain production has given a stimulus to poultry-farming. Small and large poultry farms have grown all over the State. Poultry and eggs are being consumed in larger quantities by all classes of Punjabis. People whose diet was mostly vegetarian now consume a protein-rich diet.

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[8]Aggarwal, P.C. *The Green Revolution and Rural Labour*, 1973, P. 129

Besides, the quantity of manure available for crop-raising has greatly increased.

Some Problems: Weeds and Widespread Zinc Deficiency

While the Green Revolution has generally benefited the country by providing food to the growing population, it has also created some problems. One of these is the spread of a noxious weed, *Phalaris minor*, which causes as high loss as 25 per cent in some fields (Fig. 221). This weed can be eradicated only by the use of costly weedicides. This has substantially increased the cost of wheat cultivation.

Another problem which has arisen is that of widespread zinc deficiency. In 1969-70 more than 50 per cent soils in Punjab and Haryana were found to be deficient in zinc.

Detractors of the Green Revolution attribute many evils to this breakthrough in food production. Some critics of the Green Revolution state that the new technology has benefited only big landlords and it has led to socio-economic polarization and tensions in the rural society.[9] This is untrue so far as Punjab (India) and Haryana are concerned. On account of the imposition of ceiling on land holdings at 7 hectares of double-cropped land, large estates have disappeared and there are no big landlords left in Punjab. Moreover, even small farmers who could sink a tube-well on their land have benefited from the new technology.

Stimulus to Ancillary Activities

The Green Revolution has benefited not only landowners but also farm workers who now get higher wages. It has not displaced human labour but created more work and hence a greater demand for labour. It has stimulated many ancillary activities such as tractor-repair shops, machine shops and *kheti sewa* centres, selling improved seed, fertilizers, and plant-protection chemicals (Fig. 222). Many new markets for the sale of foodgrains have developed. It has created new demand for consumer goods, such as bicycles, sewing machines, transistors, radios, watches and textiles of many varieties (Fig. 218). The number of shops selling agricultural chemicals, machinery and implements, textiles and country liquor have noticeably increased. Repair shops for tractors, diesel engines and pumpsets have multiplied. The requirements of new agriculture, in terms of fertilizers, plant-protection chemicals, pumpsets, electric-motors, pipes, sprayers and dusters are tremendous. Above all, the Green Revolution has made the villages more attractive, and this will save the towns from overcrowding. Every Punjab village today has electricity, a metalled link road, a bus to the town, possibly a small hospital, a school and a post office. The quality

[9]Frankle, F.R. *India's Green Revolution, Economic Gains and Political Costs*, Bombay, 1971

of life in the rural areas has improved a great deal and it is the best available in the country.

EAST PUNJAB AND WEST PUNJAB COMPARED

The achievement of East Punjab (India) in agricultural production can be best judged when a comparison is made with West Punjab (Pakistan) since partition of the country. Manohar Singh Gill made a comparative study of performance in agriculture in both the Punjabs, which have similar soil and climate. At the time of partition of India, West Punjab (now in Pakistan) had many advantages over East Punjab. The West Punjab inherited 55 per cent of the population, 62 per cent of the area, 70 per cent of the canal irrigation built by the British, and 70 per cent of the income of the old province. The exchange of people was almost even, 4.3 million coming to East Punjab against 4.2 million going away. But while the Hindus and Sikhs had abandoned 2.7 million hectares of land in Pakistan, of which 1.7 million were irrigated, 0.9 metres perennially, there were only 1.9 million hectares to offer to them, of which 0.53 million hectares were irrigated, barely 0.16 million perennially. Thus in 1947 the East Punjab was the poorer of the two new States, and was deficit in foodgrain by 35,000 tonnes.

Gill sums up the situation in the table below in which increase in area, yield and production of wheat and rice in the Indian and Pakistan Punjabs is given from 1960-61 to 1970-71.

Table 9. INCREASE IN AREA, YIELD AND PRODUCTION OF WHEAT AND RICE IN THE INDIAN AND PAKISTANI PUNJABS

AREA: MILLION HECTARES
YIELD: KILOGRAMS/HECTARE
PRODUCTION: MILLION TONNES

	Area			*Yield*			*Production*		
	1960-61	1970-71	% increase	1960-61	1970-71	% increase	1960-61	1970-71	% increase
Wheat									
Indian Punjab	1.40	2.30	64	1,244	2,238	80	1.72	5.15	199
Pakistani Punjab	3.38	4.39	30	886	1,138	28	2.90	4.87	68
Rice (paddy)									
Indian Punjab	0.23	0.39	60	1,008	1,765	75	0.23	0.69	200
Pakistani Punjab	—	0.73	—	905	1,344	48	0.50	0.97	94

SOURCE: *Punjab Statistical Abstract*, 1973, Punjab Government, Chandigarh (India), *Punjab Development Review and Prospects*, 1972, Punjab Government, Lahore (Pakistan)

Gill comments, "The new seeds were available to both alike. The two countries enjoyed the same opportunities and faced the same problems in the procurement of fertilizers. The wide disparity in achievement emphasizes the importance of those other factors of social structure that have in fact been so significant for the success of agricultural development. The agricultural growth rate of the Indian Punjab has been 6.6 per cent over the period 1952-53 to 1969-70 and that of India 3.1 per cent over the same period (Commerce, 1972). According to Nulty, the growth rate of agriculture in the Pakistan Punjab during 1959-60 to 1969-70 has barely been 2 per cent. One can make many guesses of the reasons for the decline of the canal colonies and the rise of the poorer eastern half. The maldistribution of land in the West Punjab, the predominance of tenancies, the lack of an institutional credit structure able to serve the majority of the medium and small farmers, the failure to complete the consolidation of land holdings, and the inadequacy of those two main carriers of all progress, literacy and the road system, explain why West Punjab lagged behind East Punjab."[10] This has a lesson for some States in India too, which are lagging behind.

Small Farmers and High Yields

When Subramaniam launched the high-yielding varieties programme, a foreign diplomat with faith in large mechanized collective farms asked him the following question. "You think you can achieve these results with your farmers with small farms? Even the bigger farmer has only 6 or 8 hectares, or at most it might be 12 hectares, and they are mostly illiterate. How are you going to persuade these farmers to adopt this new technology? If you are really serious about introducing the new technology this is the occasion to collectivize the land in all these areas, take over and convert the land into collective farms, and select proper managers. It would be easy for you to train about 20 to 50 high-level agricultural managers to take charge of these collective farms and use these farmers for the purpose of providing the labour there. You can give them their share, whatever you like, but collectivization is the only answer to the introduction of new technology; otherwise you cannot achieve results.'[11]

The independent farmers of Punjab have given the reply to the diplomat's assertion. They created the Green Revolution by adopting modern technology and yet retaining their farms. They are not parasites but workers who are also managers who arrange timely supply of inputs and also know how to grow crops. In fact many of them who are educated know it better than the so-called experts, some of whom have only book knowledge. They are the only ones who do not stop working at 5 p.m.,

[10]Gill, M.S. The Green Revolution—Success in the Indian Punjab, *Paper presented at the Centenary Celebrations of Birmingham University*, 1975

[11]Subramaniam, C. *The New Strategy in Indian Agriculture*, New Delhi, 1979, p. 46

and when irrigation, ploughing and threshing goes on, they work even at night time.

Dr S.H. Wittwer, Director, Michigan State University, who visited the region in 1975 commented, 'The greatest progress of all time in agricultural development has not been in the USA. It has been in the Punjab of India. Between 1965 and 1975, yields of rice and wheat, the two leading crops, were doubled. Punjab probably made more agricultural progress in the last ten years than any other region on the face of the earth for all time. It is a revelation to visit the area and see what is being done not only in increasing agricultural productivity but in development of technology that is at the same time labour-intensive.'

This is a worthy tribute to the farmers of Punjab, who made the Green Revolution a reality. They are the real heroes of India and deserve all praise, recognition and support.

The Green Revolution is slowly spreading eastwards in northern India. Some districts of eastern Uttar Pradesh, which have received the benefit of irrigation by canals and tube-wells are showing higher yields of wheat. The agricultural change in West Bengal is most remarkable. It is now a significant producer of wheat. Much higher yields of rice have occurred in Tamil Nadu, and coastal Andhra Pradesh. The States in which agriculture is still stagnant are Assam, Bihar and Orissa. If the scattered and fragmented holdings of the farmers in these States are consolidated, followed by rural electrification and construction of rural link roads, there will be greater progress in agricultural production. What is required is a strong political will matched with administrative efficiency.

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CHAPTER 54

IMPACT OF ADVANCED AGRICULTURAL TECHNOLOGY ON SOCIAL AND CULTURAL LIFE OF RURAL PEOPLE

A CASE STUDY OF JODHAN AND DAKHA VILLAGES IN LUDHIANA DISTRICT

THE Ludhiana District in Punjab is a Green Revolution district par excellence. In 1960 it was selected as an IADP district, and thus enjoyed the benefit of easy availability of inputs, such as chemical fertilizers and power for tube-wells. In 1962, the Punjab Agricultural University was located in this district, which enjoyed maximum advantage of high-level technology and improved high-yielding seeds of wheat, rice and other crops. Besides, it enjoys the benefit of irrigation by canals as well as by tube-wells. Consequently, it made the maximum progress, and the highest yields of wheat in the world have been recorded in this district. A real agricultural revolution has taken place in this district, and it is now growing into a "rural revolution". New ideas are striking at the roots of tradition in almost every walk of village life. A new style of living is emerging. There is ample evidence to show that the Ludhiana farmer attaches importance to good housing and education of his children. There is a marked improvement in the number of secondary schools for both boys and girls. Educated girls will seek a way of life different from that of their mothers. As in cities so in villages, they feel that it is they, and not their mothers-in-law, who should have a greater say in household expenditure and in the upbringing of children. This trend is by no means confined to the better-off farmers. It has also spread to non-agriculturists, who too have started earning more in the last few years and now look forward to a better standard of living.

With each new technique he has adopted, the farmer's ideas have changed. He has learnt the importance of crop budgets and a combination of inputs, practices and crop rotations to increase his net income. His new business outlook is reflected in the fact that he now reserves a part of his holding for seasonal vegetable crops such as *okra*, gourd and tomato. Ten years ago this practice was unheard of. In 1965 the average Sikh Jat would not grow vegetables. Regardless of its profitability, he looked upon the cultivation of vegetable crops as a degrading occupation.

Not only are the farmers of Ludhiana earning more, they are also spending more. In shaking off the old emphasis on thrift they have imparted a shock wave to the economy of the district and opened up new opportunities for non-agriculturists. Every big village in the district now has a cluster of whitewashed shops, indistinguishable from those found in any small town. Several of the larger villages have more than one bank. The new technology calls for heavy investments, and this in turn has created a new demand for credit services.

JODHAN

In Jodhan, a village with 400 households on the Ludhiana-Pakhowal Road, six tailoring establishments stock over 300 different kinds of prints and plain shades each. They are good enough to be located in any decent Indian city. Fifteen years ago, their owners used to ply their sewing machines themselves and stocked perhaps a dozen grades of cheap cloth and little else. Each of them now supervises his own team of hired tailors who are kept busy the year round.

The four provision stores in the village stock lipsticks, several brands of plastic shoes and leather sandals, talcum powder, a wide choice of hair oils, laces, ribbons, toilet soaps, vaseline, plastic buckets, notebooks, pencils, torches, biscuits, combs, brushes, incense, buttons, bleaching powder and hair-remover.

Equally enterprising are the owners of numerous shops dealing in domestic electrical appliances and fittings. Ninety per cent of the villages in the district are electrified, and there is a thriving trade in switches, plugs, bulb-holders, adapters, plastic-coated wiring, conduits, electric irons and table fans.

Another common sight is the inevitable "English wine and beer" shop. Liquor and prosperity in Punjab countryside seem to go together. There has been a manifold increase in the State's revenue from excise and other taxes on the sale of alcohol. A great many of the elders decry this trend, but to the younger generation it is a part of the process of bridging the gap between the way of life that they see in the towns and their own. The urge to spend has definitely come to stay, and the old emphasis on thrift is on the way out.

The new arrivals in the village are 15 cold drink and tea stalls and two butcher shops. Yet another calling is that of four itinerant vegetable vendors who go from house to house with bicycle-trolleys loaded with vegetables. Fresh vegetables rarely figured in the average rural household's domestic budget in the past.

Even the interior of many village houses now looks different and a colour wash is the rage. Bare mud walls have vanished. The *baithaks* (the main front rooms) are liable to change from lemon yellow and shocking pink to cabbage green from one house to another. To each his own fancy!

A great deal of reconstruction has also been taking place. Villagers rarely build their houses at one go. It is invariably done in instalments, room by room. Over the last 10 years almost every Jat house has been converted into a brick and mortar affair. The traditional building material was a mixture of mud and *bhoosa* in this village.

The brick kilns of Ludhiana have been doing a roaring trade and considerable damage too. The countryside is marked by huge, ugly hollows gouged out of the earth wherever a kiln has been at work.

There is also an acute shortage of carpenters who are needed not just to hack out roofing beams and make new door and window frames but also to furnish the new dwellings. The traditional *charpoys* (cots) and *moorhas* (stools) are rapidly giving way to chairs and tables. Out of the five carpenters two now have saw mills of their own and three are engaged in the traditional occupation.

A taste for sofa sets, which was barely discernible three years ago, now seems to have caught on. The sofa set consists of a table, two wooden arm-chairs and a three-seater, woven with imitation plastic cane, and upholstered with embroidered cushions, costing anything between Rs 500 and Rs 700. In the village, 15 families have scooters, 3 have cars, 10 have television sets, and almost every family has a radio or a transistor.

The look of the courtyards too has changed. Brick paving and cemented drains are the rule. The bullock has more or less vanished and milch cattle are being moved out to new sheds and tethering posts located on the village common. The stench of dung and urine has gone. In villages like Narangwal, where no buffalo is permitted within domestic compounds, there is not a fly in sight.

The all-too-familiar rural scene—a line of women fetching water from the well in earthen pots—is now a rare sight. The water-table in Ludhiana is not far below the surface and almost every house, including that of the average Harijan, now has its own handpump.

These changes have brought a great deal of new business to the village blacksmith. Many of the old tongs and bellow establishments have grown into neat new hardware stores, retailing steel handles, and galvanised iron and alkathene pipes, plus the usual range of farm implements. Smithy has been replaced by a modern worskhop equipped with a power lathe, five welding units, an electric drill and a nozzle-grinder, all set to undertake the overhauling of a tractor from start to finish. The villagers are quick to point out that Jodhan's mechanics can do sophisticated work too.

There are eight medical practitioners, a government dispensary and a chemist's shop in the village. There are two radio and transistor repairing shops and four tape-recorder shops. Apart from its entertainment value, the transistor radio and tape-recorder are emerging as vital functional tools. Rural broadcasts provide the farmers with a cheap, easy and swift means of keeping abreast of the latest weather forecasts, market prices and news. And the setting up of the Punjab Agricultural University's own transmitter in future will provide farmers with access to expert advice at each crucial period of the agricultural cycle.

The significance of all these changes lies in the fact that these have combined to open up a new future for hundreds of masons, brick-makers, weavers, potters, tailors, leather-workers, utensil-makers, blacksmiths, carpenters, washermen, ginners, oil-pressers, dyers, butchers, retailers, suppliers, transporters and countless others.

Despite the progressive mechanization of farms, there is an acute over-all shortage of labour. Intensive cultivation means more work, and wages have shot up by 300 per cent since 1961. The current busy season rate is often as high as Rs 15 per day, and the regulars are paid Rs 2,500 a year, plus food, clothing, two pairs of shoes and residential accommodation, compared with Rs 500 two decades ago.

There are 38 tractors in the village and the entire wheat crop is now threshed by power-driven threshers. But even these are proving inadequate. The Ludhiana farmer is willing to wait for several days in a queue outside the offices of the Agro-Industries Corporation to get his name on the list of the favoured few whose fields are harvested by State-owned combines which can reap, thresh and bag the grain, all in one operation, at a cost of Rs 245 per hectare.

The once abundant supply of landless Harijan labourers has dried up. The more prosperous villages now compete with one another to attract *bajigars* and various other itinerant communities. Several new settlements have sprung up. Some of these are surprisingly clean, with freshly plastered mud-walls in place of the old patchwork tents which used to be surrounded by mangy dogs, scraggy chickens and donkeys.

Except in the harvest season, when wages are high, able-bodied young workers are hard to come across. Many of them have left the villages to take up jobs in mills in the city. Others are getting training to become tractor and tube-well mechanics. Those who are too old to learn new trades have emerged as transporters and earn between Rs 5 and Rs 20 a day with streamlined mule-drawn buggies that run on pneumatic tyres and old truck axles.

The creaking bulloock-cart is becoming obsolete. It can no longer cope with the heavier loads that have to be carried to and from the markets and the fertilizer depots. The buggies move faster; besides, there are very few bullocks left.

There is more to the transport revolution than just this. The rapid development of village link roads has facilitated the movement of farm supplies and surpluses, and the motor-car too has invaded village squares. The use of taxis to transport marriage parties is becoming a status symbol. Heavily overloaded Ambassador cars with their cargo of garlands, grooms *et al.* are not uncommon in June, the usual month of marriages.

Social attitudes are also slowly changing. There is a new emphasis on the education of women even beyond the secondary school stage. About

15 years ago the College of Home Science at the Punjab Agricultural University found it difficult to fill its vacancies. It is now thronged with more than four times as many applicants from farm families as it can cope with. Now that they can afford to live better, farmers want educated wives to look after their homes and families.

A kitchen is a busy centre of activity in farm houses. The tea-kettle is boiling throughout the day and family members and farm-workers refresh themselves with cups of tea at least thrice a day. Farmers' wives have to bake *chapatis* for the family members as well as farm workers. One farm worker eats as many *chapatis* as three family members. Farmers' wives often complain that they have become cooks and servants of hired farm workers.

Another change which is noticeable is that on the occasion of marriages, births and religious festivals, *akhand path* of *Guru Granth Sahib* is performed in the homes of artisans and farm workers. Formerly, only well-to-do families of land-owners could afford this luxury. About five priests who read the *Granth Sahib* in relays have to be fed, and *krah prashad* is to be given to all members of the congregation.

A nuisance which has developed is the use of loud-speakers for relaying cheap and bawdy film songs. The elders decry this development, but the younger generation obviously enjoy it.

A happy change is that more money is now spent on social centres such as the *chaupal* and the adjoining *hawa-ghar*. It is here that the grey beards of the village usually get together to listen to the news, read newspapers, indulge in gossip and while away time. One measure of the health of any society is the way it looks after its old people. From the contented look and the glow on the faces of old people in Ludhians's villages it can be safely concluded that all is well.

Many think that Ludhiana is an isolated island of progress, but this is not true; it is, however, the pace-setter. The story of Ludhiana is being repeated in other districts all over Punjab and Haryana. Some of the districts are not quite as successful, but they are catching up fast. And what is happening in these two States will sooner or later make an impact on irrigated areas all over the country.

DAKHA

Dakha village in Ludhiana District is over 500 years old and is 17 kilometres away from Ludhiana, one kilometer off the main road to Ferozepur. The total cultivated area is 1,575 hectares owned by 2,720 land-owners. There are 2,564 land-owners with holdings below 2 hectares, 124 land-owners with holdings from 2 to 4 hectares, and 32 land-owners with holdings from 4 to 7 hectares. The main crops are wheat, rice, groundnut, maize, pigeonpea and fodder. The area where groundnut and maize were sown is now being used for rice cultivation. The sources of irrigation include a canal and tube-wells. In 1970-71 there were 72 wells equipped with Persian wheels worked by camels. Now there are 110 tube-wells powered by electricity and 380 run with diesel engines. The Persian wheels have been dismantled and sold as scrap.

The population of the village in 1971 was 5,341. There are three co-operative societies with a membership of 1,500. Out of the 923 families 250 have now been issued yellow cards because their annual income is less than Rs 3,600. The cards enable these famlies to purchase essential commodities from Government shops at subsidized rates.

There are two high schools, one each for boys and girls, and a college. Education facilities have provided a channel for escape from the village to easier life in the towns.

Agricultural development started in 1966 when high-yielding varieties of wheat were introduced. Due to the proximity of the Agricultural University, farming developed fast. In 1967, chemical fertilizers worth Rs 200,000 were procured by the village co-operative society. In 1980, fertilizers worth Rs 1,500,000 were used by the farmers.

The first tractor was introduced in the village in 1953. Now there are 68 tractors and 65 threshers.

TABLE 1. FARM MACHINERY IN DAKHA

Implement	*Year*		
	1970–71	1975–76	1980–81
Tractors	19	30	68
Threshers	12	20	65
Tube-wells (electrified)	25	66	110
Diesel engines	62	90	380
Wells (Persian wheel)	72	—	—

SOURCE: Balwinder Singh, Thesis for M.Sc., PAU

CHANGES IN LIFE-STYLE

Before the introduction of advanced agricultural technology, the farmers did not sell milk. In fact, selling milk was considered inauspicious. With the introduction of improved farm technology, however, the farmers need hard cash for investment. Now about 47 per cent of the farmers sell milk.

The level of development is reflected in the material possessions of the villagers. As development proceeds apace, people gradually acquire more consumer and even luxury articles such as bicycles, scooters, radios and television sets. Synthetic drinks such as Campa Cola, Limca and lemonade have become popular with the rural people. The affluent ones drink beer and whisky. Before the advent of the Green Revolution the villagers used to drink *lassi*. Now tea has replaced it. The tea-pot is kept boiling throughout the day for the refreshment of workers and members of the family.

The change in the style of clothes is all the more remarkable. The villagers no longer wear home-made cotton clothes; instead, they wear European-types coats and trousers of synthetic or mill-made cloth. Ready-made clothes are also becoming popular. The profession of weaving is gradually disappearing and the weavers are taking to other jobs. Tailors and the traditional shoe-makers have migrated to the towns.

Poultry, piggery, bee-keeping and fish-breeding have been adopted as side professions, which provide the farmers with ready cash. In ancient times meat-eating was regarded as a luxury, and only on the occasions of marriages and at social get-togethers was a goat slaughtered for a communal feast. Now the villagers eat poultry, meat and eggs regularly.

About 25 per cent of the large farmers, 12 per cent of the medium farmers and 5 per cent of the small farmers have scooters, and 83.75 per cent of the farmers of all categories have bicycles, which are used for commuting to the farm. About 45 per cent of the agricultural labourers have bicycles.

Television has become a popular source of entertainment for the villagers since the TV studio at Jullundur started functioning. About 15 per cent of educated large farmers own television sets. About 65 per cent of the farmers and 25 per cent of the agricultural labourers have radios. About 75 per cent of the farmers have wrist watches.

Marriages have become expensive. In the early sixties, before the advent of the Green Revolution, dowry included a bicycle, a sewing machine, a watch, and a radio set, but nowadays it has become a status symbol to give a scooter, a motor cycle, a television set, a fridge and other such items in dowry.

Village Artisans

Carpenters and iron-smiths have shifted to the nearby towns in large numbers. Many of them repair agricultural machinery, and some of them have started manufacturing threshers, seed-drills and other implements at Mullanpur, a town three kilometres from Dakha. Earlier they were dependent upon farmers who used to give them foodgrains at the time of each harvest. Now they have opened their own small factories and workshops. They sell machinery to farmers and earn handsome profits. In fact, they have benefited more from the Green Revolution than the farmers as their market is assured and there is no risk involved.

Water-carriers (*jhiwars*) have entered the catering trade in the town and have opened shabby restaurants known as *dhabas*.

Relationship of Agricultural Labourers and Farmers

The farmer-labourer relationship has undergone a notable change.

Money relations have replaced human relations. In the pre-technology era there was harmony between the agricultural labourers and the farming community. A family of farm labourers used to work for generations with a particular family, and they also shared each others' wail and woes. On the occasion of the marriages of their daughters the farmers helped the labourers liberally by giving gifts of foodgrains, milk and *ghee*. With the advent of advanced agricultural technology, the farmers prefer to bargain with the labourers according to the situation, and the latter also change their employers frequently according to their convenience. The farmers now prefer to employ labourers from Bihar and eastern Uttar Pradesh who accept lower wages.

Literacy has increased. The villagers have become politically conscious and they have started taking part in politics. This has led to groupism and a deterioration in inter-personal relations. Some villagers have constructed houses in their farms in order to save time that was wasted in commuting to the farm from the village and back every day. This has facilitated better management of farms, but the level of intimacy among the villagers has decreased in consequence.

Wheat Cultivation with High-yielding Seeds Costly and Difficult

Wheat cultivation in northern India is almost garden cultivation. Urban consumers do not know how difficult and costly it is to grow wheat with tube-well irrigation. In the last week of October, when the fields are dry and hard, the soil is broken with disc-ploughs. This is a hard job, and old tractors work under a great strain and emit a lot of smoke. The fields are then ploughed with tractor-drawn cultivators and levelled with a *sohāga*, which breaks the clods. Following this, embankments are made by manual labour and fields are irrigated. About the middle of November, when the fields dry up but not too much, they are ploughed again with cultivators and levelled with a *sohāga*. Before sowing, wheat seed is treated with ceresan and agrosan or captan or thiram as a protection against flag-smut, seedling blight and black-tip disease. After the seed-bed is prepared, wheat seeds are sown. Diammonium phosphate is simultaneously applied with a seed-cum-fertiliser drill, which places them at an appropriate depth with fertilizer below and seed above. Embankments are made by manual labour to facilitate irrigation. Four irrigations are commonly given, the first at the tillering stage. After a few days weedicides like Tribunil are used to destroy *Phalaris minor*, a pernicious weed found in nearly all wheat fields. Irrigation is necessary at the stage of crown-root formation, tillering and earing, and also at the milk stage. Urea is also sprinkled at these stages. When the crop ripens, it is manually harvested and threshed with a tractor-operated thresher. Wheat grains are then dried and stored in some cases in steel bins and chemicals are applied to save them from weevils.

Wheat is more easily grown in temperate America and Europe than in India. When there is appropriate moisture, which is gauged with computers, large tractors plough the land, apply the fertilizer and sow the seed in one operation. When it ripens it is harvested by combines. If the American farmers were to raise wheat like the farmers of northern India, with the use of tractors combined with so many jobs which are performed manually, their cost of production would be much higher. They are fortunate in their climate and also in having large machines which they have invented and manufactured.

Hazards in Farming

In March 1974 the entire wheat crop in Dakha was destroyed by a hailstorm. Considering that the farmers had invested much in the purchase of seed, chemical fertilizers, electricity, weedicides and mechanical as well as manual labour, it was a back-breaking blow. The hailstorm damaged wheat in numerous villages in Punjab.

There are hazards not only in wheat-growing but also in fruit-crops. Rain during February-March is injurious to mangoes, pears, litchis, as it washes down the pollen, and the activity of bees is also hampered. Bees are indispensable for seetting of fruit as they pollinate. Stormy winds also cause great damage to fruits.

Are the Farmers Satisfied?

A survey conducted to ascertain the level of satisfaction among the farmers gave the following results.

Table 2. Number and percentage of farmers with the level of satisfaction with their present occupation

Category of farmers	*Yes*		*No*		*Not certain*	
	Number	%	*Number*	%	*Number*	%
Large	11	55.00	4	20.00	5	25.00
Medium	5	20.00	15	60.00	5	20.00
Small	7	20.00	23	65.71	5	14.29
Total:	23	28.75	42	52.50	15	18.75

Source: Balwinder Singh, Thesis for M.Sc., PAU

About 52.5 per cent of the farmers are not satisfied with their profession. About 66 per cent of the small farmers and 60 per cent of the medium farmers are not satisfied with their present lot. Most of them want their children to take to other professions such as industry, business or some white-collar jobs. However, 55 per cent of the large farmers are satisfied with their occupation, while only 20 per cent of the medium and small farmers seem to be satisfied. The farmers who are satisfied with their profession are those who have some other source of income.

The uncertainty of market prices and the rising cost of inputs and goods of daily use have discouraged the farmers. The table below shows the rise in the price of inputs, taking 1967 as the base year.

TABLE 3. AGRICULTURAL INPUT PRICES IN PUNJAB, 1967 TO 1981

Input		*Years*						
		1967	1972	1974	1978	1980	1981	1982
(a)	*Tractors* (Rs)							
	Massey-Ferguson (35 H.P)	21,562	27,902	33,121	49,023	62,500	75,215	81,318
	International B-275	21,610	26,707	34,080	49,854	62,630	69,579	70,168
	Zetor 2011/2511	13,700	23,000	31,873	43,380	52,134	55,957	55,384
(b)	*Irrigation Equipment* (Rs)							
	Electric Motor AE.I (5 HP)	984	1,135	1,675	1,650	2,310	2,695	2,700
	Diesel engine (Kirloskar)	2,740	3,259	3,461	3,760	4,935	5,639	5,840
(c)	*Fuel* (Rs/litre)							
	Diesel	0.86	0.91	1.07	1.42	2.31	2.66	3.00
	Mobil oil	2.60	3.52	11.00	9.58	11.00	12.50	13.50
	Electricity charges per HP	8.00	8.00	12.00	13.00	13.00	13.00	13.00
(d)	*Labour* (Rs/litre)							
	Agricultural worker	4.24	6.69	9.50	10.00	11.00	12.40	13.00
	Skilled worker	7.06	13.42	15.50	23.00	26.00	28.00	28.00
(e)	*Fertilizers* (Rs/tonne)							
	CAN	510	578	1,095	1,015	1,600	1,600	1,600
	DAP	1,095	1,246	3,005	2,298	3,050	3,050	3,600
	Urea	840	959	2,000	1,608	2,000	2,000	2,350
	Superphosphate	402	447	961	610	900	900	940
(f)	*Insecticides* (Rs/litre)							
	BHC (10% dust)	0.25	0.45	1.20	1.10	1.25	1.25	1.50
	Malathion	7.45	15.10	32.50	34.00	38.00	39.00	40.00
	DDT (50%WP)	3.30	6.18	13.00	16.50	18.00	22.00	22.00

NOTE: Prices as on June 30 for the respective years.
SOURCE: Department of Economics, Punjab Agricultural University, Ludhiana

The crunch in the prices of inputs came in 1972 with the increase in oil prices. It will be seen that the cost of inputs has risen 300 per cent or more, but this is not reflected in the prices of commodities which the farmers sell. This situation has caused much dissatisfaction among the farmers who are now cost-conscious. No doubt their gross income has increased, but the costs have also increased. If you ask any farmer about his profit, invariably the reply is *"bachta kuchh nahin"* (no savings whatsoever). This is amply proved by a study of farm accounts of the Rupar Farm, which is run by the Punjab Agricultural University as a seed farm, with the best available expertise. The gross income was Rs 4,695 per hectare and the expenditure was Rs 4,200 per hectare in 1973-74. Thus the net income was only Rs 495 per hectare, and that also because it was a seed farm. Had wheat and rice been sold as foodgrains, there would have been no net income and the farm would have suffered a loss.

The farmers suffer much inconvenience in purchasing diesel. The supply of electricity is erratic, and the farmers have often to irrigate their fields at night. Repair of tube-wells, diesel engines and tractors is a constant drain on the farmers' resources. Most of their earnings are spent on the purchase of chemical fertilizers for the next crop. The mobility of labour and its lack of availability has created uncertainty in farming operations. Repayment of loans to banks is a constant source of worry to the farmers. Besides, crops are exposed to numerous natural hazards, viz. diseases, droughts, untimely rain, floods and hailstorms. Try as we may, fields cannot become factories. For these reasons, wise governments always support the farmers and their profession.

One cannot say whether a happier rural society has emerged with the introduction of technology. In old times the rural society was well-knit. When a farmer performed the marriage of his daughter, the entire village helped. Every family contributed milk; cots were supplied and the members of the marriage party were treated as guests of the village community. When someone died, the entire population of the village followed the funeral procession to the cremation ground. Women were safe, and cases of sexual assaults were rare. Love affairs in the village were also rare, and the offenders were socially boycotted. The elders were respected and their advice was heeded. All this is changing and a more individulistic society is emerging with a selfish commercial outlook. The serenity of old rural society is disappearing, and life is now full of tensions. But this price has to be paid so that adequate food is produced for the country's growing population.

APPENDIX I

CHRONOLOGY

LANDMARKS IN THE DEVELOPMENT OF IRRIGATION, AGRICULTURE, HORTICULTURE, VEGECULTURE, ANIMAL HUSBANDRY, POULTRY FARMING AND FISHERIES IN INDIA, 1974 TO 1981

PRIME MINISTER
JAWAHARLAL NEHRU (15 August 1947-27 May 1964)

1947, 15 Aug.	India gains Independence, country partitioned and Pakistan created. Refugee farmers from West Pakistan migrate to India.
1947, Sep.	Temporary allotment of evacuee land to refugee farmers in the Punjab (I). Central Tobacco Research Institute established at Rajahmundry (Andhra Pradesh). Central Marine Fisheries Research Institute established at Cochin (shifted to Mandapam in 1949). Central Inland Fisheries Station (now an Institute) established at Barrackpore (West Bengal).
1948	The East Punjab Consolidation of Holdings and Fragmentation Act passed by Punjab (I) Government. Reclamation of Nainital Tarai started.
1949	Quasi-permanent allotment of land to refugee farmers from West Pakistan begins at Jullundur. Tarlok Singh invents the concept of standard acre. Review of land allotments of refugee farmers in the Punjab by P.N. Thapar, Tarlok Singh and M.S. Randhawa. Central Potato Research Institute established at Patna. (It was transferred to Simla in 1956.) Fowlpox vaccine developed at IVRI, Izatnagar. The University Education Commission, under the chairmanship of Dr S. Radhakrishnan, recommends the creation of rural universities.
1950	Large-scale planting of eucalyptus hybrid in Assam. Cross-breeding of cattle started at Uruli Kanchan, Maharashtra, by Manibhai Desai, Director of Bharatiya Agro-Industries Federation (BAIF). K. M. Munshi appointed Minister, Food and Agriculture, Government of India.

Indian Agricultural Research Institute started in Delhi.
Intensive Cultivation Scheme in 19 villages at the initiative of K.M. Munshi.
V. Kurien and T.K. Patel spearhead the growth of Kaira Milk Producers' Union.
Distribution of allotment orders to land allottees in Punjab and PEPSU.
Tube-wells and tractors introduced in Punjab (I).
Planning Commission set up with Prime Minister Jawaharlal Nehru as Chairman and V.T. Krishnamachari as Vice-Chairman.
K.M. Munshi inaugurates National Festival of Tree Planting (*Vana Mahotsava*).
Garden Colony Scheme launched in Punjab (I).

1951 Delivery of possession of allotted land to refugee farmers in Punjab and PEPSU. Agricultural production stimulated.
Fertilizer factory set up at Sindri (Bihar).
Statistical Newsletter started by the ICAR.

1952 Consolidation of land holdings gathers momentum in Punjab under the guidance of Partap Singh Kairon, Development Minister and, over 445,000 hectares consolidated.
Community Development Scheme started. S.K. Dey appointed Administrator of the scheme.
Construction of Bhakra Dam started.
Rafi Ahmed Kidwai appointed Minister, Food and Agriculture, Government of India. He abolishes irksome controls on movement of foodgrains.
The Japanese mint, source of menthol, introduced into India by Sir R.N. Chopra.
A factory established at Calcutta to manufacture BHC.
The Rural-Credit Survey Committee recommended establishment of large primary credit societies and crop loans.
Indian Institute of Sugarcane Research started at Lucknow.
Frank W. Parker, a fertilizer expert, comes to India to set up the US Technical Co-operation Mission and to develop the Indo-American Programmes.
Construction of Rihand dam started in eastern Uttar Pradesh.
The Nangal dam completed.
Apple Revolution begins in Kulu Valley with expansion of apple cultivation to over 400 hectares.
Cho control work started by H.L. Uppal in Hoshiarpur District in Punjab.

1953 Punjab countryside replanned and road-system laid out under

the Consolidation of Holdings Scheme.
Roads laid in Nainital Tarai and Panjabi refugees settled.
Jute Agricultural Research Institute started at Barrackpur, West Bengal.
ICAR started fruit research scheme for Himachal Pradesh with A. R. Thapar as Officer-in-Charge. Progeny orchards of apples established and plants supplied to growers.
Cross-breeding of Jersey bulls with Sindhi undertaken in Himachal Pradesh.
Nils Lagerlof visits India and arranges for training of Indian veterinarians in animal reproduction in Stockholm.
National Extension Service Programme inaugurated.
Village roads built, school buildings constructed and streets paved in the villages.
The publication of *Rice News Teller*, whose matter was provided by the Central Rice Research Institute, Cuttack, taken over by the ICAR.

1954 Ajit Prasad Jain appointed Minister, Food and Agriculture, Government of India.
World's largest fertilizer demonstration programme started in India with TCM aid.
National Rinderpest Eradication Programme started.
Konar dam completed in Bihar.
Tungabhadra Project completed in Mysore State (Karnataka).
Koyna Project started in Bombay State (Maharashtra).

1955 National Dairy Research Institute started at Karnal.
Twenty soil-testing laboratories set up in different parts of India with TCM aid.
Fertilizer Association of India organized.
Aerey Milk Colony Scheme started by D. N. Khirodi in Bombay city.
Kakrapara Project in Gujarat completed.
Durgapur barrage completed.
Lower Bhavani Project completed in Madras (Tamil Nadu).
Nagarjunasagar Project started in Andhra Pradesh.
Report of the First Indo-American Team submitted.
A comprehensive programme of publication of books on agriculture and horticulture, and monographs on algae and fungi started by M. S. Randhawa in the ICAR.

1956 All-India Soil Survey Scheme started in the IARI.
Central Potato Research Institute started at Simla.
Composite Regional Research Stations for Cotton, Oilseeds and Millets started in different States.

Ghataprabha left-bank canal completed in Mysore (Karnataka).
Mayurakshi Project completed in West Bengal.
Rajasthan Canal Project started.
Hirakund dam completed in Orissa.
Delhi Milk Scheme started by L.C. Sikka.
Quarterly journal *Indian Horticulture* started by the ICAR.
Dean W.H. Hannah prepares a blueprint on Agricultural Universities at Pantnagar.

1957 Maithon dam in Bihar completed.
Central Institute of Fisheries Technology started at Cochin.

1958 Sunder Singh, an artisan, and S.K. Paul invent a power-driven wheat thresher at Ludhiana.
All-India Soil and Land Use Survey Organization started.
The Damodar Valley Project completed.
Failure of the hoist chamber at Bhakra dam and the plugging of the right diversion channel.

1959 S.K. Patil appointed Minister, Food and Agriculture, Government of India.
Harbhajan Singh evolves virus-resistant okra (*bhindi*) at IARI.
Institute of Agricultural Research Statistics, which made a modest beginning in 1933 as a Statistical Wing of the ICAR, comes into being. (It was strengthened and renamed Indian Agricultural Statistics Research Institute in 1978.)
Report of the Agricultural Production Team set up by the Government of India in collaboration with the Ford Foundation recommended selection of irrigated areas for intensive agriculture.
Pushkarnath develops seed-plot technique as a result of which potato seed could be raised in the plains. He also evolves high-yielding varieties of potatoes.
Central Arid Zone Research Institute established at Jodhpur (Rajasthan).
The *Indian Journal of Agriculture and Veterinary Education* and the *Indian Potato Journal* started by the ICAR.

1960 International Rice Research Institute established at Los Baños, Philippines. Over the years, this institute actively collaborated with rice research in India.
H.L. Uppal reclaimed Kanuwan swamp in Gurdaspur District.
Report of the Second Indo-American Team recommended setting up of agricultural universities.
The Gandhi Sagar dam completed on the Chambal River.
R.W. Cummings appointed Chairman of a Committee to advise State Governments on the legislation for setting up agricultural universities.

Govind Ballabh Pant University of Agriculture and Technology set up at Pantnagar, Uttar Pradesh.

1961 Nangal Fertilizer factory established.

Fertilizer Corporation of India set up at New Delhi.

Intensive Agricultural District Programme (IADP) started in seven districts. Package of agricultural practices prepared for wheat and rice cultivation in the States.

Dwarf lines of wheat incorporating Norin genes released by N.E. Borlaug at CIMMYT, Mexico. These varieties later had a major impact on India's Green Revolution.

Koyna Project in Maharashtra completed.

A quarterly journal *Agricultural Research* started by the ICAR.

1962 Labh Singh, Cotton Botanist, who discovered LSS cotton, died.

About 880 tractors manufactured in India, and 2,997 imported.

Large-scale planting of hybrid eucalyptus in Punjab.

M.S. Swaminathan notices dwarf strains of wheat in the international rust nurseries distributed by the USDA and cultivated at the IARI. He gets in touch with N.E. Borlaug and invites him to India.

Central Sheep and Wool Research Institute started at Avikanagar, Rajasthan.

Milk Schemes make great progress in Punjab.

Agricultural University set up at Udaipur, Rajasthan.

Punjab Agricultural University set up at Ludhiana, Punjab (inaugurated on 8 July 1963).

Orissa University of Agriculture and Technology set up at Bhubaneshwar, Orissa.

Grape Revolution in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Punjab and Haryana.

Indian Grassland and Fodder Research Institute established at Jhansi, Uttar Pradesh.

1963 Swaran Singh appointed Minister, Food and Agriculture, Government of India.

Agricultural Refinance and Development Corporation set up.

Indarjit Singh, an entrepreneur, manufactured peg-tooth type of thresher at Ludhiana.

N.E. Borlaug visits India. On return to Mexico he sends 100 kg seed of each of the dwarf and semi-dwarf wheat varieties and 613 primary selections in advanced generation to the IARI. The IARI arranged multi-location testing programme at Delhi, Ludhiana, Pusa, Kanpur, Pantnagar, Bhowali and Willington. Out of these, 'Kalyan Sona' was independently selected at Delhi and Ludhiana, and 'Sonalika' at Delhi.

Central Tuber Crops Research Institute started at Trivandrum, Kerala.

Two journals, *Indian Livestock* and *Pashupalan*, started by the ICAR.

The National Seeds Corporation set up.

Bhakra dam completed at a cost of Rs 492 million. It irrigates 3.5 million hectares in Punjab, Haryana and Rajasthan and also supplies power for tube-wells.

R.N. Davis, an American Consultant, introduced several varieties of soybean from the USA in India.

1964 Intensive Agricultural Areas Programme (IAAP) started in 114 blocks, with M.S. Randhawa as Director-General.

C. Subramaniam appointed Minister for Food and Agriculture and Community Projects, Government of India.

Satluj canalized between Rupar and Harike in the Punjab by H.L. Uppal and 80,000 hectares reclaimed.

PRIME MINISTER

LAL BAHADUR SHASTRI (11 June 1964–11 January 1966)

1964 Jawaharlal Nehru Krishi Vishwa Vidyalaya set up at Jabalpur, Madhya Pradesh.

Committee set up under the chairmanship of B. Sivaraman to examine problems relating to distribution of fertilizers and to suggest improvement.

India faces food crisis due to prolonged drought.

C. Subramaniam, Minister for Food and Agriculture, proposed that farmers be given incentive price. This was accepted by Prime Minister Shastri.

Government of India decides to set up agro-industries corporations in the States.

1965 About 250 tonnes of wheat seed imported from Mexico.

B.P. Pal appointed Vice-President of the ICAR. He was the first agricultural scientist to hold this post.

Government of India liberalizes industrial licencing policy for manufacture of chemical fertilizers and allows participation of the private sector.

Andhra Pradesh Agricultural University set up at Hyderabad, Andhra Pradesh.

University of Agricultural Sciences set up at Bangalore, Karnataka.

National Dairy Development Board formed at Anand, Gujarat.

Agricultural Prices Commission established.

Warehousing Corporation set up.

Food Corporation of India set up for purchase and sale of foodgrains and to ensure a reasonable support price to farmers.
Fair-price shops set up.
India becomes self-sufficient in arecanuts, producing 140,000 tonnes.
An agro-industries corporation set up in Maharashtra.
The scientific panel on animal husbandry constituted by the Ministry of Agriculture, Government of India, suggests the undertaking of an intensive co-ordinated cross-breeding programme.

PRIME MINISTER
INDIRA GANDHI (24 January 1966–24 March 1977)

1966 The Report of the Education Commission (headed by Dr D.S. Kothari) recommends the setting up of at least one agricultural university in each State.
Agro-industries Corporations set up in Bihar, Punjab and Tamil Nadu.
About 5,714 tractors manufactured in India.
Start of the Green Revolution.
Production of wheat in India 11,393 thousand tonnes.
About 18,000 tonnes of seed of dwarf varieties of wheat 'Lerma Rojo 69' and 'Sonora 64' imported from Mexico.
Neyveli fertilizer plant commissioned.
Report of the All-India Credit Review Committee recommended the setting up of Small Farmers' Development Agencies and the Rural Electrification Corporation.
Production of rice in India 30,438 thousand tonnes.

1967 Rana Partap Sagar dam completed.
Indian Farmers' Fertilizer Corporation Limited registered.
Indian Institute of Horticultural Research started at Bangalore, Karnataka.
International Rice Research Institute, Philippines, enters into an agreement with the ICAR and the USAID to participate in the develonment of rice research in India. This led to development of many high-yielding varieties of rice.
K.S. Nandpuri evolves 'Hara Madhu', a very sweet muskmelon.
All-India co-ordinated Research Project on Soybean started by the ICAR.
C.T. Patel develops hybrid cotton 'H 4', which gave a yield of 6,918 kg per hectare.
Production of potatoes in India 4,232 thousand tonnes.

1968 Twenty modern rice mills set up in various parts of the country.

Production of rice in India rises to 39,761 thousand tonnes.
Agricultural Finance Corporation set up with the object of helping commercial banks to participate in the development of agriculture.
Lachhman Singh Gill, Chief Minister, starts a crash programme for building rural link roads in Punjab.
Systematic work on cultivation of Japanese mint and extraction of menthol done by Messrs Richardson Hindustan Ltd in Tarai of Nainital, Uttar Pradesh.
'Flordasun' and 'Florda Red' varieties of peach introduced by G.S. Nijjar in Punjab.

1969 Wealth tax imposed on agricultural land.
Mahatma Phule Krishi Vidyapeeth set up at Rahuri, Maharashtra.
Punjabrao Krishi Vidyapeeth set up at Akola, Maharashtra.
Fourteen leading commercial banks nationalised.
K.S. Nandpuri evolves 'Punjab Sunhehri' musk-melon at the PAU, Ludhiana.
Setting up of the Rural Electrification Corporation and impetus to ground-water utilization with the aid of tube-wells and filter points.
Assam Agricultural University set up at Jorhat, Assam.
Frozen semen banks started in India.
Central Soil Salinity Research Institute started at Karnal, Haryana.
Production of wheat in India 18,651 tonnes.

1970 Fakhruddin Ali Ahmed appointed Minister, Food and Agriculture, Government of India.
Central Plantation Crops Research Institute started at Kasaragod, Kerala.
Y. S. Parmar creates a separate Department of Horticulture in Himachal Pradesh which provides stimulus to apple cultivation.
Haryana Agricultural University set up at Hissar, on account of bifurcation of the Punjab Agricultural University.
Cacao becomes a successful intercrop in coconut and arecanut gardens.
Indian Dairy Corporation started with V. Kurien as Chairman.
Operation flood started by the National Dairy Development Board.
Production of wheat in India 20,093 tonnes.

1971 Directorate of Agricultural Aviation started by the Government of India.
Tamil Nadu Agricultural University set up at Coimbatore,

Tamil Nadu.
Rajendra Agricultural University set up at Patna, Bihar.

1972 Ceiling on land-holdings fixed at 4-7 hectares of double-cropped land per family.
M.S. Swaminathan appointed Director-General, ICAR.
Marathwada Agricultural University set up at Parbhani, Maharashtra.
Konkan Krishi Vidyapeeth set up at Dapoli, Maharashtra.
International Crops Research Institute for Semi-arid Tropics established at Hyderabad, Andhra Pradesh, with R.W. Cummings as its first Director.
Kerala Agricultural University set up at Mannuthy, Kerala.
Apple Revolution in Himachal Pradesh with a production of 125,000 tonnes of apple.
Gujarat Agricultural University set up at Dantiwada, Gujarat.
Punjab Agricultural University establishes a research station at Gangian in Hoshiarpur District for preservation of germplasm of sucking varieties of mangoes.
Pace of the Green Revolution accelerated.
Production of rice in India 43,068 thousand tonnes.
Production of wheat in India 26,410 tonnes.
Production of wheat in West Bengal 1,152 thousand tonnes.

1973 About 20,802 tractors manufactured in India.
D.R. Bhumbla and I.P. Abrol developed technology for reclamation of saline and alkali soils at Karnal.
Browning of the Green Revolution.
Production of rice in India slides down to 39,245 thousand tonnes.
Production of wheat in India slides down to 21,778 thousand tonnes, due to sharp rise in the price of oil and chemical fertilizers.

1974 Jagjivan Ram appointed Minister, Food and Agriculture, Government of India.
Bidhan Chandra Krishi Vishwa Vidyalaya set up at Haringhata, West Bengal.
Vivekananda Laboratory, which came into existence in 1924, was transferred to the ICAR and, came to be known as Vivekananda Parvatiya Krishi Anusandhan Shala, devoted to research on hill agriculture.
National Fertilizers Ltd incorporated.
Central Soil and Water Conservation Research and Training Institute started at Dehradun.

1975 Ranbir Singh Sandhu and Satvir Jaswal select 'M 13' ground-

nut which yielded over 3 tonnes per hectare at Ludhiana.
ICAR Research Complex for North-Eastern Hills Region started at Shillong.
Chandrashekhar Azad University of Agriculture and Technology set up at Kanpur, Uttar Pradesh.
K.S. Nandpuri evolves 'Punjab Chhuhara' variety of tomato, high-yielding and capable of standing transportation over long distances by trucks.
Production of potatoes in India rises to 6,225 thousand tonnes.

1976 Central Institute of Agricultural Engineering started at Bhopal.
Central Institute for Cotton Research started at Nagpur.
National Bureau of Plant Genetic Resources set up at New Delhi.
National Bureau of Soil Survey and Land-Use Planning started functioning independently at New Delhi; shifted to Nagpur in 1978.
Narendra Dev University of Agriculture and Technology set up at Faizabad, Uttar Pradesh.
Production of fish rose to 2,400 thousand tonnes in 1976 from 1,012 tonnes in 1956.
Green Revolution gathers momentum again due to increase in procurement price.
Production of rice in India rises to 48,740 thousand tonnes.
Production of wheat in India rises to 28,846 tonnes due to increase in procurement price.
Production of coarse grains in India 30,409 thousand tonnes.
Integrated Rural Development Programme started.

PRIME MINISTER
MORARJI DESAI (24 March 1977–28 July 1979)

1977 Parkash Singh Badal appointed Minister, Food and Agriculture, Government of India.
Surjit Singh Barnala appointed Minister, Food and Agriculture, as Parkash Singh Badal becomes Chief Minister of Punjab.
Production of potatoes in India rises to 7,287 thousand tonnes.

1978 Nangal Fertilizer factory expanded.
About 40,946 tractors manufactured in India and import of tractors stopped.
The Nagarjunasagar Project completed in Andhra Pradesh. It irrigates 1.3 million hectares.
Central Agricultural Research Institute for Andaman and Nicobar Group of Islands started at Port Blair.
Production of wheat in India rises to 31,380 thousand tonnes.
Production of coarse grains in India 29,800 thousand tonnes.

Production of potatoes in India rises to 8,153.2 thousand tonnes.
Himachal Pradesh Krishi Vishwa Vidyalaya comes into being, incorporating the colleges of Agriculture at Palampur (July 1970) and Solan (July 1971).

1979 Sindri fertilizer factory modernized.

PRIME MINISTER
CHARAN SINGH (28 July 1979–14 January 1980)

1979 Brahm Parkash Choudhary appointed Minister, Food and Agriculture, Government of India.
Dr O. P. Gautam takes over as the Director-General, ICAR, and Secretary, Department of Agricultural Research and Education.
Central Avian Research Institute comes into being at Izatnagar, Uttar Pradesh.

PRIME MINISTER
INDIRA GANDHI (14 January 1980–todate)

1980 Rao Birendra Singh appointed Minister, Food and Agriculture, Government of India.
Ramagundam fertilizer project completed to manufacture ammonia and urea.
Pesticide manufacturing industry produces 76,000 tonnes of pesticides.
About 62,275 tractors manufactured in India. India has 3,35,000 tractors, out of which Punjab has 124,000 tractors.
Swaraj 8100 self-propelled combine developed by Chandra Mohan and G.S. Rihal at Mohali.
Wealth tax on agricultural lands—an inequitous, vexatious and anti-improvement measure—abolished.
India's population reaches 680 million mark.
Annual egg output rises to 12,500 million in 1980 from 2,340 million in 1961.
Production of apple in Himachal Pradesh rises to 135,475 tonnes.
Annual production of poultry products in India rises to Rs 6,600 million from Rs 600 million in 1960.
ICAR starts *Phal Phool*, a quarterly in Hindi devoted to horticulture and floriculture.

APPENDIX II

STATISTICS

POPULATION, AREA, VILLAGES, SOIL TYPES, SIZE OF HOLDINGS, IRRIGATION, PUMPSETS, TRACTORS, FERTILIZERS, YIELD OF CROPS, PROCUREMENT OF FOODGRAINS, AVAILABILITY OF FOODGRAINS PER CAPUT, HORTICULTURE, ANIMAL HUSBANDRY, POULTRY AND DAIRYING

I: POPULATION, AREA, VILLAGES, SOIL TYPE AND SIZE OF HOLDINGS

TABLE 1. POPULATION AND AREA, 1971

State/Union Territories	*Population (thousand persons)*	*Geographical area according to Surveyor-General of India (km²)*	*Density per km²*	*Percentage of rural population to total population*	*Percentage of workers to total population*
Andhra Pradesh	43,503	276,814	157	80.69	41.39
Assam (a)	14,958	99,610	150	91.13	28.35
Bihar	56.353	173,876	324	90.00	31.03
Gujarat	26,697	195,984	136	71.92	31.45
Haryana	10,037	44,222	227	82.34	26.44
Himachal Pradesh	3,460	55,673	62	93.01	36.95
Jammu & Kashmir	4,617	222,236(b)	N.A.	81.41	29.76
Karnataka	29,299	191,773	153	75.69	34.74
Kerala	21,347	38,864	549	83.76	29.12
Madhya Pradesh	41,654	442,841	94	83.71	36.72
Maharashtra	50,412	307,762	164	68.83	36.48
Manipur	1,073	22,356	48	86.81	34.57
Meghalaya	1,012	22,489	45	85.45	44.17
Nagaland	516	16,527	31	90.05	50.75
Orissa	21,945	155,782	141	91.59	31.22
Punjab	13,551	50,362	269	76.27	28.87
Rajasthan	25,766	342,214	75	82.37	31.24
Sikkim	210	7,299	29	90.63	53.19
Tamil Nadu	1,199	130,069	317	69.74	35.78
Tripura	1,556	10,477	149	89.57	27.79
Uttar Pradesh	88,341	294,413	300	85.98	30.94
West Bengal	44,312	87,853	504	75.25	27.91
Union Territories	6,342	98,286	65	31.42	32.88
All-India	548,160	3,287,782	177(c)	80.10	32.93

SOURCE : *Indian Agriculture in Brief*, Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TALBE 2. NUMBER OF DISTRICTS, TOWNS, VILLAGES AND COMMUNITY DEVELOPMENT BLOCKS

State/Union Territories	*Districts* (a)	*Towns* (b)	*Villages* (c)	*CD Blocks* (d)
Andhra Pradesh	21	224	29,428	324
Assam	13	74	23,331	130
Bihar	31	202	78,027	587
Gujarat	19	216	18,697	218
Haryana	11	65	7,064	87
Himachal Pradesh	12	36	18,929	69
Jammu & Kashmir	10	45	6,742	73
Karnataka	19	245	29,533	175
Kerala	11	88	1,268	144
Madhya Pradesh	45	250	76,847	457
Maharashtra	26	289	38,661	343
Manipur	6	8	1,993	14
Meghalaya	3	6	4,982	24
Nagaland	3	3	966	21
Orissa	13	81	51,639	314
Punjab	12	108	12,888	117
Rajasthan	26	157	35,795	232
Sikkim	4	7	215	—
Tamil Nadu	15	439	16,660	374
Tripura	3	6	5,215	17
Uttar Pradesh	55	325	124,592	875
West Bengal	16	223	41,392	335
Union Territories	19	29	4,500	96
All-India	393	3,126	629,364	5,026

SOURCE : *Indian Agriculture in Brief*, Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TABLE 3. NUMBER OF INHABITED VILLAGES IN THE STATES

State/Union Territories	*Total number of inhabited villages*
Andhra Pradesh	27,221
Assam (a)	22,224
Bihar	67,566
Gujarat	18,275
Haryana	6,731
Himachal Pradesh (b)	16,916
Jammu & Kashmir	6,503
Karnataka	26,826
Kerala (c)	1,268
Madhya Pradesh	70,883
Maharashtra	35,778
Manipur (c)	1,949
Meghalaya	4,583
Nagaland	960
Orissa	46,992
Punjab	12,188
Rajasthan	33,305
Sikkim	215
Tamil Nadu	15,735
Tripura	4,727
Uttar Pradesh	112,561
West Bengal	38,074
Union Territories (d)	4,456
All-India	575,936(e)

SOURCE: *Indian Agriculture in Brief*, Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TABLE 4. AREA IN INDIA UNDER DIFFERENT SOIL TYPES

Type of soils	*Approximate area (million hectares)*
Alluvial soils	101.2
Alluvial soils highly calcareous	8.9
Coastal alluvium	8.5
Deltaic alluvium (occasionally saline)	17.0
Alluvial soils affected by salinity and alkalinity	6.9
Desert soils	14.6
Deep black soils	6.9
Medium black soils	18.6
Shallow black soils	4.9
Black soils affected by salinity and alkalin	6.9
Black soils undifferentiated	12.5
Mixed red and black soils	10.5
Red soils	30.4
Red gravelly soils	1.6
Red and yellow soils	17.8
Laterite soils	10.1
Laterite and lateritic soils	2.0
Brown soils under deciduous	1.6
Grey and brown soils	3.6
Hill soils	2.4
Podsol soils	3.6
Forest soils laterite	6.5
Foothill tarai hill soils	5.7
Mountain meadow soils	11.7
Skeletal soils	2.4
Peat muck, very humus soils; also called bog soils, organic soils and half bog soils	0.2
Other soils (viz. mountain soils undifferentiated, glaciers and eternal snow)	11.0
Total	328.0

SOURCE: *Report of the Committee on Natural Resources* (Planning Commission) on a study on waste lands of India including saline and alkaline and water-logged lands and their reclamation measures.

TABLE 5. AVERAGE SIZE OF HOLDINGS IN THE WORLD

Country	*Year*	*Hectares*
Belgium	1970	8.35
France	1970	22.07
Italy	1970	6.93
United Kingdom	1970	55.07
Yugoslavia	1970	4.79
Canada	1971	187.54
Mexico	1970	142.28
United States	1969	157.61
Argentina	1969	270.13
Peru	1971-72	16.93
India	1970-71	2.30
Indonesia	1963	1.05
Japan	1970	1.01
Nepal	1961-62	1.23
Pakistan	1960	2.35
Zaire	1970-71	1.06
Egypt	1960-61	1.59
Australia	1970	1992.58

SOURCE : *FAO Production Yearbook, 1975*

TABLE 6. NUMBER AND AREA OF OPERATIONAL HOLDINGS, 1970-71

State	*Number* ('000)	*Percentage*	*Area* ('000 *ha*)	*Percentage*	*Average size of holding* (*ha*)
Uttar Pradesh	15,639	22.2	18,158	11.2	1.16
Bihar	7,577	10.7	11,480	7.0	1.52
Andhra Pradesh	5,420	7.7	13,586	8.4	2.51
Tamil Nadu	5,314	7.5	7,709	4.8	1.45
Madhya Pradesh	5,299	7.5	21,194	13.1	4.00
Maharashtra	4,951	7.0	21,179	13.1	4.28
West Bengal	4,216	6.0	5,062	3.1	1.20
Rajasthan	3,727	5.3	20,341	12.5	5.46
Karnataka	3,551	5.0	11,368	7.0	3.20
Orissa	3,407	4.8	6,449	4.0	1.89
Gujarat	2,433	3.4	10,000	6.2	4.11
Kerala	2,305	3.3	1,593	1.0	0.70
Assam	1,964	2.8	2,883	1.8	1.47
Punjab	1,375	2.0	3,974	2.4	2.89
Haryana	913	1.3	3,447	2.1	3.70
Jammu & Kashmir	979	1.4	916	0.6	0.94
Himachal Pradesh	609	0.9	931	0.6	1.53
Remaining States and Union Territories	814	1.2	1,854	1.1	2.28
All-India	70,493	100.0	162,124	100.0	2.30

SOURCE: *All-India Report on Agricultural Census, 1971*

TABLE 7. TOTAL NUMBER AND AREA OF OPERATIONAL HOLDINGS ACCORDING TO SIZE

Size class (ha)	*Number* ('000)	*Percentage*	*Area* ('000 *ha*)	*Percentage*
Below 0.5	23,178	32.9	5,446	3.8
0.5 - 1.0	12,504	17.7	9,099	5.6
1.0 - 2.0	13,432	19.1	19,282	11.9
2.0 - 3.0	6,722	9.5	16,353	10.0
3.0 - 4.0	3,959	5.6	13,646	8.4
4.0 - 5.0	2,684	3.8	11,929	7.4
5.0 - 10.0	5,248	7.4	36,305	22.4
10.0 - 20.0	2,135	3.0	28,521	17.6
20.0 - 30.0	401	0.6	9,344	5.8
30.0 - 40.0	120	0.2	4,178	2.6
40.0 - 50.0	45	0.1	2,050	1.3
50.0 & above	65	0.1	5,971	3.7
Total	70,493	100.0	162,124	100.0

SOURCE: *All-India Report on Agricultural Census, 1970-71*

II: IRRIGATION, PUMPSETS, TRACTORS AND FERTILIZERS

TABLE 8. WORLD IRRIGATION STATISTICS

Country	*Area irrigated* (*million hectares*)
China mainland	74.000
India	37.640
USA	16.932
Pakistan	11.971
USSR	9.900
Iraq	4.000
Indonesia	3.797
Japan	3.390
Mexico	3.300
Italy	3.150
Iran	3.107
UAR	2.940

SOURCE: Framji, K.K. and Mahajan, I.K., 1969

TABLE 9. NET AREA IRRIGATED BY DIFFERENT SOURCES, 1973-74, STATE-WISE (thousand hectares)

State/Union Territories	*Canals*			*Tank*	*Wells*		*Others*	*Total*
	Government	*Private*	*Total*		*Tubewells*	*Other wells*		
Andhra Pradesh	1,492	—	1,492	1,027	112	533	117	3,281
Assam (b)	71	291	362	—	—	—	210	572
Bihar	894	4	898	82	560	157	623	2,320
Gujarat (c)	190	3	193	36	127	966	19	1,341
Haryana	1,012	—	1,012	(a)	624	95	5	1,736
Himachal Pradesh	—	—	—	(a)	1	1	92	94
Jammu & Kashmir	86	204	290	1	2	(a)	9	302
Karnataka	452	1	453	366	1	273	108	1,201
Kerala	222	10	232	76	—	5	144	457
Madhya Pradesh	712	1	713	119	19	657	137	1,645
Maharashtra	281	18	299	222	—	840	111	1,472
Manipur (d)	—	—	—	—	—	—	65	65
Meghalaya (c)	—	—	—	—	—	—	48	48
Nagaland	—	—	—	—	—	—	33	33
Orissa	558	—	558	185	26	109	—	878
Punjab	1,284	5	1,289	—	1,418	262	7	2,976
Rajasthan	844	—	844	233	41	1,222	38	2,378
Tamil Nadu	924	(a)	924	929	26	905	32	8,816
Tripura	—	—	—	2	—	5	23	30
Uttar Pradesh (e)	2,437	2	2,439	322	2,590	1,599	291	7,241
West Bengal (f)	629	331	960	303	—	17	209	1,489
Union Territories	30	—	30	5	38	9	34	116
All-India	12,118	870	12,988	3,908	5,585	7,655	2,355	32,491

SOURCE: *Indian Agriculture in Brief*, Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TABLE 10. AREA IRRIGATED BY DIFFERENT SOURCES AND CROPS
(thousand hectares)

Source/Crop	*1950-51*	*1965-66*	*1970-71*	*1973-74*
A. *Source-wise*				
Government canals	7,158	9,859	11,972	12,118
	(34.3)	(37.4)	(38.5)	(37.3)
Private canals	1,137	1,099	866	870
	(5.5)	(4.2)	(2.8)	(2.7)
Tanks	3,613	4,258	4,112	3,908
	(17.3)	(16.2)	(13.2)	(12.0)
Wells	5,978	8,653	11,887	13,240
	(28.7)	(32.8)	(38.2)	(40.7)
Others	2,967	2,475	2,266	2,355
	(14.2)	(9.4)	(7.3)	(7.3)
Total (net irrigated area)	20,853	26,344	31,103	32,491
	(100.0)	(100.0)	(100.0)	(100.0)
B. *Crop-wise*				
Rice	9,844	12,909	14,339	14,676
	(43.8)	(41.8)	(37.5)	(36.5)
Wheat	3,402	5,401	9,924	10,747
	(15.1)	(17.5)	(26.0)	(26.7)
Sorghum	463	714	614	677
	(2.0)	(2.3)	(1.6)	(1.7)
Total (cereals)	16,378	21,888	28,093	29,333
	(72.6)	(70.9)	(73.5)	(73.0)

SOURCE: *Indian Agriculture in Brief*, Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TABLE 11. SALIENT FEATURES OF IRRIGATION PROJECTS (COSTING Rs 100 MILLION AND ABOVE)

No. (by State)	*Project*	*Source of water*	*Capital cost (Rs million)*	*Gross area to be irrigated*	*Cost per acre of area to be irrigated (Rs)*
ANDHRA PRADESH					
(1)	Nagarjunasagar Project	River Krishna	1,220.200	—	—
(2)	Tungabhadra L.B. Canal	River Tungabhadra	230.400	450,000 (187,000 Andhra Pradesh 86,000 Karnataka)	510
(3)	Tungabhadra H.L. Canal		130.0	—	—
BIHAR					
(1)	Kosi Project	River Kosi	459.200	1,426,000	322
(2)	Gandak Project	River Gandak	Bihar 407.287 Uttar Pradesh 1,130.054	Bihar 2,647,000 Uttar Pradesh 598,000	— —
(3)	Sone Barrage, including remodelling of the Sone Canal System	River Sone	144.300	7,34,000 3,07,000	—
GUJARAT					
(1)	Broach Stage I (Narmada)	River Narmada	430.979	962,600	—
(2)	Ukal	River Tapi	337.264* (Irrig.)	391,700*	Total cost 58
(3)	Mahi Stage I	River Mahi	249.275	460,000	—
(4)	Mahi Stage II (Kadana)	River Mahi	164.800	500,000	—
MADHYA PRADESH					
(1)	Tawa Project	River Tawa	202.373	788,000	
TAMIL NADU					
(1)	Prambikulam-Aliyar Project	—	155.953 (Irrig.)	266,000	—
MAHARASHTRA					
(1)	New Khadakwasla	River Mutha	116.150	77,000	—
(2)	Purna	River Purna	128.400 (Irrig.)	152,000	—
(3)	Warna	River Warna	322.548	364,000	—
KARNATAKA					
(1)	Hidkal (Ghataprabha Stage II)	River Ghataprabha	131.800	178,000	—
(2)	Bhadra	River Bhadra	319.300 (Irrig. portion)	244,663	1,305

TABLE 11 *(Continued)*

No. (by State)	*Project*	*Source of water*	*Capital cost (Rs million)*	*Gross area to be irrigated*	*Cost per acre of area to be irrigated (Rs)*
ORISSA					
(1)	Mahanadi Delta Irrigation Scheme	River Mahanadi	343.398	1,608,000	351
(2)	Salandi	River Salandi	112.100	175,000	430
RAJASTHAN					
(1)	Rana Pratap Sagar	River Chambal	—	—	—
(2)	Rajasthan Canal		1,387.000	2,875,000	—
(3)	Banas Project	River Banas	100.700	133,000	757
UTTAR PRADESH					
(1)	Ramganga Project	River Ramganga	3,85.331 (Irrig.)	1,706,100	226
(2)	Matatila (Stages I and II)	River Betwa	119.939	409,580	294
WEST BENGAL					
(1)	Kangsabati	River Kangsabati and River Kumari	252.590	—	266

SOURCE: *History of Irrigation in India*, CWPC, New Delhi

TABLE 12. NUMBER OF PUMPSETS ENERGISED AND VILLAGES ELECTRIFIED (AS ON 30 JUNE 1980)

State	*Total No. of villages*	*Villages electrified*	*% villages electrified*	*% rural population covered by electricity*	*Pumpsets energized*
Andhra Pradesh	27,221	16,812	61.8	86.5	393,867
Assam	21,995	4,415	20.1	30.8	1,809
Bihar	67,566	20,628	30.5	44.3	152,206
Gujarat	18,275	11,168	61.1	77.8	207,656
Haryana	6,731	6,731	100.0	100.0	207,537
Himachal Pradesh	16,916	9,153	54.3	68.3	1,676
Jammu & Kashmir	6,503	4,552	70.0	68.7	986
Karnataka	26,826	16,325	60.9	76.3	293,170
Kerala	1,268	1,268	100.0	100.0	80,048
Madhya Pradesh	70,883	22,733	32.1	51.1	284,287
Maharashtra	35,778	25,808	72.1	86.0	609,958
Manipur	1,949	322	16.5	54.4	10
Meghalaya	4,583	596	13.0	29.1	47
Nagaland	960	334	34.8	52.5	Nil
Orissa	46,992	17,420	37.1	59.4	13,696
Punjab	12,188	12,126	100.0	100.0	269,262
Rajasthan	33,305	13,933	41.8	52.0	185,677
Sikkim	215	53	24.7	16.8	Nil
Tamil Nadu	15,735	15,570	98.9	99.8	897,365
Tripura	4,727	780	16.5	49.6	255
Uttar Pradesh	112,561	39,325	34.9	44.9	365,885
West Bengal	38,074	13,219	34.7	52.7	24,334
Total (States)	571,251	253,311	44.3	65.1	3,989,730

SOURCE: *Indian Agriculture in Brief*, Sixteenth Edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TABLE 13. STATE-WISE ESTIMATED NUMBER OF TRACTORS AND DIESEL PUMPSETS (AS ON 31 MARCH 1980)

State/Union Territories	*No. of tractors*	*No. of pumpsets*
Andhra Pradesh	12,470	145,331
Assam	1,080	789
Bihar	12,450	133,000
Gujarat	15,460	567,500
Haryana	48,150	70,000
Himachal Pradesh	960	800
Jammu & Kashmir	1,180	630
Karnataka	8,870	48,945
Kerala	2,310	26,649
Madhya Pradesh	15,750	93,170
Maharashtra	14,400	214,490
Manipur	110	—
Meghalaya	21	300
Nagaland	4	—
Orissa	1,800	9,100
Punjab	81,200	268,000
Rajasthan	24,800	58,000
Sikkim	—	—
Tamil Nadu	10,750	117,124
Tripura	45	105
Uttar Pradesh	68,150	851,000
West Bengal	1,600	86,500
Total (States)	321,470	2,691,433
Total (Union Territories)	11,950	12,711
Total (States and Union Territories)	333,420	2,714,144

SOURCE: Ministry of Food and Agriculture, Government of India

TABLE 14. CONSUMPTION, PRODUCTION AND IMPORTS OF NITROGENOUS, PHOSPHATIC AND POTASSIC FERTILIZERS (1969-70 TO 1978-79, during April-March; thousand tonnes)

Year	*N*			P_2O_5			K_2O	
	Consumption	*Production*	*Imports*	*Consumption*	*Production*	*Imports*	*Consumption*	*Imports*
FOURTH PLAN								
1969-70	1,356	731	667	416	224	94	210	120
1970-71	1,479	833	477	541	228	228	236	120
1971-72	1,798	949	481	558	290	248	300	268
1972-73	1,839	1,055	665	581	330	204	348	325
1973-74	1,829	1,050	659	650	325	213	360	370
FIFTH PLAN								
1974-75	1,766	1,187	884	472	331	286	336	437
1975-76	2,149	1,508	996	467	320	361	278	278
1978-79	3,420	2,173	1,233	1,106	778	244	592	517

SOURCE : Fertilizer Association of India

TABLE 15. FERTILIZER FACTORIES IN PRODUCTION (STATE-WISE LIST)

No.	*State, name of the factory and location*	*End-product*
	I: IN PRODUCTION	
	Andhra Pradesh	
1	Andhra Fertilizers, Tadepalle	SSP
2	Andhra Sugars, Tanuku	SSP
3	Coromandel Fertilizers, Visakhapatnam	Urea, UAP
4	FCI, Ramagundam	Urea
5	Hyderabad Chemicals & Fertilizers, Maula Ali	SSP
6	Krishna Industrial Corporation, Nidadavole	SSP
7	Liberty Pesticides & Fertilizers, Visakhapatnam	SSP
	Assam	
8	Chemical Unit of AIA, Chandrapur	SSP
9	HFCL, Namrup	AS, urea
	Bihar	
10	Bihar State Superphos Factory, Sindri Institute	SSP
11	SAIL, Bokaro	AS
12	HFCL, Barauni	Urea
13	FCI, Sindri	AS, urea, TSP
14	TISCO, Jamshedpur	AS
	Delhi	
15	DCM, Delhi	SSP
	Goa	
16	Zuari Agro Chemicals, San Coale	Urea, NPK, UAP, DAP, NP/NPK
	Gujarat	
17	Adarsh Chemicals & Fertilizers, Udhna	SSP
18	Anil Starch Products, Bhavnagar	SSP
19	Anish Chemicals, Ahmedabad	SSP
20	GSFC, Baroda	AS, Urea, DAP
21	IFFCO, Kalol	Urea
22	IFFCO, Kandla	NPK, H_3PO_4
23	JK Chemical Works, Pandesara	SSP
24	Paushak, Baroda	SSP
25	Viraj Chemicals, Nandesari	SSP
	Haryana	
26	National Fertilizers, Panipat	Urea
	Karnataka	
27	Chamundi Chemicals, Munirabad	SSP
28	Gammon Fer-Chems, Belagula	SSP
29	Mangalore Chemicals & Ferts, Mangalore	Urea NP/NPK

TABLE 15 (*Continued*)

No.	*State, name of the factory and location*	*End-product*
	Kerala	
30	FACT, Udyogamandal	AS, ACI, APS, SSP
31	FACT, Ambalamedu	Urea, NPK, DAP, NP/NPK
	Madhya Pradesh	
32	Dharamsi Morarji Chemicals Co., Kumhari	SSP, SSP
33	SAIL, Bhilai	AS
	Maharashtra	
34	Bharat Fertilizer Industries, Bombay	SSP
35	Dharamsi Morarji Chemicals Co., Ambernath	SSP
36	Noble Chemicals, Ghatkopar	SSP
37	RCFL, Trombay	Urea, nitro-phosphate, ammonium nitrophosphate, urea
38	Maharashtra Agro Industries Development Corporation, Panvel	SSP
39	Western Chemical Industries, Bombay	SSP
40	Rama Krishi Rasayan (formerly West India Chemicals), Loni-Kalbhor	SSP
	Orissa	
41	Orissa Fertilizers & Chemicals, Rourkela	Pelofos
42	SAIL (Fert. Plant), Rourkela	CAN
43	SAIL, Rourkela	AS
44	FCI, Talcher	Urea
	Punjab	
45	National Fertilizers, Nangal	CAN, urea
46	National Fertilizers, Bhatinda	Urea
	Rajasthan	
47	Bharat Alums & Chemicals, Alwar	SSP
48	Hindustan Copper, Khetri	SSP, TSP
49	Hindustan Fertilizer Industries, Udaipur	SSP
50	Hindustan Zinc, Udaipur	SSP, H_3PO_4
51	Hindustan Chemicals, Bhilwara	SSP
52	Khicha Industries, Udaipur	SSP
53	Liberty Pesticides & Fertilizers, Udaipur	SSP
54	Madhuvan Chemicals & Fertilizers, Udaipur	SSP, SSP
55	Maharana Khanij Udyog, Udaipur	SSP
56	Shriram Fertilizers & Chemicals, Kota	Urea
	Tamil Nadu	
57	Kothari (Madras), Ennore	SSP, ACI
58	Coimbatore Pioneer, Coimbatore	SSP
59	EID-Parry (India), Ranipet	SSP
60	EID-Parry (India), Ennore	AS, APS
61	Madras Fertilizers, Manali	Urea, DAP, NPK
62	Neyveli Lignite Corporation, Neyveli	Urea

TABLE 15 (*Continued*)

No.	*State, name of the factory and location*	*End-product*
63	Premier Fertilizers, Cuddalore	SSP
64	Shaw Wallace, Avadi	SSP
65	SPIC, Tuticorin	Urea, DAP, NP/NPK
66	FCI, Gorakhpur	Urea
67	Girraj Fertilizer & Chemicals, Shikohabad	SSP
68	Indian Explosives Ltd, Panki	Urea
69	IFFCO, Phulpur	Urea
70	New Central Jute Mills, Varanasi	ACI
71	Rallis India, Magarwara	SSP, SSP
	West Bengal	
72	HFCL, Durgapur	Urea
73	Hindustan Lever, Haldia	H_3PO_4
74	SAIL, Durgapur	AS
75	IISCO, Burnpur-Kulti	AS
76	Jayshree Chemicals & Fertilizers, Khardah	SSP, SSP
77	Phosphate Co., Rishra	SSP
	II: UNDER IMPLEMENTATION	
	Gujarat	
78	Gujarat Narmada Valley Fertilizers, Bharuch	Urea
79	KRIBHCO, Hazira	Urea
	Haryana	
80	Dharuhera Chemicals, Dharuhera	SSP
	Maharashtra	
81	RCFL, Thal Vaishet	Urea
	Punjab	
82	Shivalik Fertilizers, Hoshiarpur	SSP
	West Bengal	
83	HFCL, Haldia	Urea, nitro-phos'
	III: APPROVED IN PRINCIPLE	
	Andhra Pradesh	
84	Nagarjuna Fertilizers & Chemicals, Kakinada	Urea, NPK
	Bihar	
85	Bihar Caustic & Chemicals, Palamau	AC
	Gujarat	
86	Polymer Corporation	AS
	Haryana	
87	Dalmia Dairies, Mohindergarh	SSP
88	HSIDC, Panipat	SSP, TSP

TABLE 15 (*Continued*)

No.	State, name of the factory and location	End-product
	Madhya Pradesh	
89	FCI, Korba	Urea
90	M.P. Agro Morarji Fertilizer, Jhabua	Urea, mono ammonium phosphate
	Maharashtra	
91	Deepak Fertilizer Products, Taloja	
	Orissa	
92	Paradeep Project, Paradeep	NP/NPK
	Punjab	
93	Agricultural Sales Corporation, Patiala	SSP
94	DCM Chemical Works, Bhatinda	SSP
95	PSIDC, Hoshiarpur	SSP
96	Varinder Agro Chemicals, Ludhiana	SSP
	Rajasthan	
97	Industrial Supplies & Services, Udaipur	SSP
	Uttar Pradesh	
98	Modi Spinning & Weaving Mills, Bareilly	SSP
99	P.C. Arya, Bulandshahr	SSP

SOURCE: Fertilizer Association of India

III: YIELD OF CROPS, PROCUREMENT OF FOODGRAINS AND NET AVAILABILITY OF FOODGRAINS PER CAPUT

TABLE 16. AVERAGE YIELD PER HECTARE OF SELECTED CROPS IN INDIA (1951-52 TO 1978-79) (kilograms)

Year	*Rice*	*Wheat*	*Groundnut*	*Cotton (lint)*	*Jute*	*Sugarcane (cane)*
1965-66	862	827	554	104	1,062	43,717
1966-67	863	887	604	114	1,210	40,336
1967-68	1,032	1,103	759	123	1,293	46,665
1968-69	1,076	1,169	653	122	1,002	49,236
1969-70	1,073	1,209	720	122	1,326	49,121
1970-71	1,123	1,307	834	106	1,186	48,322
1971-72	1,141	1,380	823	151	1,255	47,511
1972-73	1,070	1,271	585	127	1,280	50,933
1973-74	1,151	1,172	845	142	1,412	51,163
1974-75	1,045	1,388	724	161	1,211	49,855
1975-76	1,235	1,410	935	138	1,367	50,903
1976-77	1,088	1,387	747	144	1,807	53,383
1977-78	1,308	1,480	866	157	1,210	56,160
1978-79	1,339	1,574	846	167	1,308	50,160

SOURCE: Directorate of Economics and Statistics, Ministry of Agriculture and Rural Reconstruction, New Delhi

TABLE 17. PROCUREMENT OF FOODGRAINS (ACCORDING TO CALENDAR YEAR) (thousand tonnes)

Calendar year	*Rice*		*Wheat*		*Coarse-grains*		*Total*	
1965	2,951	(7.5)	379	(3.1)	688	(2.7)	4,018	(5.2)
1966	3,100	(10.1)	219	(2.1)	690	(3.2)	4,009	(6.4)
1967	2,785	(9.1)	779	(6.8)	898	(3.7)	4,462	(6.8)
1968	3,373	(9.0)	2,373	(14.3)	1,059	(3.7)	6,805	(8.2)
1969	3,581	(9.0)	2,417	(13.0)	383	(1.5)	6,381	(7.6)
1970	3,043	(7.5)	3,183	(15.8)	488	(1.8)	6,714	(7.6)
1971	3,462	(8.2)	5,088	(21.3)	307	(1.0)	8,857	(9.2)
1972	2,550	(5.9)	5,024	(19.0)	91	(0.4)	7,665	(8.1)
1973	3,462	(8.8)	4,531	(18.3)	431	(1.9)	8,424	(9.7)
1974	3,482	(7.9)	1,885	(8.7)	278	(1.0)	5,645	(6.0)
1975	5,042	(12.7)	4,098	(17.0)	423	(1.8)	9,563	(10.6)
1976	5,999	(12.3)	6,618	(22.9)	236	(0.8)	12,853	(11.9)
1977	4,443	(10.4)	5,170	(17.8)	132	(0.5)	9,745	(9.7)

SOURCE: Ministry of Food, Government of India, New Delhi

TABLE 18. COMPARATIVE STATISTICS OF PRODUCTION, PROCUREMENT, IMPORTS AND OFFTAKE FROM PUBLIC DISTRIBUTION SYSTEM, 1966-1977, AND TOTAL NUMBER OF FAIR-PRICE SHOPS (million tonnes)

Year	*Total food-grain production*	*Total procurement*	*Procurement as percentage of production*	*Imports of foodgrains*	*No. of fair-price shops*
1967	74.231	4.462	6.0	8.671	109,581 (in 1965)
1968	95.052	6.805	7.2	5.694	—
1971	108.422	8.657	8.2	2.054	121,032
1972	105.168	7.665	7.3	0.445	165,081
1973	97.026	8.424	8.7	3.614	200,655
1974	104.665	5.645	5.4	4.874	—
1975	101.063	9.563	9.5	7.407	240,210
1976	120.833	12.853	10.6	6.483	236,196
				5.190 (Average)	

SOURCE: Based on Annual Bulletins on Food Statistics issued by the Ministry of Food, Government of India

TABLE 19. PER-CAPUT NET AVAILABILITY OF FOODGRAINS IN INDIA (INCLUDING NET IMPORTS) (ounces per day)

Year	*Rice*		*Wheat*	
	(oz/day)	*(g/day)*	*(oz/day)*	*(g/day)*
1951	5.6	158.76	2.3	65.20
1952	5.6	158.76	2.0	56.70
1955	6.3	178.60	2.1	59.53
1960	6.6	187.11	2.8	79.38
1965	7.4	209.78	3.3	93.55
1970	6.7	189.94	3.6	102.06
1972	7.0	198.45	4.5	153.09
1976	6.7	189.94	3.8	107.73

SOURCE: Ministry of Food, Government of India

IV: HORTICULTURE

TABLE 20. AREA ('000 HA) AND PRODUCTION ('000 TONNES) OF BANANA

State	Banana			
	1966-67		1979-80	
	Area	*Production*	*Area*	*Production*
Andhra Pradesh	16.6	285.7	19.1	321.3
Assam	20.0	261.0	23.1	299.5
Bihar	7.2	82.5	8.8	44.1
Gujarat	11.7	448.8	15.5	205.3
Haryana	—	—	—	—
Himachal Pradesh	0.1	0.3	—	—
Jammu & Kashmir	—	—	—	—
Karnataka	15.4	114.4	16.6	80.6
Kerala	45.6	344.9	50.3	622.1
Madhya Pradesh	2.2	61.5	6.3	67.6
Maharashtra	30.6	904.3	47.9	1,136.6
Manipur	—	—	2.4	31.2
Meghalaya	—	—	3.0	40.6
Nagaland	—	—	—	—
Orissa	13.5	106.3	17.8	155.0
Punjab	—	—	—	—
Rajasthan	—	—	—	—
Sikkim	—	—	—	—
Tamil Nadu	42.0	765.5	56.8	1,245.0
Tripura	3.4	24.9	2.6	16.5
Uttar Pradesh	0.6	10.9	0.6	2.3
West Bengal	—	—	—	—
Andaman and Nicobar Islands	0.3	1.0	0.9	3.8
Arunachal Pradesh	—	—	—	—
Dadra and Nagar Haveli	—	—	—	—
Mizoram	—	—	2.7	2.0
Pondicherry	—	—	—	—
India	209.2	3,412.0	274.4	4,273.5

SOURCE: Ministry of Agriculture, Government of India (Crops Division)

TABLE 21. AREA ('000 HA) AND PRODUCTION ('000 TONNES) OF GRAPES (IN 1979-1980)

State	*Area*	*Production*
Andhra Pradesh	0.8	19.1
Assam	—	—
Bihar	—	—
Gujarat	—	—
Haryana	0.4	1.9
Himachal Pradesh	—	—
Jammu & Kashmir	—	—
Karnataka	5.4	134.6
Kerala	1.0	3.3
Madhya Pradesh	—	—
Maharashtra	2.1	31.5
Manipur	—	—
Meghalaya	—	—
Nagaland	—	—
Orissa	—	—
Punjab	0.5	5.5
Rajasthan	—	—
Sikkim	—	—
Tamil Nadu	—	—
Tripura	—	—
Uttar Pradesh	—	—
West Bengal	—	—
Andaman and Nicobar Islands	—	—
Arunachal Pradesh	—	—
Dadra and Nagar Haveli	—	—
Mizoram	—	—
Pondicherry	—	—
India	10.2	195.9

NOTE: These are projected estimates

SOURCE: Ministry of Agriculture, Government of India (Crops Division)

TABLE 22. AREA ('000 HA) AND PRODUCTION ('000 TONNES) OF MANGO (IN 1979-80)

State	*Area*	*Production*
Andhra Pradesh	126.6	1,614.0
Assam	30.8	47.2
Bihar	129.0	1,289.5
Gujarat	22.9	229.0
Haryana	4.0	9.0
Himachal Pradesh	—	—
Jammu & Kashmir	—	—
Karnataka	37.4	262.2
Kerala	62.5	738.0
Madhya Pradesh	24.1	241.0
Maharashtra	14.8	88.8
Manipur	0.2	0.5
Meghalaya	—	—
Nagaland	—	—
Orissa	74.5	949.9
Punjab	7.1	44.3
Rajasthan	—	—
Sikkim	—	—
Tamil Nadu	34.3	480.1
Tripura	4.1	37.7
Uttar Pradesh	327.5	1,922.0
West Bengal	58.0	406.0
Andman and Nicobar Islands	—	—
Arunachal Pradesh	—	—
Dadra and Nagar Haveli	0.3	3.5
Mizoram	—	—
Pondicherry	0.3	0.6
India	958.4	8,363.3

NOTE: These are projected estimates

SOURCE: Ministry of Agriculture, Government of India (Crops Division)

TABLE 23. AREA ('000 HA) AND PRODUCTION ('000 TONNES) OF APPLE (IN 1979-80)

State	*Area*	*Production*
Andhra Pradesh	—	—
Assam	—	—
Bihar	—	—
Gujarat	—	—
Haryana	—	—
Himachal Pradesh	42.4	146.4
Jammu & Kashmir	56.0	470.0
Karnataka	—	—
Kerala	—	—
Madhya Pradesh	—	—
Maharashtra	—	—
Manipur	0.1	0.3
Meghalaya	—	—
Nagaland	—	—
Orissa	—	—
Punjab	—	—
Rajasthan	0.1	0.2
Sikkim	—	—
Tamil Nadu	—	—
Tripura	—	—
Uttar Pradesh	38.0	95.0
West Bengal	—	—
Andaman and Nicobar Islands	—	—
Arunachal Pradesh	2.3	6.7
Dadra and Nagar Haveli	—	—
Mizoram	—	—
Pondicherry	—	—
India	138.9	718.6

NOTE: These are projected estimates

SOURCE: Ministry of Agriculture, Government of India (Crops Division)

V: ANIMAL HUSBANDRY, POULTRY AND DAIRYING

TABLE 24. NUMBER OF LIVESTOCK AND POULTRY IN INDIA (million)

Item	*1961*	*1966*	*1972*	*Percentage change of Col. 4 over Col. 3*
Buffaloes				
(A) Females over 3 years				
(i) Breeding				
(a) In milk	12.46	12.92	15.07	(+) 16.6
(b) Dry and not calved even once	11.78	12.59	13.54	(+) 7.6
(ii) Working	0.49	0.39	0.37	(—) 4.4
(iii) Others	0.30	0.24	0.26	(+) 7.0
Total	25.03	26.16(d)	29.24	(+) 11.8
(B) Young stock	18.50	18.59	20.12	(+) 8.2
Total buffaloes	51.21	52.95	57.43	(+) 8.4
Sheep	40.22	42.02	39.99	(—) 4.8
Goats	60.86	64.59	67.52	(+) 4.5
Horses and ponies	1.33	1.15	0.94	(—) 18.1
Pigs	5.18	5.04	6.90	(+) 36.9
Camels	0.90	1.03	1.11	(+) 7.9
Mules	0.05	0.07	0.07	—
Donkeys	1.10	1.05	0.99	(—) 5.7
Other livestock	0.02	0.03(h)	0.05(h)	(+) 66.6
Total (livestock)	336.43	344.11	353.34	(+) 2.7
Total (poultry)	114.25(e)	115.45(f)	138.54(g)	(+) 19.9
Fowls	95.79	102.62	124.14	(+) 20.4
Ducks	6.70	9.69	9.01	(—) 7.0
Others	1.84	1.23	1.41	(+) 14.7

SOURCE: *Indian Agriculture in Brief*, Sixteenth edition, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, Government of India, New Delhi, 1977

TABLE 25. VALUE OF EXPORTS AND IMPORTS OF SELECTED COMMODITIES IN THE AGRICULTURE SECTOR (thousand rupees)

Commodity	*Exports*			*Imports*		
	1974-75	*1975-76*	*1976-77*	*1974-75*	*1975-76*	*1976-77*
Living animal chiefly for food	226	3,604	28,786	5,292	2,038	1,784
Meat and meat preparations	52,491	110,044	178,832	178	71	824
Dairy products and eggs	878	2,405	14,435	248,852	273,363	392,407
Fish and fish preparations	650,005	1,258,904	1,782,297	15,593	11,235	184
Feedstuff for animals	1,035,322	1,066,223	2,565,346	7,173	10,380	13,693
Hides, skins and fur skins undressed	4,222	1,854	7,886	7,755	5,251	2,567
Animals and vegetable crude materials n.e.s.	1,167,315	874,719	1,065,427	32,922	32,121	38,340
Animal, vegetable oils and fats	344,556	371,961	505,000	348,519	169,798	1,179,891

SOURCE: *Monthly Statistics of Foreign Trade of India*, March 1977, published by Department of Commercial Intelligence and Statistics, Calcutta

TABLE 26. STATE-WISE PRODUCTION ('000 TONNES) OF COW-MILK AND BUFFALO MILK (IN 1978-79)

No.	*State/Union Territories*	*Milk production*
	STATE	
1	Uttar Pradesh	5,500.00
2	Punjab	3,050.00
3	Andhra Pradesh	2,400.00
4	Gujarat	2,400.00
5	Madhya Pradesh	2,100.00
6	Bihar	1,900.00
7	Rajasthan	1,800.00
8	Haryana	1,700.00
9	Maharashtra	1,300.00
10	Tamil Nadu	1,260.00
11	WestBengal	1,200.00
12	Karnataka	1,125.00
13	Kerala	550.00
14	Assam	435.00
15	Jammu & Kashmir	225.00
16	Orissa	216.00
17	Himachal Pradesh	80.00
18	Manipur	55.50
19	Meghalaya	52.00
20	Tripura	17.50
21	Nagaland	3.00
	Total (States)	28,359.00
	UNION TERRITORIES	
22	Delhi	146.00
23	Goa, Daman and Diu	40.50
24	Arunachal Pradesh	35.00
25	Chandigarh	17.50
26	Pondicherry	15.00
27	Andaman and Nicobar	2.00
28	Mizoram	1.00
29	Dadra and Nagar Haveli	0.80
	Total (Union Territories)	221.80
	Total (All-India)	28,580.80

SOURCE: *Draft Fifth Five-Year Plan (1974-79)*, Ministry of Food and Agriculture, Government of India

TABLE 27. PROGRESSIVE ACHIEVEMENT IN MILK HANDLING

Milk handling	1972-73	1975-76	1976-77	1978-79
(i) No. of dairy plants	132	161	178	186
(ii) Daily average throughout of milk in public/ co-operative sector dairy plants (million litres)	2.90	3.82	4.44	5.30

SOURCE : Dairy Division, Ministry of Food and Agriculture, Government of India

TABLE 28. MILK PRODUCTS FACTORIES IN PUBLIC/COOPERATIVE SECTOR (IN 1980) (tonnes)

No.	State/Union Territories and dairy plants	Capacity	Procurement
	ANDHRA PRADESH		
1	Hyderabad	200,000	133,900
2	Vijayawada	150,000	89,000
3	Sangamjagrarlamudi	150,000	85,000
4	Proddutur	150,000	50,100
5	Chittoor	100,000	44,600
	BIHAR		
6	Barauni	100,000	95,000
7	Patna	100,000	7,050
	GUJARAT		
8	Anand	700,000	514,000
9	Banaskantha	150,000	130,050
10	Rajkot	45,000	22,500
11	Mehsana	450,000	372,400
12	Sabarkantha	150,000	132,000
	HARYANA		
13	Bhiwani	15,000	8,200
14	Jind	50,000	28,600
15	Rohtak	100,000	28,000
	MAHARASHTRA		
16	Miraj	120,000	116,500
17	Jalgaon	100,000	83,000
18	Warna Nagar	100,000	61,050
19	Udgir	120,000	35,950

TABLE 28 (*Continued*)

No.	*State/Union Territories and dairy plants*	*Capacity*	*Procurement*
	RAJASTHAN		
20	Bikaner	100,000	49,400
21	Jodhpur	100,000	28,600
22	Alwar	100,000	22,600
	PUNJAB		
23	Amritsar (Verka)	65,000	47,900
24	Bhatinda	60,000	23,750
25	Ludhiana	100,000	50,500
26	Hoshiarpur	75,000	35,200
	UTTAR PRADESH		
27	Aligarh (Creamery)	25,000	34,800
28	Moradabad	60,000	16,900
29	Meerut	100,000	46,000
30	Varanasi	100,000	1,600
	WEST BENGAL		
31	Siliguri (Matigara)	100,000	15,800
	TAMIL NADU		
32	Madurai	150,000	120,000

SOURCE : Dairy Division, Ministry of Agriculture, Government of India

TABLE 29. MAIN LIQUID MILK PLANTS IN OPERATION IN PUBLIC CO-OPERATIVE SECTORS (IN 1980) (tonnes)

No.	States/Union Territories and dairy plants	Capacity	Procurement
	ANDHRA PRADESH		
1	Anantapur	20,000	7,950
2	Chittoor	50,000	44,600
3	Kurnool	25,000	22,950
4	Karim Nagar	12,000	5,000
5	Mudukur	25,000	17,800
6	Nellore	40,000	16,500
7	Nizamabad	12,000	4,700
8	Rajahmundry	25,000	14,500
9	Visakhapatnam	50,000	23,500
10	Varangal	12,000	5,600
11	Khamam	12,500	1,500
	ASSAM		
12	Gauhati	10,000	7,100
13	Jorhat	6,000	1,500
	BIHAR		
14	Darbhanga	6,000	200
15	Gaya	—	—
16	Ranchi	6,000	2,300
17	Bhagalpur	2,000	700
18	Bokaro	20,000	—
	CHANDIGARH		
19	Chandigarh (Mohali)	60,000	34,850
	DELHI		
20	Mother Dairy (Delhi)	400,000	226,550
21	Delhi Milk Scheme	375,000	199,300
	GUJARAT		
22	Ahmedabad	240,000	190,000
23	Baroda	100,000	89,700
24	Bhavnagar	10,000	7,000
25	Surat	150,000	157,500
26	Junagarh	25,000	6,050
27	Baroch	50,000	22,700
28	Jamnagar	25,000	4,450
	GOA		
29	Ponda	10,000	9,200

TABLE 29 (*Continued*)

No.	*States/Union Territories and dairy plants*	*Capacity*	*Procurement*
	HARYANA		
30	Ambala	20,000	16,200
31	Faridabad	50,000	7,300
	HIMACHAL PRADESH		
32	Mandi	10,000	5,100
33	Nahan	5,000	3,300
	JAMMU & KASHMIR		
34	Jammu	10,000	2,000
35	Srinagar	10,000	1,700
	KARNATAKA		
36	Bangalore	150,000	145,000
37	Belgaum	10,000	11,400
38	Bhadravati (Shimoga)	10,000	7,400
39	Gulbarga	10,000	2,400
40	Hubli Dharwar	10,000	12,200
41	Kudigee	4,500	12,000
42	Mangalore	10,000	7,000
43	Mysore	60,000	51,300
44	Davengere	6,000	1,900
	KERALA		
45	Alleppey	3,000	4,500
46	Ernakulam	10,000	14,400
47	Trivandrum	20,000	38,700
48	Calicut	6,000	7,500
49	Palghat	6,000	6,500
50	Kottayam	6,000	5,500
51	Cannanore	10,000	2,100
	MANIPUR		
52	Imphal	6,000	2,600
	MAHARASHTRA		
53	Aurangabad	35,000	33,300
54	Bombay Aarey		
55	Bombay Worli	1,100,000	750,200
56	Bombay Kurla		
57	Dhulia	160,000	138,300
58	Kolhapur	85,000	68,650
59	Nagpur	100,000	62,000
60	Nasik	50,000	53,400
61	Poona	100,000	121,000
62	Sholapur	60,000	55,000
63	Nandura	60,000	—

TABLE 29 (*Continued*)

No.	*States/Union Territories and dairy plants*	*Capacity*	*Procurement*
	MADHYA PRADESH		
64	Bhopal	20,000	21,450
65	Gwalior	10,000	4,300
66	Indore	20,000	14,500
67	Jabalpur	10,000	4,550
68	Ujjain	60,000	8,000
	ORISSA		
69	Cuttack	6,000	1,950
	PONDICHERRY		
70	Pondicherry	10,000	11,800
	PUNJAB		
71	Jullundur	50,000	34,500
	RAJASTHAN		
72	Jaipur	20,000	39,500
73	Ajmer	50,000	33,800
	TAMIL NADU		
74	Madras-Madhavaram	125,000	110,500
75	Madras-Ambattur	200,000	63,000
76	Erode	160,000	113,350
77	Chidambaram	5,000	1,700
78	Coimbatore	16,000	35,000
79	Vellore	30,000	34,000
80	Kodaikanal	2,000	2,100
81	Kanya Kumari	2,000	11,150
82	Thanjavur	16,000	6,500
83	Trichy-Srirangam	6,000	5,900
84	Ootacamund	30,000	19,900
	TRIPURA		
85	Agartala	2,000	1,450
	UTTAR PRADESH		
86	Agra	10,000	7,400
87	Allahabad	10,000	2,000
88	Almora	4,000	400
89	Haldwani	10,000	3,700
90	Mathura	10,000	15,000
91	Lucknow	40,000	11,300
92	Dehradun	20,000	1,350
93	Varanasi	—	—
94	Gorakhpur	10,000	450
95	Kanpur	50,000	8,200

TABLE 29 (*Continued*)

No.	*States/Union Territories and dairy plants*	*Capacity*	*Procurement*
96	Bareilly	10,000	2,100
97	Faizabad	30,000	17,000
	WEST BENGAL		
98	Calcutta-Haringhata	300,000	69,400
99	Calcutta Central Dairy	—	—
100	Dhankuni	400,000	15,900
101	Durgapur	55,000	5,000
	SIKKIM		
102	Torthang	5,000	500

SOURCE: *Dairying in India*, 1979

TABLE 30. CATTLE-FEED PLANTS IN INDIA AND THEIR CAPACITY

No.	*State and Union Territories*	*No. of feed plants*	*Total capacity (tonnes/annum)*
1	Arunachal Pradesh	1	
2	Bihar	1	36,500 (as supplied by NDDB)
3	Gujarat	8	245,725
4	Haryana	2	73,000 (as supplied by NDDB)
5	Himachal Pradesh	2	2,400
6	Kerala	3	2,016
7	Maharashtra	15	406,980
8	Meghalaya	1	800
9	Orissa	9	3,222
10	Punjab	5	25,000
11	Rajasthan	1	12,000
12	Tamil Nadu	10	32,601
13	Tripura	1	1,000
14	West Bengal	5	50,000
15	Goa	1	351
16	Dadra and Nagar Haveli	1	120
17	Pondicherry	2	2,000
	Total	68	893,715

SOURCE : Ministry of Food and Agriculture, Government of India

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