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I. INTRODUCTION

The research and educational programmes of the Indian Council of Agricultural Research, carried out through agricultural universities, central institutes, national bureaux, all-India co-ordinated research projects and *ad-hoc* research schemes, made further progress during the year. Some of the significant new developments in research, education and extension education are indicated below.

**Research**

A Central Institute for Agricultural Research in Andaman and Nicobar Islands was established with headquarters at Port Blair. This Institute will deal with inter-disciplinary problems for deriving benefit from the vast potential existing in Andaman and Nicobar group of islands for horticulture, plantation crops, animal husbandry and fisheries. In addition, the problems of fixed crops like rice will be attended to.

Another important step taken to assist the neglected areas is the sanctioning of the following four projects in tribal areas:

1. Safflower research at Girijan Krishi Kendra at Rastakutibai, Srikakulam, Andhra Pradesh.
2. Operational Research Project for economic development of tribal people in Melghat, Amravati district.
3. Study of natural, physical resources, socio-economic constraints and farm and forest practices of 3 tribal districts in Madhya Pradesh.
4. Operational Research Project for development of tribal area in Mandla district.

In addition, a National Agricultural Research Project with a total outlay of Rs. 400 million was developed with partial credit support from the World Bank. The major aim of this project is to assist agricultural universities to enhance their capacity for carrying out location-specific research in major food crops.

To strengthen agricultural research in certain priority areas, the following projects were approved by the Governing Body of the Indian Council of Agricultural Research for support from
the balances of the erstwhile commodity committees and cess funds:

(a) Strengthening research in pulses and oilseeds through a 3-pronged strategy:

(i) Introduction of pulses and oilseeds in crop rotations in irrigated farming systems and, more particularly, in the command areas of major irrigation projects.

(ii) Improvement of the yield of pulses and oilseeds in rainfed areas through improved water harvesting, plant protection, seed production and post-harvest technologies.

(iii) Introduction of pulses and oilseeds as inter-crops both in annual and perennial cropping systems.

(b) Research in sugarcane with particular emphasis on the testing and popularization of early-maturing varieties which can help extend the crushing season in sugar factories and introduce rice-sugarcane and wheat-sugarcane rotations.

(c) Stimulation of lac production through enhanced home consumption of lac by popularizing the use of lac in coating urea so as to minimize leaching losses of fertilizer.

(d) Initiation of an all-India co-ordinated research programme for increasing the income and employment potential of landless labour families.

It is proposed to initiate a co-ordinated research project specifically designed to identify and develop methods of assisting landless labour families in the major market-shed areas of Bombay, Calcutta, Delhi, Hyderabad and Madras as well as in areas characterized by the simultaneous occurrence of a large percentage of landless labour families and a considerable potential for generation of additional income and employment through integrated attention to production and post-harvest technologies and agro-industries.

Education

The Himachal Pradesh Government established in November 1978 a separate agricultural university with the main campus at Palampur. This university will develop research centres in the
major agroecological zones of the state and will have a second campus at Solan.

To meet the manpower requirements of the north-eastern states, an agricultural college was established near Ghaspani, Nagaland, under the North-eastern Hill University. This college will pay particular attention to imparting training in systems of land management which can render jhum or shifting cultivation unnecessary.

The Jammu and Kashmir Government has also taken a decision in principle to establish an agricultural university, and appropriate assistance is being extended to get such a university started soon.

To assist the ecologically and economically handicapped regions of the country to develop their full potential for agricultural growth, a manpower development programme is being initiated by the Indian Council of Agricultural Research from out of the balances of the erstwhile commodity committees as well as from the cess funds. The aim of this programme will be to assist the neglected, backward, tribal, drought and flood-prone areas to have adequate trained manpower for research and training work in the respective regions.

Extension Education

Proposals were developed for organization of national demonstration on a systems basis encompassing the entire farming family and the entire farming system. Additional operational research projects were developed. A proposal for the establishment of Krishi Vigyan Kendras in neglected regions was formulated and approved by the Governing Body of the Indian Council of Agricultural Research.

Golden jubilee of the ICAR

Realizing that a dynamic agricultural production programme cannot be sustained without a dynamic agricultural research and training base, the Royal Commission on Agriculture had recommended the establishment of the Indian Council of Agricultural Research. The ICAR was started on 16th July, 1929 and it would, thus, be completing 50 years of service to Indian Agriculture in 1979. To commemorate the Golden Jubilee, the following programme has been drawn up by a National Organizing Committee headed by the Union Minister of State for Agriculture and Irrigation and the Vice-President of the ICAR.
(1) A massive programme designated 'Lab-to-land Project' designed to transfer the latest technology based on principles of ecology and economics to the fields of small and marginal farmers on the basis of a systems approach. Monitoring of the impact of this programme will be in terms of the additional income and opportunities for gainful employment generated and not merely in terms of production units.

(2) Organization of an international symposium on 'Agricultural Research and Education Systems for Development'.

(3) Release of suitable publications such as 'A History of Agriculture in India', 'A History of ICAR' and 'Fifty Years of Agricultural Research and Education'.
II. ADMINISTRATION

The Department of Agricultural Research and Education (DARE) of the Ministry of Agriculture and Irrigation provides the necessary governmental linkages for the Indian Council of Agricultural Research (ICAR).

The major functions of the DARE are as follows:

(i) To look after all aspects of agricultural research and education (including animal sciences and fisheries); involving co-ordination between the Central and State agencies;

(ii) To attend to all matters relating to the Indian Council of Agricultural Research; and

(iii) To attend to all matters concerning the development of new technology in agriculture, animal husbandry and fisheries, including such functions as plant and animal introduction and exploration, and soil and land-use survey and planning.

The DARE carries out such government functions as may be necessary for the effective working of the ICAR. The Director-General of the ICAR is also the Secretary to the Government of India in the DARE.

The DARE is intended basically to provide administrative servicing and support to the ICAR. Within the overall framework of Government policies, the ICAR is vested with full authority to determine basic strategies, formulate operational policies, develop necessary programmes and ensure their implementation on sound technical and economic principles. The main idea of the reorganized set-up of the ICAR is to vest it with the autonomy essential for the effective functioning of a scientific organization and to deal with sister departments of the Central Government, with State Governments and with International Agricultural Research Centres through the DARE.
The main objectives of the ICAR are:

(i) To undertake, aid, promote and co-ordinate agricultural, animal husbandry and fisheries education, research and its application in practice, development and marketing by all means calculated to increase scientific knowledge of the subject and to ensure its adoption in everyday practice;

(ii) To act as a clearing house of information not only in regard to research but also in regard to agricultural and veterinary matters generally;

(iii) To establish and maintain a reference and research library in pursuance of the objectives of the Council; and

(iv) To do such other things as the Council may consider necessary or conducive to the attainment of the above objectives.

The ICAR is responsible for coordinating and directing a well-organized national grid of co-operative research. In this system different sets of institutions are involved, viz., 21 Agricultural Universities, 32 Central Institutes, 3 Project Directorates, 54 All India Coordinated Research Projects and 4 Tribal Projects.

Organizational Set-up

According to the reorganized set-up, the ICAR Society has been made compact and specifically related to its scientific charter. The Minister for Agriculture and Irrigation to the Government of India is the President of the Council and the Minister of State in the Ministry dealing with the ICAR is the Vice-President. The Society is assisted in its task by a Governing Body headed by the Director-General, ICAR. The Governing Body has as its members Hon’ble Members of Lok Sabha and Rajya Sabha, representatives of agricultural and rural interests, eminent agricultural and other scientists, Vice-Chancellors of agricultural universities, Directors of ICAR Institutes, Secretaries of the Government of India in the Ministry of Finance (Department of Expenditure), Planning, Department of Agriculture and also the Chairman of the University Grants Commission. The Governing Body assists in formulating the policies of the ICAR, scrutinizes and approves the research programmes and projects and controls the budget of the Council. The recommendations of the Governing Body become operative only after they are approved by the President of the ICAR.
The Governing Body in its turn is assisted by the following Committees:

(a) Standing Finance Committee for examining research and other proposals and schemes having financial implications and also for examining the annual budget of the Council before submission to the Governing Body.

(b) Norms and Accreditation Committee for dealing with matters relating to agricultural universities.

(c) Eight Regional Committees constituted to cover the research and training needs of the major agro-ecological regions. These Committees include as members, members of the ICAR Society and Directors of ICAR Institutes in the region, the technical representatives of the agricultural universities, Central Institutes and Department of Agriculture of the Government of India in the region and the State Departments and farmers of the region nominated by the President. These Committees review the status of agricultural research and education in the respective regions and make necessary recommendations to the Governing Body relating to location-specific problems of that region.

(d) Scientific Panels of the ICAR are constituted for various disciplines to consider schemes and projects relating to these disciplines. There are also joint panels between the ICAR and related research organizations like the CSIR, ICMR and ICSSR. Besides considering schemes for research, the scientific Panels may advise the Governing Body on technical matters and draw its attention to gaps in the current research and training efforts.

AGRICULTURAL RESEARCH SERVICE

The Agricultural Research Service was constituted on 1-10-75. The cadre strength for the different grades of the Service at its initial constitution was fixed at 4800. For initial induction into the service the Agricultural Scientists Recruitment Board screened 3113 eligible existing employees of the Council, out of whom 3094 have so far been approved for induction into the Service. For recruitment to Grade S-1 (scale of pay Rs. 700—1300) of the Service, three all-India competitive examinations had been held since the inception of the Service. As a result, 1383 candidates
were offered appointments to Grade S-1. The ASRB has also undertaken recruitment action for filling posts of scientists in Grade S-2 and S-3 on the basis of open advertisements.

The Agricultural Research Service envisages a system of 5 yearly assessment of promotion or grant of advance increments to the eligible scientists. The promotion of persons in higher grades is irrespective of the occurrence of vacancies. Persuant to this, the first assessment of scientists, who were eligible on 31-12-1975, was completed and 947 scientists were promoted to higher grades and 280 scientists were granted advance increments ranging from 1 to 3. The second assessment, which was due on 31-12-1976, has also, more or less, been completed and 589 scientists have been promoted to higher grades and 189 scientists were given advance increments ranging from 1 to 3. In all, 1536 scientists were promoted to higher grades and 469 scientists were given advance increments.

A Central Staff College for Agriculture is functioning at Hyderabad to impart training facilities to scientists recruited under the Service of the Council.

All posts under the Council, the incumbents of which are engaged in performing technical services in support of research and education, whether in the laboratory, workshop or field or in areas like library, documentation, publication and agricultural communication constitute the Technical Services. These Services came into force from 1-10-1975. There is no common cadre. The posts are borne on the strength of respective Institutes or the Headquarters of the Council as the case may be.

Just like the Agricultural Research Service, the Technical Service of the ICAR also envisages a system of 5 yearly assessment of promotion or grant of advance increments within the grade of the category irrespective of the occurrence of vacancies. So far, 1205 persons have been given promotions in the Service and 108 have been given advance increments.

The posts of Administrative Officers in the Scale of pay of Rs. 700—1300 and above in the Institutes form a common cadre of Administrative Officers. Posts of Assistant Administrative Officers and below in the administrative side are institute based. Twenty-four Assistant Administrative Officers have so far been promoted as Administrative Officers and 14 Administrative Officers and 9 Assistant Administrative Officers have so
far been promoted to the posts of Senior Administrative Officers in accordance with the provisions of the rules.

With a view to providing adequate career advancement to the supporting staff, the supporting staff was restructured recently. As a result of the restructuring 1807 persons belonging to this category have been given promotions from the lower grade to the higher grade.

Two appreciation courses on Improvement of Administrative Efficiency for the Senior Administrative Officers, Administrative Officers and Assistant Administrative Officers of the Institutes, were organised at the Indian Agricultural Research Institute, New Delhi in collaboration with the Institute of Secretariat Training and Management, New Delhi, with the following aims:

(i) To promote an intelligent appreciation of office procedure and management;

(ii) To emphasise the importance of human relations in personnel management and expose the participants to certain modern concepts; and

(iii) To promote a better understanding of financial rules and regulations and to develop a proper attitude in their application.

Fifty-five officers belonging to these categories have been trained.

Training courses in Administrative and Financial Rules for superintendents, assistants, senior clerks and junior clerks of the research institute were organised during the year in 10 centres at the various institutes located in the country. The first phase of the training programme was completed during the year and the training course had received widespread support and considerable enthusiasm from the officers and staff of the Research Institutes.

A training course in Administrative Vigilance was conducted at the IARI for the administrative officers and scientists of various grades. Forty-two participants drawn from 26 research institutes attended the course.

The Council has also provided necessary forums, like the Grievance Cells and Joint Councils to enable the staff to ventilate their grievances and to represent on various services matters.
STAFF COLLEGE

The ICAR established a Central Staff College for Agriculture at Hyderabad in September, 1976, to provide training in the principles of scientific management of agricultural research and development. At present, it is located temporarily on the Campus of the Andhra Pradesh Agricultural University where 50 hectares of land has been provided for its permanent location.

Since inception, the Staff College started foundation training courses for the Scientists-probationers recruited to the Agricultural Research Service of the Council. These courses inculcate in the young scientists an awareness of the rural socio-economic set-up, the role of agriculture in national development, the infrastructure and operational aspects of ICAR, and also offer them basic skills required for agricultural research.

Each foundation course is of 3 months duration. During 1978, about 330 Scientists of S-1 Grade completed their training. So far, 9 batches totalling 840 in all have been trained.

The Administrative and Accounts Officers of the ICAR attended a Workshop on the needs of Agricultural Research Institutes of one week duration at this College in March, 1978. In December, 1978, a joint meeting of the Staff College and the Officers of ICAR Research Institutes concerned with the work of probationers was held to streamline the training programme.

For the benefit of Senior Scientists (S-3/S-4 cadre) of ICAR Institutes who were heading the Divisions in the various disciplines, a course of research management was held from 18th to 30th December, 1978. One Scientist each from 30 ICAR Institutes participated in this training programme.

AGRICULTURAL SCIENTISTS RECRUITMENT BOARD

The Agricultural Scientists Recruitment Board was set up in December, 1973, by the Indian Council of Agricultural Research with the approval of the Cabinet. The Board has a whole-time Chairman, who is assisted by an administrative office headed by a Secretary. The other officers of the Board are the Controller of Examinations, a Deputy Director (Recruitment) and five Section Officers besides non-gazetted staff.

The Agricultural Scientists Recruitment Board is entrusted with the recruitment to all scientific and technical Senior Class
I posts in the scale of Rs. 1100—1600 (Revised) and above in the fields of Agriculture, Animal Husbandry and allied sciences for all research institutes (including their regional research stations) under the ICAR and Class II and above posts at the Headquarters of the Council.

The Chairman, Agricultural Scientists Recruitment Board, also approves recruitment action for Class II and Junior Class I posts at the research institutes of the ICAR, in addition to rendering advice in all matters relating to recruitment and other service matters of the employees of the ICAR and research institutes under it.

In addition to the work relating to recruitment entrusted to it, the Board is also consulted: (i) in all matters relating to methods of recruitment to posts for and under the Council and approval of Recruitment Rules for different posts; ii) on the principles to be followed in making appointments and promotions to posts and suitability of candidates for such appointments and promotions; and (iii) in such disciplinary matters affecting the persons in the posts equivalent to class II and above in the Central Government serving under the Council and in its research institutes, as the President, in consultation with the Agricultural Scientists Recruitment Board, may specify.

It also arranges for: (i) recruitment to A.R.S. in Grade S-1 by holding an all-India competitive examination at various centres, (ii) induction of existing eligible scientists into Agricultural Research Service in Grades S, S-1, S-2 and S-3 and S-4 and above, and (iii) five-yearly assessment of scientists for merit promotion/advance increments.

Recruitment: During the year 1978 the Board advertised 138 posts for recruitment of agricultural scientists to be posted in various Agricultural Research Institutes of the ICAR including the Headquarters. Against this the Board recruited 166 scientists (including posts advertised earlier than 1978) for lateral entry through selection to different grades.

Induction into A.R.S.: The induction of 94 agricultural scientists into the Agricultural Research Service was accomplished during the year.

Five-Yearly Assessment: The Chairman, Agricultural Scientists Recruitment Board, constituted Assessment Committee for
each professional subject/discipline with eminent scientists belonging to the particular discipline being its members. The Board assessed 992 agricultural scientists during the year.

Agricultural Research Service Examination: An all-India competitive examination for the Agricultural Research Service (third in series) was conducted by the Board from 1 February to 4 February 1978 at 12 centres in India, viz. Bangalore, Bombay, Calcutta, Chandigarh, Cuttack, Coimbatore, Delhi, Gauhati, Hyderabad, Jodhpur, Lucknow and Nagpur. This examination was conducted in 42 disciplines and 747 vacancies were to be filled in through this examination. The number of candidates admitted to the examination was 5,037 including 237 Scheduled Caste and 34 Scheduled Tribe candidates. In this examination, 483 candidates including 44 of Scheduled Castes and 6 of Scheduled Tribes were selected for appointment to the Agricultural Research Service.
The tremendous growth of human population and incredible human interference with the natural ecosystem has accelerated the decline in reserves basic to agriculture, viz. plant, animal, soil and water. According to the estimates of the International Union for Conservation of Nature and Natural Resources (IUCN), the world is losing, on an average, one animal species or subspecies every year, and more species became extinct in the last 80 years than during the period from AD 80 to 1900. About 1,000 species of birds and animals are now believed to be in danger, and nearly 10 per cent of the world's flowering plants, amounting to 20,000 to 30,000 species, are becoming rare or facing extinction. It is therefore necessary to devise a means of preserving plants and animals and harness them for human welfare through appropriate scientific mechanisms.

Soil is another non-renewable basic resource. Since all the available arable land has been brought under cultivation, the only alternative now left to us is to maximize productivity to keep pace with the ever-growing demands for agricultural products. The uncanny exposure of land to natural forces and its indiscriminate use without concern for the long-term effects has rapidly reduced the production potentiality of our soils. Urgent steps are, therefore, necessary to check the eroding forces and preserve the productive value through appropriate survey and land-use plans.

Realizing the incalculable value of natural resources in promoting agricultural production and the imminent dangers they face today from a variety of causes, the Indian Council of Agricultural Research established during the Fifth Five-Year Plan 2 National Bureaux, one for the conservation of plant genetic resources and the other for soil survey and land-use planning. Besides strengthening the activities in both the bureaux, the following additional programmes were proposed to be undertaken during the Sixth Five-Year Plan (1978-83).

*All-India Co-ordinated Research Project on Germplasm Collection*

India is endowed with immense diversity in a number of agri-horticultural crops, viz. rice, maize, grain legumes, brassicas,
tree cotton, jute, citrus, mango and banana. Since some of these crops originated in India and have evolved through hybridization with their closely related species, much genetic diversity is available in these crops. This genetic wealth is now primarily concentrated in the tribal-dominated tracts—now in the wake of scientific, technical and industrial development—where the spread of high-yielding varieties has posed a threat to the existence or survival of local land races. The products of years of natural and human selection, the native cultivars constitute genetic treasures possessing valuable traits like resistance to diseases and pests, adaptability to environment and quality characteristics. Human selection has also generated much variability in locally improved superior genotypes—ginger in Himachal Pradesh, and taros, yams, leafy brassicas, jute, tree cotton, glutinous rice and pop maize in the north-eastern region. Further, natural diversity in many crops prevails in the forests, e.g. for *Musa*, *Citrus* and *Mangifera* in the north-eastern region. Systematic collection of all this diversity from areas of cultivation and naturally occurring stands must be planned.

To co-ordinate the work on germplasm collection and preservation in the country, it was proposed to initiate an All-India Co-ordinated Research Project on Germplasm Collection.

**Gene sanctuaries**

It is proposed to preserve the habitats where considerable genetic variability occurs in economically important plants. For example, there are pockets of natural plant wealth in the north-eastern Himalayan region where immense diversity occurs in *Citrus*, *Musa*, *Oryza*, *Saccharum* and *Mangifera*. Some valuable genes for resistance to brown planthopper were identified in the rice collections from Mizoram. It is proposed to establish a gene sanctuary for *Citrus indica* in Meghalaya within the overall concept of biosphere preserves.

**All-India Co-ordinated Programme for Research on Under-utilized Plants**

The economic value of several naturally occurring plant species is yet to be fully realized and tapped. The late Dr Harbhajan Singh had made a compilation of the wild edible plants of the Himalayan region. Some of these plants, like *Chenopodium album*, have a great potential for phyto-mass production. Following the increase in the price of petroleum products, natural rubber derived from *Hevea brasiliensis* has become economically attractive and important. There are also annuals like guayule (*Parthenium argent-
tatum) whose latex compares fairly well with the product obtained from *Hevea*. Hence introduction and testing of guayule in arid and semi-arid regions deserve immediate attention. Under this coordinated programme work on all such species, both occurring within the country and those which can be introduced from abroad, will be initiated.

**Protecting endangered species**

The Botanical Survey of India undertook studies on several rare and endangered plants that could be preserved either in their native habitat or in botanic gardens. At its suggestion the Government of Meghalaya established a 'Pitcher Plant Sanctuary' in Khasi hills. A more extensive study of endangered species is necessary both in plants and animals. Fortunately, in recent years, some of the Himalayan orchids and *Dioscorea* species which were facing extinction have been collected and preserved.

**National Bureau of Animal Genetic Resources**

India is rich in its animal wealth. The 1972 Livestock Census of India gave the population of cattle as 178.8 million, of buffalo as 57.9 million, of goat as exceeding 68 million (20 per cent of the world’s population), and of sheep as exceeding 40 million. The country has also large populations of pigs, poultry, horses, ponies and camels. There are unique animals like mithun and yak in the North-Eastern Himalayan Region. For ensuring the success of the large number of programmes of animal husbandry taken up for providing supplementary income and employment to small and marginal farmers and landless labour, our genetic wealth in farm animals needs to be conserved and utilized effectively.

Some of the objectives of the proposed National Bureau of Animal Genetic Resources are:

(i) to evaluate the various breeds of cattle, buffaloes, goats, sheep and other species;

(ii) to stimulate programmes for improvement in the various breeds and give adequate support;

(iii) to take steps for the preservation of germplasm both as live animals and by setting up frozen semen banks for storage of certain number of minimum doses of semen of sires under evaluation at various centres of research;

(iv) to undertake surveys for the evaluation of merits or attributes of breeds threatened with extinction; and
(v) to undertake systematic cataloguing of animal germplasm, and for establishing a data bank and information service on animal genetic resources.

Central Institutes and National Research Centres for Buffalo, Goat, Avian Species, Mithun and Yak

The ICAR proposes to establish separate central research institutes for research on buffalo, goat and avian species including poultry. This is being done to preserve and improve the germplasm of farm animals which are yet to receive adequate multidisciplinary scientific attention. In addition, National Research Centres for Mithun and Yak are being established in Arunachal Pradesh and Nagaland.

National Bureau of Fish Genetic Resources

The fish fauna of India is one of the richest in the world, and is noted for its rich and diverse cyprinoid and siluroid fishes. There are roughly 1,800 species of fish. Only a few of these are commercially important. These are available in varied types of water bodies having diverse ecological conditions and somewhat widely varying geographical locations. Some of these are cultivated in different parts of the country for the past many years, the most important among them being carps (Catla catla, Labeo rohita, L. calbasu, Cirrhinus mrigala, C. cirrhosa, Tor spp., etc.), several species of catfishes and murrels. However, these species are still not properly domesticated and a planned genetic selection or breeding programme is yet to be attempted. It is believed that some of these could be definite strains or varieties having one or more advantageous characters.

In addition to these indigenous fauna, several freshwater species such as the trouts, the European and the Chinese carps, the Gourami and the African mouth breeder (Tilapia mossambica) have been introduced in the country. Among these, the common carp (Cyprinus carpio) and the trouts were subjected to considerable amount of selection work and genetic manipulation, as a result it is difficult to trace their original wild parent stock and the gene pool of the pure species is taken as lost for all practical purposes.

Although hybridization has not made a significant headway in the country, yet due to the spread of composite fish culture of closely allied species, there is scope for the occurrence of several hybrids. Hence, there is a danger that the original wild stock may become rare.
It is proposed to establish a National Bureau of Fish Genetic Resources. Three centres are proposed to be set up at Dhauli, Kakdwip and Cochin for freshwater, brackishwater and saltwater fishes respectively. The chief responsibilities underlined for the Bureau are:

(i) collection of principal genetic material of both fin-fish and shell-fish from different eco-systems;

(ii) assessment of salient genetic qualities, and preservation and cataloguing of the genotypes;

(iii) survey of the location of natural habitats and breeding areas of such known types and maintenance of relevant data;

(iv) compilation of information on the interaction of genotypes for all major groups;

(v) studies on the morphometric and karyotypic features of important varieties; and

(vi) recommendations on possible steps to conserve genetic resources of endangered species.

Since a large programme of both inland and marine aquaculture is being initiated it is essential that steps are taken to preserve the native genetic resources of all aquatic organisms. When the ecology of the pond is changed due to the introduction of high-yield technology, there will be new problems of fish diseases not so far faced. There is also urgent need for establishing several marine parks, fish sanctuaries or underwater gardens for preserving the habitats where great variability occurs in a wide range of aquatic fauna.

**All-India Co-ordinated Project on Economic Ornithology**

India, has nearly 13 per cent of the bird species occurring in the world. Knowledge on the economic aspects of birds, viz. beneficial and harmful effects on agriculture, is still fragmentary. It was therefore proposed to initiate an All-India Co-ordinated Programme on Economic Ornithology involving 8 different research centres. These centres will also assist in conserving useful birds.

**Strengthening quarantine arrangements**

With the expansion in the activities relating to plant collection and exchange through IBPGR and international research centres, it is essential that the complex problem of spread of pests and diseases through seed and other propagation material
is faced scientifically. There is need for strengthening both home quarantine arrangements as well as quarantine facilities for receiving material from abroad. In addition to establishing a Division of Plant Quarantine in the National Bureau of Plant Genetic Resources, it is also proposed to organize an All-India Co-ordinated Programme of Research in Seed Pathology.

In addition to strengthening the available facilities for plant quarantine, it is also essential to develop facilities for animal quarantine. For this purpose, an off-shore quarantine island may have to be developed. Such off-shore quarantine facilities could also help in introducing into India the European honeybee, coconut germplasm, etc.

The National Bureau of Plant Genetic Resources and the National Bureau of Soil Surveys and Land-Use Planning continued their programmes during the year, and the following were some of their achievements.

**STRENGTHENING OF PLANT GENETIC RESOURCES**

*Germplasm exchange*

About 75,000 seed and planting material of cereals, pseudocereals, millets, oilseeds, pulses, fruits and vegetables, forage crops, fibre- and sugar-yielding plants, medicinal and aromatic plants, ornamentals, tuber crops, narcotics, beverage crops and industrial crops were procured from foreign countries. There were 206 requests for seed from abroad. These were complied with, making available 10,686 accessions of seed under phytosanitary conditions.

*Exploration and collection*

The Bureau collected 2,200 samples of economic plants and their wild relatives from Maharashtra, Punjab, tribal areas of Madhya Pradesh, Gujarat, Goa, Tamil Nadu, and the cold arid regions of Lahaul and Spiti. Over 10,000 exotic and indigenous materials were made available to plant breeders for use in their programmes for genetic improvement of crops.

Through the Indo-Soviet Protocol germplasm of temperate fruits and nuts were collected from the Central Asian Republics of the Soviet Union.

Germplasm of winged bean and tropical fruits from Java were collected and added to the existing stock.
Additional jute collections

The Jute Agricultural Research Institute, Barrackpore, added 160 new stocks from the North-Eastern Region, Madhya Pradesh and Uttar Pradesh to its existing germplasm collections of 329. These new stocks comprised the members of both the cultivated jute species, viz. Corchorus capsularis and C. olitorius. These collection expeditions also indicated many unexplored rich pockets of genetic materials which need to be explored soon for enriching the jute genetic wealth of the country.

Plant quarantine

Of the 75,000 samples received for the quarantine processing in the National Bureau of Plant Genetic Resources, 70,339 samples were imported from different countries. A large number of pests and pathogens were intercepted. These included pests like Chlorops pumilionis, Carpophilus freemani, Alphitobius sp., Sitophilus granarius, a large number of bruchid and mite species, phycitid moths, etc. Wherever possible the infested samples were given suitable disinfestation and/or disinfection treatment before release to the actual users. Using X-ray radiography of 4,020 imported seed samples, infestation due to bruchids and seed-infesting chaleidoids was detected in 782 samples.

The risks involved in the import of coconut germplasm, both as nut as well as pollen, were investigated and the following suggestions made:

(i) nuts should be imported only in a dehusked state;
(ii) all imported nuts should be subjected to methyl bromide fumigation immediately on import; and
(iii) the imported nuts should be grown in individual containers for at least 3 months in isolation.

Characterization of germplasm

Rice bean: The entire germplasm of 308 indigenous cultivars and 95 exotics was evaluated, and superior genotypes having desirable characters identified.

Pea: The performance of Portuguese selection 'EC 33866' was excellent when multiplied and tested under farmers' conditions as well as in the demonstration plot of the Indian Agricultural Research Institute. The seed of 6 new wrinkled and smooth-seeded selections were given to the Project Co-ordinator for multi-location testing.
**Winged bean**: Germplasm collections of 52 accessions, both indigenous and exotics, were grown at New Delhi for evaluation and multiplication. Useful strains for green pods, seeds, tubers and green forage were identified for further testing.

**Clusterbean**: Selection of 'IC 9229/P3' was picked up for multiplication. It combined high grain yield with bacterial-blight resistance. It showed consistency in its yield potential by giving significantly higher yield than the controls 'Durgapura Safed' and 'Sona'. It was a branched-type main-season variety of 160-165 days duration. Its pods were 5.4 cm long, producing 9-10 seeds per pod; the 100 seed weight was 3.4 g.

While screening the clusterbean (guar) germplasm 'N.C.4/P2-1', a single-stemmed, all node-bearing selection, was picked up as a photoinsensitive type. It gave 10/12 q grain yield/ha during spring/summer and in rainy season in different years at Delhi and Jodhpur. Since it is photoinsensitive it could be grown in both the seasons. This variety can be recommended to the farmers for general cultivation.

**Cataloguing of germplasm**

In collaboration with the Information Sciences, Genetic Resources at Boulder, Colorado, USA, computer-aided programmes were developed for cataloguing, storage and retrieval of useful information in clusterbean.

**Soil Survey and Land-Use Planning**

**Soil Resources Inventory and Mapping**: The National Bureau of Soil Survey and Land-Use Planning completed the soil inventory and mapping of about 4.7 million hectares in the states of Punjab, Himachal Pradesh, Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Kerala, West Bengal and North-Eastern Region. The soil survey reports with soil maps and land-use plans were helpful in identifying problem and potential areas and furnishing the necessary information for planning and implementation of projects/experiments in the integrated rural development districts, hill and backward areas, Bundelkhand Region (Uttar Pradesh and Madhya Pradesh), agricultural university campuses, etc.

**Interpretation of soil maps for available soil moisture**

Studies to relate the soil units delineated on the map with available soil moisture, taking into consideration the precipitation patterns in the semi-arid region of Hissar (Haryana), made it
possible to recommend crops for rainfed agriculture in *kharif* (wet season) and irrigation needs in *rabi* (winter). A rational crop calendar for varying textural families is given below:

<table>
<thead>
<tr>
<th>Soil textural family</th>
<th>Available moisture CM in 10 cm profile</th>
<th>Rainfed</th>
<th>Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tohana (fine clay loam to clay)</td>
<td>21</td>
<td>Rice (<em>kharif</em>), wheat and gram (in <em>rabi</em>)</td>
<td>Rice (<em>kharif</em>), wheat (1 to 2 irrigations)</td>
</tr>
<tr>
<td>Hissar (fine loamy)</td>
<td>16</td>
<td>All climatically adopted <em>kharif</em> crops</td>
<td>Cotton (<em>kharif</em>), wheat (3 to 4 irrigations)</td>
</tr>
<tr>
<td>Jugloan and Talwandi (coarse loamy)</td>
<td>11</td>
<td>Pearl millet and <em>kharif</em> pulses</td>
<td>Cotton (<em>kharif</em>), wheat and gram (4 to 6 irrigations)</td>
</tr>
<tr>
<td>Thaska and Banra (pondy)</td>
<td>8</td>
<td>Dewgram (moth)</td>
<td>Wheat, gram and mustard (6 to 7 irrigations)</td>
</tr>
</tbody>
</table>

**Remote sensing**

LANDSAT imagery analysis for the present drainage system and buried channels in the deserts of western Rajasthan coupled with geomorphic studies and ground truth data revealed that the dry beds of the prior and present drainage channels are potential zones for ground-water exploitation.

**Rezoning of wheat regions**

Keeping in view the need for micro-level zoning of wheat varieties for fitting them into the 8 agro-ecological regions adopted by the Indian Council of Agricultural Research, the National Bureau made a detailed analysis of the existing wheat zones for rationalizing the same according to soil and agro-climatic parameters.

**Land irrigability evaluation**

Of the 0.182 million hectares surveyed in Kachcha (Bhuj), Rajkot and Surendranagar districts of Gujarat and classified under 33 soil series, 45 per cent of the land had moderate to severe limitations, 20 per cent were under the marginal class and the remaining 35 per cent were temporarily classified as unsuitable;
90 per cent of the limitation was due to soil characteristics/properties and 10 per cent due to drainage and topographic problems.

**Hydrological soil properties**

The hydrological properties of soils play an important role in the ground-water assessment. The intake rates of soils of Ahmednagar district in many parts of the irrigated area revealed that the subsoil was somewhat impermeable, thus restricting the movement of water. There was a build up of hydrostatic pressure in the confined strata. Excessive irrigation, ignoring the requirement of net irrigable depth for standing crops has resulted in the rise of ground-water table to the level of the hydrostatic head in the wells above the saturated aquifers. Provision of suitable outlets, introduction of intercepting drains, determination of irrigation frequency with respect to irrigable depths, etc., are recommended.

About 27 per cent of the samples of well-water indicated high to very high salinity with medium sodium hazards; only 3 per cent of the waters could be used for normal irrigation; pH was high (8.1) and sodium per cent was high when compared with other cations. Quality control of irrigation water and provision of drainage were stressed.
IV. RESEARCH ACCOMPLISHMENTS

1. CROPS—RICE

New high-yielding varieties

Based on the results of the trials conducted under the All-India Co-ordinated Rice Improvement Project, 'IET 2361', 'IET 3257' and 'IET 2815' were recommended to the Central Sub-committee on Release of Varieties. 'IET 4094', 'IET 2730' and 'IET 3231' were selected for minikit trials during 1979. In addition, a number of promising lines were identified for the different agroclimatic conditions of the country. They include 'IET 2683', 'IET 5850' in the early group, 'IET 4094' in medium-duration group, and 'IET 5656', 'IET 5854', 'IET 5897' and 'IET 5899' in the late group. The long slender-grained 'R 711-4', maturing in 115 days, would be released in Maharashtra. Other promising varieties identified for Maharashtra included 'VDN 416-34-3-17', 'VDN 8-11-39' and 'VDN 8-11-2-12'. 'Sona', with very good fine grain and milling and cooking qualities, was found to be suitable in Karnataka. 'TNAU 8870' ('Cul 2410'×'TR 22'), having high yield potential (5 tonnes/ha) and maturing in 100-105 days, was found promising in Tamil Nadu. The momentum towards stabilizing rice production had set in, and the country had the record harvest of 52 million tonnes in 1977-78—almost 25 per cent more than in the previous year.

Varieties for problematic areas

The major emphasis in rice research was on developing suitable varieties and production technology for different problem areas.

Varieties for rainfed uplands

'IET 1444' ('Rasi') and 'CR 143-22' gave very good performance, yielding 3.2 tonnes/ha in co-ordinated trials on uplands. 'CRM 13-3241', a mutant maturing in 70 days, with a yield of 2.5 to 3.0 tonnes/ha, seemed to have the potential of being incorporated into multiple-cropping systems. A promising culture, 'IET 2232', maturing in 105 days, was identified for eastern Uttar Pradesh. 'Sauvarnamodan' ('Ptb 42'), a selection from Assam collection, was released in Kerala. Among the released
varieties most suited for uplands were ‘Bala’ and ‘Cauvery’ for all India, and ‘Annapurna’ for Kerala and Orissa.

**Varieties for low-lying areas**

In co-ordinated trials, operational research project areas and in regional trials, ‘CR 210-1009’ and ‘CR 210-1011’, from a series of ‘Pankaj’×‘Jaganath’ crosses, showed a high yield potential of 4.5 tonnes/ha at 40-60 kg N under 30-40 cm of standing water. The International Workshop on Deep-Water Rice held during 17-18 August at Calcutta identified ‘Jalmagan’ and ‘Madhukar’ for Uttar Pradesh, ‘64-117’ for Bihar, and ‘Jaladhi 1’ and ‘Jaladhi 2’ for West Bengal for deep-water areas; and ‘Jalpalaban’ for West Bengal, ‘FR 13A’ and ‘FR 43B’ for Orissa, ‘Pla 4’ for Andhra Pradesh, ‘Ptb 15’ for Kerala, ‘Co 14’ for Tamil Nadu and ‘Madhukar’ and ‘Chakia 59’ for Uttar Pradesh for intermittently flood-prone areas. ‘IET 3257’ was identified as tolerant to submergence of one week and was recommended for release in parts of West Bengal, Bihar and Orissa.

**Varieties resistant to pests and diseases**

‘IET 2815’, possessing tolerance to stem-borer and green leafhopper and resistance to blast and tungro virus, was recommended for release. Some of the new lines having resistance to diseases and insect pests have been identified. ‘CR 189-62-15’, ‘CR 199-1’, ‘CR 402-15’ and ‘CR 402-17’ were resistant to gall-midge, blast, green planthopper and tungro virus, while ‘CR 95-952-1’ and ‘CR 95-11-2-6-1’ were resistant to gall-midge, green leafhopper and blast. Six lines of Assam Rice Collection (‘ARC 13536’, ‘ARC 13530’, ‘ARC 13909’, ‘ARC 13872’, ‘ARC 13506’ and ‘ARC 13556’) were found to be resistant to brown planthopper. ‘Vikram’ was resistant to gall-midge in Karnataka and Maharashtra, and ‘TNAU A 8027’ to brown planthopper in Tamil Nadu.

**Multiple cropping**

Rice-wheat rotation is becoming increasingly popular in Punjab, Haryana and West Bengal. With the development of short-duration varieties of rice like ‘CRM 13-3241’, maturing in 70 days, it has become possible to take two crops of rice during kharif and one of wheat during rabi in Orissa at Sakhigopal.

When the first crop of ‘CRM 13-3241’ was drilled on 18 June and harvested on 28 August and the second crop of ‘Tainan 3 Mutant’ was planted on 3 September and harvested in the third week of November, about 7 tonnes of paddy could be obtained and there was enough time for wheat cultivation, afterwards.
Technology for high yields on uplands

Sowing of 'Annapurna' in lines 20 cm apart at a seed rate of 50 kg/ha, spraying of propanil 14 days after sowing at the rate of 2.5 kg ai/ha to control grassy weeds (mostly *Echinochloa colonum*) and application of 40 kg N/ha in 3 splits (20 kg N/ha after weeding, 10 kg N/ha when the crop was 40 days old, and 10 kg N/ha at booting) gave substantial yield of 4 tonnes/ha at Sakhigopal in the coastal Puri district of Orissa.

N management in wetlands

Field experiments indicated that 30 kg N/ha applied as 5 tonnes of compost to the wet soil either a week before or at puddling, followed by 30 kg N applied as chemical fertilizer at puddling, gave grain yield on a par with the yield obtained with the best split application of 60 kg N/ha. This dispensed with post-planting application of N, not practicable on rainfed wetlands.

At the Central Rice Research Institute, *Azolla* could be cultivated in the field throughout the year. Inoculation of transplanted rice fields with small amounts of *Azolla* was found to meet the N requirements of rice at later growth stages.

Plant protection

In the trials during the *rabi* season on chemical control of insect pests, dipping the roots of seedling in 0.02 per cent Dursban, followed by Ekalux spray at 30 DAT and Carbofuran granules at 55 DAT, was found to be the best combination. It increased the yield by 1.8 tonnes. In another experiment, sheath-blight could be effectively controlled with Bavistin.

Investigations on the biological control of insect pests showed that the average egg consumption by predator mirid-bug was 2.8, 5.0, 2.2 and 1.6 eggs of brown planthopper, white-backed planthopper, gall-midge and hispa, respectively, indicating that the predator preferred the eggs of the white-backed planthopper.

Germplasm resources

The national germplasm bank located at the Central Rice Research Institute has nearly 15,000 accessions. Areas where gene erosion is rapidly taking place were identified, and a co-ordinated collection programme was launched for systematic collection
and evaluation of germplasm. The national gene bank was enriched with 65 more local cultivars, including 15 typical lowland types, collected from Orissa during the kharif of 1977 and 1978.

**Trisomic lines in indica rice**

On morphological and cytological bases, 12 primary trisomics were identified in an *indica* rice cultivar ‘Sona’. Localization of genes belonging to different linkage groups on specific chromosomes has been taken up and so far the gene for awning (*An*) was located on chromosome 2 and the gene for purple pericarp (*Prp*) was assigned to chromosome 7.

**Inheritance of blast resistance**

Studies on the inheritance of resistance to blast indicated that resistance in ‘Tetep’, ‘Tadukan’ and ‘Zenith’ was governed by 3 pairs of dominant genes. Of them any 2 would confer resistance in these varieties in crosses with susceptible varieties, ‘Karuna’, ‘Krishna’ and ‘Co 13’. In a cross between resistant ‘Pankaj’ and ‘Taichung (Native) 1’, the involvement of 2 pairs of dominant duplicate genes conferring resistance to the cultivars was indicated, the genes being located on different loci.

**Physiology**

The physiological changes in plants affected with bacterial (BLB) and viral (tungro) diseases showed that the phenol metabolism and certain growth-regulators like cytokinins and absisic acid played an important role in susceptibility.

At 0 N level ‘Rasi’ absorbed more N from the soil than ‘Tella Hamsa’; but at 60 kg N ‘Tella Hamsa’ was marginally superior. Likewise, at 0 N level ‘Mahsuri’ was marginally superior to ‘RPW 6-17’, whereas at 60 kg N the reverse was true.

‘IET 2683’, ‘IET 4097’ and ‘IET 4106’ were found to have good drought sustenance. ‘FH 575’, ‘RPA 5824’, ‘FH 171’, ‘IET 4097’ and ‘IET 4106’ had recovered from drought very fast, within one day. Nearly 65 per cent of the evapotranspiration losses were found to occur during the day—the peak being from 2 to 4 p.m.—while the rest occurred during the night.

The crop directly seeded on puddled soil gave as much yield as the transplanted crop, and occasionally even more. Its growth efficiency was also superior.
Operational Research Projects

A substantial reduction in the use of insecticides for the control of rice gall-midge and stem-borer was achieved in the integrated pest control project area through advance forecasting of the extent of infestation based on meteorological conditions. Brown planthopper was kept under check by constant surveillance and timely application of insecticides over infested pockets. The coverage with high-yielding varieties during the kharif was increased to 80 per cent in uplands and 46 per cent in medium lands, from 12 per cent before the initiation of the project. ‘CR 1009’, a new selection, was found to be good for moderate depth of water (30 to 50 cm). It yielded 4.0 to 4.5 tonnes/ha as against 2.0 to 3.5 tonnes/ha by the local varieties. It also tolerated complete submergence for 7 to 10 days at the vegetative stage in flood-prone areas under the project.

Efficient water management was achieved over the command area by laying out prefabricated cement field channels. It increased the area under irrigation by 30 to 200 per cent. The cost of water-management works came to Rs. 76/ha on the basis of the area benefited.

Composite fish culture was found to be highly remunerative and became popular with the farmers as a subsidiary occupation in Orissa. It gave good economic return with moderate investment in a short period of 2 to 6 months.

BARLEY

New high-yielding varieties

Six improved barley varieties were identified by the last All-India Barley Research Workshop for cultivation under different agroclimatic conditions in the country.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Area for which recommended</th>
<th>Conditions for which recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>'DL 158'</td>
<td>North-Western Plains</td>
<td>Rainfed, irrigated, timely sown</td>
</tr>
<tr>
<td>'DL 120'</td>
<td>Do.</td>
<td>Do.</td>
</tr>
<tr>
<td>'DL 171'</td>
<td>Do.</td>
<td>Do.</td>
</tr>
<tr>
<td>'DL 36'</td>
<td>North-Eastern Plains</td>
<td>Irrigated, late-sown</td>
</tr>
<tr>
<td>'DL 88'</td>
<td>Do.</td>
<td>Do.</td>
</tr>
<tr>
<td>'DL 100'</td>
<td>Central Plains</td>
<td>Rainfed</td>
</tr>
</tbody>
</table>
Based on the results of the All-India Co-ordinated Trials, the Workshop also recommended ‘Ratna’, ‘Jyoti’ and ‘K 125’ for rainfed late-sown regions; ‘Ratna’ and ‘Jyoti’ for saline-alkaline soils; ‘K 125’ and ‘K 141’ for diara lands; and ‘K 247’ in rice fallows, particularly in Orissa. These barley varieties also out-yielded the high-yielding varieties of rainfed late-sown wheat on diara lands and on saline-alkaline soils, indicating barley to be better suited and more profitable than wheat when grown under stress. ‘Bilafa 2’, developed in Rajasthan, was found to be tolerant to salinity, capable of giving 20 q/ha at a salinity level of 16 mmhos/cm.

MAIZE

New composites

Based on the results of co-ordinated trials, 3 medium-duration composites ‘Mansar’ (‘Super 1’), ‘Trikuta’ (‘C 5’) and ‘Nishat’ (‘C 7’) were recommended for Jammu and Kashmir. They gave more yield than ‘C 2’, the composite under cultivation. The early-maturing ‘Tarun’ (‘Syn P 200’×‘Kisan’), resistant to most foliar diseases, was recommended for cultivation in Uttar Pradesh. ‘Manjari’ and ‘Hunis’ were found to be suitable in Maharashtra. ‘Manjari’ gave 16 per cent more yield and matured 15 days earlier than ‘Vijay’. ‘Hunis’ gave 59 per cent more yield than the locals. ‘Diara’ was found to be suitable to the riverine areas of Bihar. When planted by end of April or early May, ‘Diara’ could be harvested before the floods, which generally come in August.

New hybrids

White hybrid ‘VL 43’ did well in the hill regions of Uttar Pradesh and Himachal Pradesh and yellow hybrid ‘EH 2380’ in the Himalayan belt and in Uttar Pradesh and Bihar.

Promising material for rabi cultivation

Since rabi cultivation is becoming popular in Bihar and Uttar Pradesh, a systematic testing programme was organized during the past 3 years. Hybrids ‘EH 400175’ and ‘EH 400475’ and composite ‘VC 80×(‘Eto’×‘Tu’×‘Br 2’) gave 15 per cent more yield than the locals and were resistant to foliar diseases. Among the released hybrids, ‘Deccan 101’, ‘Hi-starch’ and ‘Ganga 5’ performed well.
**Intercropping**

Research showed that blackgram and groundnut could be intercropped without reducing the yield of maize.

**Aflatoxin production**

‘Ganga 5’ and ‘Shakti Opaque 2’ produced the least quantity of aflatoxin B1. Aflatoxin production was minimum in grains stored at below 15°C and below 75 per cent relative humidity. The removal of husk and a proper drying of ears before storage was found desirable.

**WHEAT**

The upward growth trend in wheat yield was maintained during 1977-78, when the production was 31.32 million tonnes as against 29.04 million tonnes in 1976-77. This increase was the result of incessant research efforts to produce high-yielding disease-resistant varieties and formulate an improved production technology under the All-India Co-ordinated Wheat Improvement Project.

**New high-yielding varieties**

The following high-yielding varieties suitable for different agro-climatic regions of the country were identified.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Area for which recommended</th>
<th>Conditions for which recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>'HW 135'</td>
<td>North-Eastern Plains Zone.</td>
<td>Late sown, irrigated, good fertility</td>
</tr>
<tr>
<td>'HP 1303'</td>
<td>Do.</td>
<td>Timely sown, irrigated, good fertility</td>
</tr>
<tr>
<td>'HD 2236'</td>
<td>Central Zone</td>
<td>Do.</td>
</tr>
<tr>
<td>'LOK 1'</td>
<td>Do.</td>
<td>Do.</td>
</tr>
<tr>
<td>'HW 517'</td>
<td>Peninsular Zone</td>
<td>Timely sown, irrigated</td>
</tr>
</tbody>
</table>

‘Ajanta’ (‘BDW 519’), maturing in 90-95 days and yielding about 15 q/ha, was identified for Maharashtra. ‘Raj 1418’, suited to Rajasthani, was found to be tolerant to root nematode (*Heterodera avenae*) and resistant to rust. ‘CC 464’ and ‘HD 2189’ were resistant to most of the rust races existing in Maharashtra, where they were found suitable for cultivation on highly fertile irrigated soils.

16 M of A&I/78-3
Multiline varieties

The multiline approach in wheat helped in identifying ‘MLKS 11’, ‘KSML 3’, and ‘KML 7408’, which resembled ‘Kalyan Sona’ in morphological and economic characters but possessed a high degree of resistance to different races of rusts. This programme will help reduce the build-up of new races. Areas where the rust inoculum gets built up early were planned to be saturated with resistant lines. The Nilgiri and Palni Hills of Tamil Nadu often act as the foci of infection for black rust and also partly for brown rust. A new variety, ‘HW 517’, resistant to all the races of rusts, was identified for southern hills and was released for adaptive trials and large-scale seed multiplication during the rabi of 1978. Its cultivation would cut down the initial rust inoculum that comes to the states in peninsular and central India.

Weed control

Wild oats and Phalaris minor became problematic weeds in wheat-growing areas. The results of trials conducted for several years showed that application of tribunil @ 1.0 kg to 1.5 kg ai/ha 30 to 40 days after sowing helped in effective control of Phalaris minor. Dosane @ 1.25 kg to 1.5 kg ai/ha was observed to be equally effective for the control of both Phalaris minor and wild oats. Dosanex and Exp. 3002 herbicides showed promise for controlling grassy weeds.

Plant protection

Spraying with 0.4 per cent Bavistin or 0.28 per cent Cuman L was effective against black rust and increased the yield by 9 per cent, whereas 0.37 per cent Zinab increased the yield to the extent of 16 per cent. The ‘molya’ disease, caused by Heteroderma avenae, became a problem in Rajasthan. Application of DBCP @ 30 litres/ha with irrigated water 15 days before sowing increased the yield by 95 to 100 per cent over the control and reduced the population of nematodes by 80 per cent. The flag smut, loose smut and the stinking smut could be very effectively controlled with vitavax. Bavistin was effective against loose smut. Agrosan GN and copper carbonate were effective against the stinking smut. Dithane Z/75 and Dithane M-45 could control black rust when 4-6 sprays were given to the wheat crop.

Sowing time

The optimum time for sowing wheat was found to be the first fortnight of November for long-duration varieties and the second
fortnight of November for short-duration varieties in the northwestern plains, and the first fortnight of November in the remaining zones of the country except in Karnataka.

National Genetic Stock Nursery

This nursery comprises the best stocks from the viewpoint of resistance to diseases, good grain type, straw strength, tillering capacity, and quality characters for making chapatis, bread, biscuits and other confectionery items. About 5,000 wheat varieties collected from different international and national programmes have been screened and new ones are continuously added and supplied every year to 30 centres in the country. This nursery was also supplied to Nepal, Bhutan and Afghanistan. This material is serving as a crossing-block for breeding.

Pathology

Pathologists constantly surveyed the virulence of rusts prevalent in the wheat-growing area of the country to know the shift in the pathogenic population. Races 21, 42, 40, 117, 34 of black rust, races 77, 162, 104 and 12 and their biotypes of brown rust, and races 14, 20 and 38 and their biotypes of yellow rust were found to be most widely distributed in the country. Virulent races like 11, 14, 15C, 122 and 295 of black rust and race 1 of yellow rust would make many a wheat variety susceptible.

Quality

Varieties from the Initial Evaluation Trials were tested for protein and chapati-making quality at the Punjab Agricultural University, Ludhiana, and those from the Uniform Regional Trials were tested for all characters at the quality laboratory of the Indian Agricultural Research Institute, New Delhi. At Ludhiana the range of protein in the varieties was found to vary from 9.97 to 15.37 per cent. Several varieties having good chapati-making properties were identified.

Promising strains of triticales were studied for milling, baking, rheological characteristics and nutritional quality. Quality tests were conducted on macaroni wheats at the Central Food Technological Research Institute, Mysore.

Screening for drought

A National Drought-Screening Nursery was organized for the first time in the wheat project. The nursery comprised 89 strains of *Triticum aestivum*, 14 strains of *T. durum*, 9 strains
of triticale and 6 of barley. Nurseries were raised at 28 locations in the country with the following objectives:

1. To screen wheat varieties to drought under different agroclimatic conditions.
2. To develop suitable concepts, indices and strategies to guide selection procedure.
3. To have a germplasm bank of genotypes for drought.
4. To use the best selected genotype in future breeding programme.

**SORGHUM**

*New hybrids and varieties*

Based on the results of co-ordinated trials, 'CSH 7R', 'CSH 8R' and 'SPV 86' were identified for *rabi* cultivation. 'CSH 8R' and 'SPV 86' performed better than 'M 35-1' in Maharashtra. A high-yielding *Sriga*-resistant 'Moti' was released in Andhra Pradesh.

For *kharif* cultivation, 2 recommended hybrids, 'CSH 5' and 'CSH 6', combining high yield with superior grain quality, became popular. They proved to be good in Senegal, Upper Volta, Ethiopia, Pakistan and Philippines also. 'CSH 6' did exceptionally well in African countries characterized by erratic and low rainfall and seemed to have the potential to be a hybrid for all the semi-arid situations across continents. 'SPH 61' performed well in Maharashtra and was recommended for pre-release multiplication.

'SB 1066' and 'SB 1067' were developed in Karnataka, and 'Maldandi' in Maharashtra.

*New technology*

The new production technology for *rabi* cultivation included advanced dates of sowing, basal application of fertilizer @ 40 kg N/ha and 40 kg P₂O₅/ha, full seed rate of 10-12 kg/ha and carbofuran seed treatment. For *kharif* cultivation early planting with the onset of monsoon to avoid shootfly problem, plant population of 180,600 to 200,000 plants/ha, and application of 40 kg N and 40 kg P₂O₅/ha, were recommended.

*Multiple and mixed cropping*

The cultivation of safflower or chickpea after the harvest of sorghum hybrids 'CSH 5' and 'CSH 6' in years of normal rainfall
proved to be economic in the black-soil areas stretching from southern Rajasthan through western Madhya Pradesh, parts of the Vidarbha region in Maharashtra, and parts of Andhra Pradesh and Karnataka. Intercropping with greengram, pigeonpea, cowpea and groundnut gave 20 per cent additional returns and improved the soil fertility.

PEARLMILLET (BAJRA)

New hybrids

Hybrids ‘CM 46’, ‘BM 46’, ‘PHB 47’, ‘MBH 110’ and ‘GHB 27’, based on diverse male-sterile lines and restorers, were identified during the kharif of 1977. ‘CM 46’ and ‘MBH 110’ showed resistance to downy-mildew (less than 10% during successive years). They gave on an average over 20 q/ha during the last 2 years of testing. Another hybrid, ‘HS 1’, released in Haryana, also possessed resistance to downy-mildew. ‘BJ 104’ and ‘BK 560’ showed resistance to downy-mildew in Maharashtra.

During 1977 the grain yields of the hybrids ranged from 16.2 to 24.5 q/ha, while those of the populations ranged from 10.4 to 16.3 q/ha. The highest-yielding population could thus touch the base of the lowest-yielding hybrid, indicating the need to intensify improvement of the populations. The best populations were ‘WC-C 75’ and ‘DC 3’, but the former had better resistance to downy-mildew. ‘CN 74’, a composite, appeared to be promising in Maharashtra and was tolerant to downy-mildew.

Diversification of cytoplasmic sources

Among the 3 sources of male-sterility, CMS lines with A\textsuperscript{s} cytoplasm showed only 1.3% susceptibility to downy-mildew, compared with more than 21% in lines based on A\textsubscript{1} and A\textsubscript{3}. A\textsubscript{s}-based lines could not be directly used as they were very tall and late. Intensive efforts were, therefore, made to develop early, short-statured and disease-resistant CMS lines.

Germplasm collection

Over 365 land races of pearlmillet were collected from Rajasthan in co-operation with the International Crops Research Institute for the Semi-Arid Tropics, 60 from Maharashtra, some from Gujarat, 142 from Gwalior and 1,109 strains from Auranagabad.
Integrated production technology

When 40 kg N/ha and 1 kg ai/ha of atrazine were applied pre-emergence, the yield of pearl millet was 2 to 3 times that obtained without fertilizer and weedicide.

Intercropping

Intercropping of paired rows of pearl millet (30/70 cm) with 2 rows of greengram increased total production besides providing additional income and supplementary legume food. Pearl millet-greengram system gave 3 to 6 q/ha greengram as a bonus without any loss in millet yield.

Seed-dressing for downy-mildew control

CGA 1-82-50, found effective against infection and spread of downy-mildew at the University of Mysore, was registered as RIDOMIL 25 WP. In an experiment conducted at Hissar, treated ‘HB 3’ registered 1.4% downy-mildew plants against 62.5 percent in the control, indicating the effectiveness of fungicide seed-dressing in eliminating the seed-borne or soil-borne infection even in the most susceptible host. Large-scale trials on soils having diverse textures and pH were planned. Combined with varietal resistance, seed-dressing might confer near-immunity to pearl millet against downy-mildew.

Transplanting

It was demonstrated that transplanting of 2 to 3-week-old seedlings of pearl millet would be feasible, that it would compensate for plant loss, that culling and transplanting of healthy seedlings would reduce disease infection and that it would enhance yield.

Transplanting was found to check rapid yield decline due to direct seeding, particularly in the late-sown crop. Timely direct sowing, however, gave more grain yield than delayed transplanting.

Ergot

Research has shown that a provision of pollen at the right time in abundance could hinder or eliminate ergot infection and that a reduction of the time-lag between protogyne and anthesis might reduce ergot infection.

Natural incidence of ergot was observed on Cenchrus ciliaris at Durgapura and Jodhpur, and on Panicum antidotale at Hissar.
Cross-inoculation studies with *Pennisetum typhoides* and *Panicum antidotale* honey-dew produced characteristic ergot symptoms on both the hosts.

**Tissue culture**

At the Downy-Mildew Laboratory, Mysore, diseased and healthy pearl millet tissues were cultured on media and helped to grow, differentiate and develop. The isolation of healthy from diseased tissue would hasten the breeding efforts for developing genetically pure and disease-free strains. Such studies need to be extended to other diseases of millets, particularly to ergot and smut, where sources of resistance were well-nigh identified.

**FINGERMILLET (RAGI)**

**New varieties**

All the 11 African germplasm entries were free from viruses. ‘JNR 852’ in the mid-late trial yielded more than the check, ‘PR 202’ (20 q/ha). None of the entries in early and late group gave more yield than ‘PR 202’, though ‘PES 176’, ‘TNAU 9’, ‘JNR 1008’ and ‘EC 4847’ in the early group gave more than 20 q/ha. ‘PR 722’ (25.4 q/ha) in the late group yielded nearly as much as ‘PR 202’ (25.8 q/ha).

**Virus resistance**

All the 11 African germplasm entries were free from viruses in the field, particularly from mottle-streak virus. ‘IE 906’, ‘HR 47-8A’, ‘MS 2623’, ‘MS 2778’ and ‘AK 2’ were free from streak virus, while ‘TNAU 30’, ‘TNAU 31’, ‘TNAU 35’ and ‘Ak 1’ were resistant to mottle-streak virus.

**Production practices**

Early sowing of fingermillet at 22.5 cm × 7 cm yielded more grain. Direct seeding and transplanting gave similar yields in early sowings, but transplanting proved superior to direct seeding when sowing was delayed. When 40 kg N/ha was combined with 20 kg of *Azotobacter*, the grain yield was 75 per cent more than in the control (8 q/ha) at Bangalore.

**Disease management**

Varieties planted during the third week of June were least susceptible to blast neck and finger infections, besides being free from downy-mildew. Late-planted fingermillet had more of foot-rot, streak and mottle-streak viruses.
MINOR MILLETS

New varieties

The performance of Setaria entries ‘ISE 119’ and ‘ISE 480’, Paspalum entries ‘IPS 147-1’, ‘JNK 364’ and ‘Keharpur’, and Echinochloa ‘K 1’ was commendable. The average grain yield during the last 2 years of testing was more than 13 q/ha.

Varieties of Panicum had a low potential of 6.5 to 9.5 q/ha, indicating the need for intensifying breeding. P. miliare ‘IPM 410’ and P. miliaceum ‘PV 346’ and ‘MS 4806/2’ were promising.

Paspalum ‘IPS 147-1’ and P. miliare ‘IPM 410’ performed exceedingly well during the last 2 years and were hence proposed for release.

Production practices

Setaria gave high yield when planted at 22.5 cm × 7 cm till the last week of July. Delayed planting and higher or lower population significantly reduced yields. The response of Setaria up to 60 kg N and 20 kg P:O₃/ha was encouraging.

Early-planted Paspalum gave higher yield than the late-planted crop. Paspalum also responded well to fertilization up to 60 kg N and 20 kg P:O₃/ha.

POTATO

‘Kufri Lauvkar’ and ‘Kufri Dewa’ varieties were released, and ‘Kufri Navteja’ and a number of genotypes were identified for release. ‘SLB/D-192’ established its merit in the Srinagar Valley. Some of the promising cultures were ‘E 3797’ and ‘BS/C-1753’ for areas having mild winter in Uttar Pradesh, ‘G 697’, ‘SLB/Z-569’, ‘JF 4870’, ‘JE 802’ for the different agroclimatic regions in the plains, and ‘SLB-Z 864-13’, ‘SLB/2-886-27’ and ‘SLB/F-3-44’ for the Nilgiri Hills. ‘C 697’ and ‘SLB/D-192’ were found to have a good export potential.

‘JF 4870’, ‘JF 303’, ‘JF 4841’ and ‘EM/H-1602’ were selected for their wide adaptability in the varied ecological conditions in the Indo-Gangetic plains and the plateau region. ‘JF 4870’, which proved to be the best for yield and other economic characters, was recommended by the workshop held in November 1978 at Jullundur for release as a commercial culture under the name ‘Kufri Badshah’ in Punjab, Haryana, Uttar Pradesh, Bihar,
Bengal, Orissa and the plateau region of Maharashtra. Apart from having field resistance to late-blight and showing a slow rate of degeneration, it consistently outyielded the commercial ‘Kufri Chandramukhi’ and ‘Kufri Sindhuri’ for the last 5 years. ‘Kufri Badshah’ has round-oval, slightly flattened tubers with shallow eyes and pale-yellow flesh and is suitable for early and main cropping.

Hybrids ‘JF 4870’, ‘E 1486’, ‘F 6787’ and ‘JE 808’ performed well at the Haryana Agricultural University, Haryana.

Storage studies

Treatment of ware potatoes with CIPC (chloropham) @ 2-3 g/bag could inhibit sprouting and check weight losses during long storage in improved warehouses.

Control of diseases and pests

Dithane M-45 and Difolatan proved good for the control of both early and late blights. The incidence of black scurf was effectively reduced by treatment with 0.5 per cent Agallol and Brassicol.

Soil treatment with Brassicol @ 30 kg/ha or Captain @ 13.6 kg/ha and tuber treatment with RH 3928 reduced the powdery-scab infection and increased yield. Treatment of tubers with 500 ppm of G3 was found to be most effective in controlling brown-rot infection. Surveillance studies carried out during the past years showed that, contrary to popular belief, in Punjab aphids appear earlier in the first week of December, unlike at Pantnagar, Kanpur, Farrukhabad, Kalyani, Rajguru Nagar and Chhindwara, where they appear in the fourth week of December. Hence precautionary sprays with aphicides should be started early in Punjab when potato is grown for seed.

Tamik and Phorate were efficient not only for controlling aphids but against a wide spectrum of insect pests like cutworms and white-grubs. Aldrin gave best results in controlling cutworm damage. Kelthane and Tranid proved to be the best miticides.

Basalin (Fluchrolin) was found to be a very effective weedicide at the Haryana Agricultural University, Hissar.

Potato was raised very successfully on usar soil at the Daleep Nagar farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. On an average, it yielded
300 q/ha. The cost of cultivation was Rs. 12,120 with total income of Rs. 24,000 and net income of Rs. 11,880 per hectare.

PULSES

There was stagnation in the production of pulses over several years because their cultivation had become less remunerative than that of other crops. In view of the importance given to pulses during the last 2 years, the trend had been contained and a momentum in increasing production of pulses had been gained. Last year several high-yielding disease-resistant varieties were evolved and management practices developed which would help accelerate the production of pulses.

New varieties

The All-India Pulses Research Workshop recommended for release a number of varieties for different agroclimatic conditions in the country.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Areas for which recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickpea</td>
<td>'BG 203'</td>
<td>North Plains West Zone and North Plains East Zone</td>
</tr>
<tr>
<td>Chickpea</td>
<td>'K 468'</td>
<td>North Plains East Zone</td>
</tr>
<tr>
<td>Lentil</td>
<td>'Pant 406'</td>
<td>North Plains West Zone</td>
</tr>
<tr>
<td></td>
<td>'Pant 209'</td>
<td></td>
</tr>
<tr>
<td>Khesari</td>
<td>'LSD 6', 'LSD 3' (low neurotoxin 0.2 to 0.3% BOAA)</td>
<td>Eastern and Southern Zone</td>
</tr>
<tr>
<td>Pea</td>
<td>'L 106'</td>
<td>North Plains East Zone and North Plains West Zone</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>'BDN 1'</td>
<td>Bihar</td>
</tr>
<tr>
<td>Blackgram</td>
<td>'Pant U 19', 'U 20', 'UG 1152'</td>
<td>North-West Zone</td>
</tr>
<tr>
<td>Greengram</td>
<td>'ML 12', 'KL 26'</td>
<td>North Plains West Zone, North Plains East Zone and Central Zone</td>
</tr>
<tr>
<td>Horsegram</td>
<td>'Hebbal'</td>
<td>Karnataka</td>
</tr>
<tr>
<td></td>
<td>'Hurali 1'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>'Hurali 2'</td>
<td></td>
</tr>
</tbody>
</table>

'K 851' greengram in Maharashtra and 'Co 4' blackgram in Tamil Nadu showed promise.
Breeding for disease resistance

Since diseases have been serious causes for the low productivity of pulses, several sources of genetic resistance were identified for use in breeding for resistance.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
<th>Diseases to which resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickpea</td>
<td>'JG 1'</td>
<td>Collar-rot</td>
</tr>
<tr>
<td>Chickpea</td>
<td>'RS 2', 'RC 212', 'L 4485', 'P 79', 'JG 74', 'GW 4', 'CW 14', 'T 13' and 'G 53'</td>
<td>Blight, stem-rot</td>
</tr>
<tr>
<td>Lentil</td>
<td>'JG 1'</td>
<td>Collar-rot</td>
</tr>
<tr>
<td></td>
<td>'P 79', 'JG 74', 'GW 4', 'CW 14', 'T 13' and 'G 53'</td>
<td>Blight, stem-rot</td>
</tr>
<tr>
<td>Pea</td>
<td>'L 185', 'L 6857', 'P 388'</td>
<td>Wilt</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>'Pant B 75', 'ICRISAT 3783'</td>
<td>Wilt and rust</td>
</tr>
<tr>
<td>Blackgram</td>
<td>'4-5-2'</td>
<td>Powdery-mildew</td>
</tr>
<tr>
<td>Greengram</td>
<td>'12-4', '4-34' and '15227'</td>
<td>Yellow-mosaic virus</td>
</tr>
</tbody>
</table>

Disease control

Research on the chemical control of the disease resulted in the development of effective control schedules for Cercospora leaf-spot of greengram with sprays of Bavistin and for powdery-mildew of pea, greengram and blackgram with sprays of wettable sulphur. Systemic insecticides like disulfoton, phorate and aldicarb applied in granular form at sowing time proved very effective against the major pests of kharif and rabi pulses. Endosulfan and monocrotophos sprays were effective in controlling pod-borer damage in pigeonpea and chickpea. At the Haryana Agricultural University, seed treatment with mineral oil E 9267 of Indian origin was found to be very effective in controlling the root-rot of greengram.

Rhizobial inoculation

Several efficient Rhizobium cultures were isolated, and it was demonstrated that rhizobial inoculation gave the same response as obtained from mineral nitrogen at a fraction of the cost.

Multiple cropping

New crop sequences involving pulses were developed and shown to be profitable. Experiments carried out over the last
4 years have demonstrated that pigeonpea, blackgram and green-
gram could be successfully grown in early September after a kharif
crop of maize in Bihar on rainfed lands. The variety of pigeon-
pea found suitable for such summer sowings is the medium-late
'Bahar'. With the availability of short-duration varieties, pigeonpea
can now be grown in a new cropping sequence as a 90-day
summer crop (from the first week of April to the first week of
July) to be followed by maize or rice. Cowpea-niger rotation
was found to be more remunerative than a single crop of niger
in the tribal areas of Orissa and Madhya Pradesh.

SOYBEAN

Nearly 200,000 hectares were covered by soybean during the
kharif of 1978-79, and the major contribution was from Madhya
Pradesh.

An early-maturing 'UPSM 19', which yields as much as
'Bragg' and has field tolerance to insect pests and diseases, was
recommended for cultivation in the Northern Hills Zone. 'Ankur'
was recommended for cultivation in the Kalimpong hill areas of
West Bengal. 'PK 71-21' ('Alankar'), which has resistance to
yellow-mosaic, better germination, and good yield potential, was
released for cultivation in Uttar Pradesh. 'JS 2' and 'UPSM 19'
were recommended for the lateritic zones of Purulia, Bankura,
Midnapur and parts of Birbhum of West Bengal. 'Hardee 8-3'
('Improved Pelican') continued to do well in the southern region.

'PK 73-135', 'PK 74-289', 'PK 74-264', 'JS 4' and 'PK 74-
296' showed promise in the Northern Hills Zone. In the plains,
'PK 73-86' and 'PK 73-92' proved to be much superior to the
existing varieties, 'Bragg', 'Ankur' and 'Alankar'. They yielded
25 to 30 per cent more, were tolerant to yellow-mosaic and re-
sistant to rust and other foliar diseases. 'PK 73-92' and 'JS 72-
44' were recommended for pre-release trials in farmers’ fields in
the central region.

For obtaining maximum production, the most suitable date
of planting soybean was found to be between 25 June and 10 July
in northern and central plains. In the eastern plain, planting on
15 July gave the highest yield, though plantings beyond 10 July
may not be possible because of frequent rains.

A significant response to phosphorus was observed in the
hills and the central plains, but not in the tarai region of Uttar
Pradesh. There was a slight response to potash at Jorhat. In poor soils 20 N, 60 P and 40 K along with inoculation with bacterial culture gave the best results.

Soybean intercropped with maize, pigeonpea, sesame and cotton gave higher economic returns than the pure crops. Two rows of soybean between two double-spaced rows of maize, pigeonpea, cotton and sesame gave the best results. These observations were confirmed at Pantnagar, Delhi, Jabalpur and Parbhani.

Experiments conclusively proved that soybean plots must be kept weed-free up to 30 days after planting for maximum yield. Where hand-weeding is expensive or not possible because of frequent rains, pre-emergence application of Lasso \( @ \) 2 kg ai/ha would be effective for controlling weeds. Sencor, a new weedicide, proved even better than Lasso.

Seed treatment with 0.2 to 0.4 \% Thiram not only checked seed and soil-borne diseases like seedling rot but also improved plant stand without affecting nodulation. Soil application of Thimet \( @ \) 10 kg/ha was effective for checking the attack of white-flies and pea stem-flies. The attack by defoliator Bihar hairy caterpillar was controlled by 0.1 \% spray of Thiodan or Ekalux. A combined spray of Thiodan and Metasystox \( @ \) 0.1 \% each minimized the spread of yellow-mosaic.

The Soya Production and Research Association had reportedly marketed through the Education Department more than 1,000 tonnes of the soya product 'Nutrinuggets' (50 \% protein) to meet the demand of school children. About 215 tonnes of soya panjerei (high-protein low-cost food) was supplied \( @ \) Rs. 2.85/kg. To popularize the use of soya foods, 82 news articles, 27 radio talks, and 5 technical newsletters were issued by the Soya Production and Research Association. The Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani, published a bulletin, 'Soybean for Health', containing useful information. Home-science specialists are engaged in soybean utilization in common protein-rich foods and their popularization in the country.

**OILSEEDS**

**Groundnut**

A massive hybridization programme was launched, and at 12 centres 121 fresh crosses were made, mostly involving parents from the subspecies hypogaea and fastigiata. Crosses in-
volving *Arachis hypogaea* and *A. monticala* were made to induce drought tolerance and increase the number of mature pods per plant.

‘Ah 114’ from Karidi, ‘M 13’ from Ludhiana and ‘T 64’ from Uttar Pradesh proved to be superior yielders. ‘Ah 114’ and ‘M 13’ were found to be moderately resistant to the tikka disease at Rajendranagar.

In the Spanish group ‘SM 1’ (Hyderabad), ‘X 14-4-8-13’ (Kadiri) and ‘Robout 33-1’ (Kadiri) yielded better than the rest. ‘Robout 33-1’, a top-ranking culture during the past 2 years, was reported to be moderately resistant to the defoliating caterpillar *Plusia* species at Dharwar.

In the Spanish group ‘C 501’ (Ludhiana), ‘MK 374’ (Kadiri) and ‘TMV 10’ (Tindivanam) were high yielders. ‘TMV 10’ was tolerant to the tikka disease at Rajendranagar.

In the Virginia bunch group ‘C 501’ (Ludhiana), ‘MK 374’ (Kadiri) and ‘TMV 10’ (Tindivanam) were high yielders. ‘TMV 10’ was tolerant to the tikka disease at Rajendranagar.

In the Virginia runner group ‘M 13’ (Ludhiana) and cross ‘X 1-2-3-1-12-B’ (Kadiri) maintained superiority in yield and soil production per day.

‘Ah 7747’ and ‘EC 76447’ in the bunch group and ‘Ah 7244’ in the spreading group showed high resistance to the tikka disease and rust at Aliyarnagar.

The National Institute of Nutrition reported that out of 40 varieties screened ‘J 11’, ‘Karad 4-11’ and ‘Kopergaon 11’ showed resistance to aflatoxin production.

Deficiencies of mineral nutrients in the soil have a direct effect on plant growth, pod-bearing and pod health. Spraying of 25% ppm ethrel 45 days after sowing was found to improve pod-filling. Application of succinic acid @ 750 g/ha recorded 20% increase in pod yield. Cobalt nitrate @ 500 ppm applied 30 days after sowing increased the nodule weight and number. At Coimbatore ‘J 11’, ‘14-4’, ‘Spanish Improved’ and ‘TMV 8’ proved to be tolerant to drought.

On irrigated lands, a spacing of 30 cm × 10 cm gave the highest yield at Tindivanam. ‘M 13’ at Ludhiana responded favourably to the spacings of 30 cm × 15 cm, and 30 cm × 22.5 cm. But the new variety ‘MH 2’ responded well only at a closer spacing of 15 cm × 15 cm. At Samrala ‘M 13’ on rainfed lands gave more pod yield at a spacing of 30 cm × 10 cm.
In a spacing-cum-manural trial at Tindivanam, encouraging results were obtained when potash was applied @ 80.5 kg/ha. But the optimum dose of potash for irrigated bunch groundnut crop was found to be 77.2 kg/ha. Application of the entire amount of potash as a single dose gave better response than split application at Dhadesugur (Karnataka).

At Dharwar application of 250 kg of gypsum in 2 splits—125 kg/ha broadcast at sowing and 125 kg/ha band-placed on surface at flowering—gave better results with the Spanish variety ‘DH 3-30’. The yield levels with gypsum application were 20% more than from the controls.

At Jalgaon, a mixture of groundnut and sunflower gave the highest monetary return when rainfall was even, and sunflower alone did well when rainfall was uneven. Groundnut-pigeonpea mixture in 3:1 proportion at Aliyarnagar and groundnut-blackgram mixture at Tindivanam gave better economic returns. At Dharwar groundnut-chilli was the best.

In a multiple-cropping trial on rainfed lands at Tindivaram, groundnut (‘Pol 2’) followed by blackgram was the best.

Patchy, uneven crop stand, a great constraint for obtaining good yields, could be overcome by sowing bold seeds. When the seeds were treated with captan @ 2 g/kg of seed and heptachlor @ 25 kg/ha, the stand was better (1,377,000 plants per hectare), resulting in a pod yield of 3,070 kg/ha.

Phosalone (0.075 %) was effective in controlling sucking insects, aphids, jassids and thrips. For controlling the white-grub, Fensulphothion was superior to phorate and carbofuran. Phosalone, either as a spray or as a dust, was effective against the leaf-miner. Carbofuran 3 G and BHC 10 % dust were found effective against the pod-borer.

Four sprays of Dithane M-45 gave maximum protection against the tikka disease. Seed dressing-cum-fungicidal spraying with dithane M-45 reduced the tikka infection by 77.6%. Bavistin mixed with Dacolin or Dithane M-45 and Duter (0.2 %) were effective in the control of the tikka leaf-spot, which reduced the yield by 50%. Dithane M-45 (0.25 per cent), Difolaton (0.2 %) and sulphur dust (15 kg/ha) reduced the infection of rust by 28%.
Torja

At Hissar, Katihar and Shillongani co-ordinated centres, 721 germplasm collections were maintained.

‘Pant Rai 15’ in the early-maturing group and ‘Pant 26/21’ and ‘RLM 29’ in the late-maturing group did well on irrigated lands. The promising strains identified in the early-maturing group included ‘Pant Rai 18’, ‘RH 7711’ and ‘RID Pusa Bold’ for irrigated lands, and ‘RK 9’ and ‘R 76-1’ for rainfed lands. Under the late-maturing group the promising strains were ‘RLM 84’, ‘RH 7515’, ‘Pant Rai 19’, ‘RK 12’ and ‘RH 763’.

Brown saron

‘BSIK 2’ gave the highest yield at Katihar, and ‘Pusa Kayani’ maintained its superiority at Kanpur.

Rai

At Hissar, Katihar and Shillongani, 1,658 germplasm lines were maintained.

Three progenies, viz. ‘4-76-9-2’, ‘5-76-8-1’ and ‘8-76-1-1’, were found to have bolder seed than ‘Prakash’. A few non-shattering lines were isolated at Hissar. Progenies ‘17-76-16-1’, ‘15-76-1-1’ and ‘18-76-11-1’ were not only tolerant to Alternaria, white-rust and mildew, but yielded significantly more than the standard, ‘Prakash’. Ten lines having less than 10% Alternaria incidence were identified. Strain ‘No. 310’ was resistant to white-rust. Seven lines were tolerant to aphid infestation.

For the control of aphids and other pests, 2 sprayings of methyl demeton (0.025%), dimethoate (0.03 %), Navacran (0.025 %) or endosulfan (0.035 %) were found effective. One spray was not found to be sufficient.

Sesamum

The Mahatma Phule Krishi Vidyapeeth, Rahuri, released ‘Phule Til No. 1’ for general cultivation. ‘RC 25’, ‘NP 6’, ‘MT 67-52’ and ‘Til No. 1’ in the early group and ‘T 12’, ‘T 13’ and ‘B 67’ in the medium group showed promise. ‘IS 282’ and ‘IS 476’ had minimum flower infestation by Antigastra. ‘NP 6’ and ‘M 3-2’ were resistant to the fall-fly. ‘B 67’, ‘MP 6-3’, ‘TGC 34’, ‘5 TC 30’ and ‘IS 1’ were resistant to leaf-curl, root-rot and phylldy.

At Jabalpur, application of 30 kg N/ha resulted in the highest yield of 570 kg/ha with a cost : benefit ratio of 1 : 13.
A dose of 60 : 60 : 40 NPK/ha (N applied in splits) gave the maximum yield of 413 kg/ha at Karimnagar. At Jalgaon application of 50 kg N/ha gave a yield of 324 kg/ha. At Jabalpur, application of farmyard manure, phosphate and Azotobacter not only increased the yield but also improved the seed size and oil content. At Sumerpur (Rajasthan) sulphur application was found beneficial. Mixed cropping of sesamum with cowpea in a 1 : 1 ratio gave the highest economic return.

Endosulfan 4 % dust (20 kg/ha) was found most effective against the leaf-roller. For controlling phyllody, spraying of Phionetor (0.03%) was found better. Carbaryl (0.02%) was effective against the leaf-roller and gallfly and carbaryl 10% dust against the shoot-webber.

Bavistin (0.02%) could effectively control the disease complex of sesamum. Seed treated before sowing with captan 0.3% + Benlate 0.2 % recorded the lowest incidence of root-rot. Sulphur dust at 30 kg/ha was effective against Alternaria blight and powdery-mildew. Dithane M-45 (0.2 %) in 2 foliar sprays gave maximum control (54%) of Phytophthora blight.

Safflower

Over 9,065 accessions were maintained and evaluated at Annegeri, Coimbatore, Jalgaon, Rajendranagar and Varanasi.

‘G 1131’, ‘G 1157’, ‘G 992A’, ‘G 2200’ and ‘G 327’ were found to have copious amounts of oil, big heads, semi-compressed branches and bold seeds. ‘JLA 979 C’ and ‘1564 B’ had large capsules. ‘P Coy’, ‘PL 195895’ and ‘N 1-1-5’ showed resistance to rust, besides ‘SF 438’, ‘1654-1’ and ‘6503’. In varietal trials, cultures ‘83’, ‘A.1’, ‘S 144’, ‘No. 673’, ‘C 438’, ‘APRR 1’ and ‘Tara’ were found promising.

A seed rate of 7.5 kg/ha was found to be optimum both at Jalgaon and Phaltan, where the optimum dates for sowing were the second and third weeks of October, respectively. Highest yields were recorded when plants were thinned 10 days after germination; later stages of thinning reduced yields. At Annegeri, growing groundnut in the kharif and safflower in the rabi was the best cropping sequence. Studies at Jalgaon revealed that safflower followed by kharif sorghum should be popularized. Inter-cropping of safflower and wheat gave the highest cost-benefit ratio at Annegeri. Safflower + chickpea in a 1 : 2 proportion gave the highest monetary return at Coimbatore. Safflower + sorghum recorded more yield than all other combinations at Jalgaon.

16 M of A & 1/78—4
At Rajendranagar and Phaltan, dimethoate (0.05%) successfully controlled the aphid.

**Linseed**

Over 2,000 germplasm collections were maintained, and 5 of these were found to be resistant both to rust (*Melampsora lini*) and powdery-mildew (*Oidium lini*). Ten lines were found resistant to powdery-mildew, and 529 to rust.

Over 440 crosses were made to combine resistance to powdery-mildew and rust with high yield.

**Sunflower**

In the scheme for the production of super-elite and elite seed of sunflower the following quantity of elite seeds were produced and supplied to state agencies for further multiplication.

<table>
<thead>
<tr>
<th>Centre</th>
<th>Variety</th>
<th>Quantity of seed produced (q)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajendranagar, Hyderabad</td>
<td>'Ec 68414'</td>
<td>17</td>
</tr>
<tr>
<td>Bangalore (Karnataka)</td>
<td>'Ec 68415'</td>
<td>32</td>
</tr>
<tr>
<td>Bhuvanisagar (Tamil Nadu)</td>
<td>'Ec 68415', 'Ec 68414'</td>
<td>42, 40</td>
</tr>
<tr>
<td>Akola (Maharashtra)</td>
<td>'Ec 68414'</td>
<td>120</td>
</tr>
<tr>
<td>Kanpur (Uttar Pradesh)</td>
<td>'Ec 68414'</td>
<td>40</td>
</tr>
</tbody>
</table>

Germplasm collections were studied and lines possessing desirable agronomic traits like early maturity, dwarf habit, high amount of oil, bold seed, high yield, self-fertility and rust resistance were identified.

'EC 101495' ('Cernianka 66') was found to have dwarf growth habit and early maturity (75-80 days). It was tested during the last 4 years and was found suitable for mixed cropping and as a catch crop.

Extensive large-scale trials revealed the superiority of hybrid sunflower 'BSH 1' over the presently cultivated open-pollinated varieties. It is now at the pre-release stage.

For rainfed regions, a package of practices such as spacing of 60 cm x 20 cm, a seed rate of 9.9 kg/ha and application of 40 kg N, 20 kg P₂O₅ and 40 kg K₂O per hectare was recommended. Pre-soaking of seeds for 12 hours before sowing was found to give better germination, good crop stand and early
seedling vigour on rainfed lands. About 10 irrigations would be required when sunflower is to be grown as an irrigated crop. The critical stages for irrigations were found to be when the crop was (i) 20 days old (bud-initiation stage); (ii) 35-40 days old (button stage); and (iii) at the flowering and grain-formation stages.

Sunflower could be grown both as a pure crop and mixed with finger millet (ragi) or with groundnut crop (one row of sunflower for every 6-8 rows of groundnut).

To overcome the problems of seed filling, hand pollination is recommended at the time of full bloom. Six to eight hand pollinations during the morning hours daily or on alternate days would increase yield up to 25%. For an additional expenditure of Rs. 185 per hectare, the additional yield would be 2.47 quintals per hectare.

Sunflower seeds have a seed-coat-imposed dormancy of 40-50 days and embryo dormancy of about 10 days. Application of TIBA during grain development at a concentration of 240 ppm was found to increase yield by 24% by increasing the sink capacity of the head by mobilization of photosynthate to the head. Soil application of magnesium and sulphur @ 20 and 40 kg/ha increased seed yield.

Rust (caused by Puccinia helianthis) could be controlled effectively by spraying Dithane M-45 or Z-78 at 0.2% concentration. For the control of the Heliothis caterpillar, spraying Endosulfan @ 27 ml/18 litres of water at full-bud-formation stage and 15 days after the first spray was recommended.

Niger

In the National Varietal Trial ‘IGP 76’ at Igatpuri and ‘No. 71’ at Raichur yielded 225 kg/ha and 287 kg/ha, respectively. ‘IGP 72’, ‘RCR 70’, ‘RCR 354’, ‘RCR 232’, ‘Phule 5’ and ‘Phule 4’ were promising.

Line sowing from the middle to the end of June at a spacing of 20 cm x 10 cm and application of 20 kg N/ha resulted in significantly higher yields.

Castor

Over 855 lines of germplasm were maintained at Rajendra-nagar.
‘Girija’ was released for cultivation in Maharashtra. Sowing in lines at a spacing of 90 cm × 45 cm with 2 seeds/hill and 60 kg N and 40 kg P₂O₅/ha were found to be the best practices. A project to control castor semilooper (Achaea janata) through biological means by employing parasite Telenomus was taken up in Andhra Pradesh, where the pest had become a menace.

COTTON

The following 9 hybrids and varieties were recommended for cultivation in various parts of the country.

Hybrids

‘Savitri’ (‘RHR 253’) : An inter-specific hybrid developed by the Mahatma Phule Krishi Vidyapeeth, Rahuri, recommended for cultivation as an irrigated crop in the Deccan Canal area of Maharashtra.

‘Godavari’ : A hybrid developed by the Marathwada Krishi Vidyapeeth, Parbhani, recommended for cultivation in the Marathwada region.

‘Suguna’ (‘CPH 2’) : A medium-staple hybrid developed at the Regional Research Station of the Central Institute for Cotton Research, Coimbatore, recommended for irrigated and assured-rainfall tracts of Tamil Nadu.

Varities

‘F 414’ : A hirsutum variety developed by the Punjab Agricultural University, recommended for cultivation in Punjab.

‘H 777’ and ‘H 655’ : Varieties of hirsutum developed by the Haryana Agricultural University, recommended for cultivation in Haryana.

‘Suman’ (‘CP 15/2’) : A medium-staple hirsutum variety recommended for cultivation in Tamil Nadu.

‘MCU 9’ (‘ELS 481’) : A hirsutum variety developed by the Tamil Nadu Agricultural University, recommended for cultivation in Tamil Nadu.

‘LD 133’ : A desi cotton variety (arboreum) developed by the Punjab Agricultural University, recommended for release in Punjab.
'HD 11': A desi cotton variety developed by the Haryana Agricultural University, recommended for pre-release multiplication and trials.

The sowing time of 'Bikaneri Nerma' in Punjab could be conveniently extended up to the first week of June without loss in yield.

The paired-row method of planting provided scope for increasing plant population as well as better interculturing. The skip-row method of sowing with alternate furrow irrigation saved irrigation water by 20-30%, besides providing better aeration and more sunlight. In rice fallows of Andhra Pradesh, sowing cotton on the slopes of ridges in ploughed land was found to increase yields by 30% compared with sowing among rice stubble. On rainfed lands, ridging and furrowing drained the excess water when there was heavy rain and conserved water for the lean period. This practice gave 10 to 15% more yield.

Intercropping cotton with greengram and groundnut resulted in additional income. Soaking seed in 0.01% succinic acid and fungicide for 4-5 hours improved germination. When paraquat @ 2.5 litres/ha plus magnesium chlorate @ 0.5 kg/ha were applied when 80% of the bolls had opened, the remaining green bolls were forced to open 15-20 days earlier, resulting not only in an early harvest of the crop but also in reducing the carryover of the pink bollworm.

An operational research project on integrated management of pests of cotton was implemented in 2 villages of the Coimbatore district where farmers were about to give up cotton cultivation because of heavy pest infestation. The technology developed at the Regional Station, Coimbatore, was fully extended to the area. 'Varalaxmi' and 'MCU 5' were sown within a very short period. The summer ratoon crop of cotton was not grown. Alternate host plants were removed from the area. Specific and safe insecticides were applied in the correct proportions, and at the proper time manuring, irrigation and weeding operations were carried out. The farmers obtained 25 to 30 quintals of seed cotton per hectare with less than 3% damaged seed cotton, with only 6-9 sprays, as against 11-20 sprays in the non-project area.

Mechanical properties of treated cottons

Yarns of 'Sanjay', 'Virnar', 'Hybrid 4', 'Hampi', 'Sujay', 'JK 79', 'K 8' and 'Bharati' were mercerised and cross-linked in the following ways: (i) conventional; (ii) premercerised under
stretch, washed, dried and cross-linked in wet state (MDCL); and
(iii) mercerised as in (ii) but cross-linked soon after mercerisation
(MWCL).

The results showed that in the MWCL treatment the tenacity
retention was much better than in the MDCL treatment.

Fermentation of cellulose

About 11 cellulosic substrates were bleached with sodium
chlorite, powdered in a grinding mill, and sieved to get 25-mesh
powder. Each substrate was treated with cellulose of known
strength at 50°C for 24 hr. Wheat-straw pulp, jute-stalk pulp,
bagasse, cottonseed hulls, newspaper waste, rice husk, sawdust
and cotton-stalk powder were readily hydrolysed. Though the
time required to get maximum hydrolysis varied with each sub-
strate, 24 hr was suitable in all the cases.

Enrichment of cattlefeed

The straw of rice and wheat, the stubble and stalks of
sorghum and cotton and the shells of groundnut were tested for
the feasibility of producing microbial proteins. Preliminary stu-
dies indicated paddy and wheat straw to be good sources of cellu-
losic substrates for supporting the growth of micro-organisms.
Protein addition was maximum when *Penicillium funiculosum*
was grown on pretreated rice and wheat straw, followed by growing
*Trichoderma viride* 9414 and *Trichurus spiralis*. Acid-treated
and ammoniated straw supported better growth. Crude protein
increased by 40% when *P. funiculosum* was grown on acid-treated
and ammoniated straws; the increase was 60% with *Candida utilis*.

Ginning outturn and fibre characters

Tests on 45 samples showed no systematic change in the gin-
ning percentage as well as fineness values of different pickings of
any of the varieties or hybrids grown in Andhra Pradesh and
Tamil Nadu.

Use of chitin from prawn-shell waste

In laboratory pot-culture studies, ‘MCU 5’ plants grown on
soil receiving chitin from prawn-shell waste remained healthy
despite inoculation with *Verticillium dahliae*, although on un-
amended soil the plants were stunted and their leaves had wilted
after 3 months. The experiment would be laid out in the field at
Coimbatore.
JUTE

About 180 collections of Corchorus capsularis and C. olitorius from north-eastern region and central India were added to the existing germplasm.

‘JRO 524’ at Sorbhog (Assam) yielded 23.26 q/ha. ‘TJ 42’, ‘TJ 32’ and ‘TJ 40’ gave yields ranging from 25.24 to 26.29 q/ha —significantly more than the standard ‘JRO 7835’ (average yield 22.63 q/ha) at Bahraich.

At the Jute Agricultural Research Institute, Barrackpore, ‘TJ 26’, ‘TJ 40’ and ‘JRO 524’ yielded 28.15, 27.51 and 27.38 q/ha, respectively, but the varietal differences were not statistically significant. At Katihar, ‘JRO 524’ yielded, on an average, 23.84 q/ha, followed by ‘TJ 23’, with a yield of 22.18 q/ha. At Krishnagar (West Bengal), ‘JRO 632’ gave an average yield of 28.11 q/ha, followed by ‘TJ 23’ (26.98 q/ha).

At Coimbatore tossa jute yielded 21.30 q/ha, with 30 kg N/ha. Application of water-hyacinth in the form of compost as a substitute for farmyard manure had a beneficial effect on jute. Its residual effect on the succeeding rice or wheat crop was significant.

At Sorbhog application of magnesium had a positive impact on yields, although in the absence of fertilizer the effect was not significant. Boron had a beneficial effect on the quantity as well as quality of the fibre. Lime application had a good effect on tossa jute, but not on white jute ‘JRC 21-2’. The mean yields without and with lime were 14.92 and 21.76 q/ha in the case of tossa jute and 14.52 and 15.72 q/ha in the case of white jute, respectively. Lime application at Kendrapara reduced the incidence of stem-rot.

Since lime application gave uniformly good results wherever jute was cultivated, it should be recommended as a general practice.

A number of jute-based multiple-cropping systems were developed, the economical and popular system being jute-rice-potato + wheat. Wheat was intercropped with potato.

Bavistin, Democron and Metasystox gave good results at Katihar against root-rot. Democron and Metasystox were very effective in controlling vectors of leaf-mosaic in white jute also.
Application of TFP @ 4 kg/ha coupled with light hand-weeding gave better weed control. The deterioration of fibre quality due to plant age could be overcome considerably by incorporating nitrogenous fertilizer into the retting system at the rate of 0.5% of the plant weight.

The jute-decorticator developed at the Jute Agricultural Research Institute was found to be superior on all counts. The capacity of the prototype was 3.6 tonnes of green plants per man-hour. The total expenditure on fibre production by decortication and short retting was Rs. 470 per hectare as against Rs. 565 per hectare by the conventional method. Further, the gain due to premium on high quality was estimated at Rs. 480 per hectare.

**Blending with yarns and fabric**

Jute sacking-cloth lost strength after soaking in water for 21 days, but there was no loss of strength in the combination fabric prepared from jute yarn and HDPE tape. The abrasion resistance of the blended fabric was more or less the same as that of all-jute cloth. These results indicate the possibility of using blended cloth to make sacks for grain storage for better resistance to retting when moisture is high.

**Blending with leaf fibre of pineapple**

Leaf fibre of pineapple stapled to a length of 32 mm and opened in a single-opener machine could be blended with cotton in different proportions and yarns of 14s count could be spun on the cotton system. But the performance of the blended yarns gradually deteriorated with higher proportion of pineapple leaf fibre.

**Processing of woollenized jute**

Tossa jute was woollenized and processed through standard jute machinery after making some adjustments. A sample blanket and knitted sweater were prepared, which were comparable with the products made from coarse wool in their appearance and feel. The quality of the products improved when polypropylene and wool were mixed with woollenized jute.

**Viscose rayon from jute-stick pulp**

The viscose derived from jute-stick pulp was ripened for different periods. About 3,000 metres of yarn was obtained, of which about 550 metres of thread was reeled into hanks.
High-grade charcoal from jute stick

Following a 2-stage carbonization process, a high-grade charcoal having good yield was obtained from pressed jute sticks. The mixed carbon content of the charcoal was 90% more, and the charcoal was very close to or even better than the CS-grade hardwood charcoal. Even jute sticks obtained from freshly harvested mature jute plants presented no problem in the carbonization process.

Jute root-cuttings for paper pulp

Pulps made from jute stick and root cuttings having the same permanganate number, but made separately, were blended in different proportions. The strength of the hand-made sheets of paper improved with an increase in the proportion of root cuttings in the blend. Certain proportion of such pulp when mixed with better-quality pulps might produce special types of paper.

Light-weight non-wovens from mill wastes

Trials of single-step blending and dyeing with pigment dyes on small webs from blends of jute and cotton wastes were successful. Subsequently, dyed non-woven fabrics could be continuously prepared and no coagulation separation and problems arose in the impregnatator even when the dye and the blender were used simultaneously.

Filter media from non-wovens

The filtration efficiency of non-woven filter media from raw caddies was found to be more than that obtained from blends of crimped jute caddies, but the filter life and dust-holding capacity of the latter was much better. Thus media from blends of crimped caddies might be used as the primary, and those from raw caddies as the secondary, to optimize durability and efficient filtration performance.

Fibre at different growth stages

Fibre was observed to have the poorest crystallite orientation at the beginning of plant growth. The orientation would improve with age and the value attained at about 45 days would be retained throughout the life of the plant, although in some cases the orientation started deteriorating after about 130 days, indicating the possibility of a fall in the tensile strength of fibre.
Fine structure of woollenized jute

X-ray diagrams of NaOH-treated jute indicated some relationship between crimp development and decrystallization and extent of conversion to cellulose II structure. The presence of lignin in jute facilitated the formation of crimp when woollenized with NaOH.

Fibre from husk of green coconut

Three mixed bacterial retting cultures were isolated which, after necessary adaptation and activation, were tested for their effectiveness in retting green coconut husks in liquid media containing suitable nutrients. The results indicated that clean fibres could be extracted from the treated husks after about 10 days of retting.

Use of palm-seed fibre

Fibres from palm-seed were processed on jute machinery. There was no difficulty in running the fibre in jute card either alone or in blending with jute. When Katasoftner with batching emulsion was used, the processibility of the fibre or its blends improved.

MESTA

‘AMC 108’ was recommended for release in Andhra Pradesh, where it did exceedingly well. ‘AC 21-2’ of *Hibiscus cannabinus* performed well at Bahraich, Amadalavalasa and Katihar and ‘CPEL’ at Coimbatore.

‘HS 7910 *(H. sabdariffa)* yielded on an average 32.83 q/ha at Pusa. ‘AS 486’ was recommended to be field-tested in Orissa. In the Sorbhog area, where tossa jute crop is highly susceptible to nematode infestation, mesta has done exceedingly well.

Application of ferro-chrome as a source of calcium gave exceedingly good results with mesta in the Srikakulam area of Andhra Pradesh. Alkaline soils up to 8.5 pH in the Vijayawada area were found suitable for producing the seed crop of jute. The yields recorded were around 9.9 q/ha.

Aramena

Aramena (*Urena lobata*), a fibre crop resistant to wilt, was found suitable for areas where Hooghly wilt is rampant on jute.
Sanhemp

‘SJ 67-34’ was recommended for release in Madhya Pradesh by the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The day-neutral type of sanhemp was found to be valuable, and a specific cross-combination between ‘T 6’ and ‘Hoshangabad’ resulted in a profusely flowering, fast-growing high-yielding hybrid. The increase in fibre percentage was significant.

TOBACCO

Chewing varieties ‘Vairam’, ‘Bhagyalakshmi’ and ‘Thangam’ were recommended for release in Tamil Nadu, and ‘Prabhat’ in the nutu-tobacco growing areas of Andhra Pradesh. A cigar-wrapper variety, ‘S 5’, and 2 hookah varieties ‘HD 65-40’ and ‘DD 437’, were recommended for release in West Bengal. ‘CTRI Special’, an improved variety of flue-cured Virginia tobacco, was released for cultivation in the black soils of Andhra Pradesh.

Maize in the kharif and chewing-tobacco in the rabi, with inter-cropping of radish or green onion or garlic and maize in summer, were recommended for the Pusa area of Bihar. Growing fingermillet (ragi) in the kharif and chewing tobacco in the rabi was found to be beneficial in Tamil Nadu.

In the Hunsur area, flue-cured Virginia tobacco should be planted from mid-May to mid-June to obtain a high yield of quality tobacco. Sesamum-bidi tobacco sequence was found to be beneficial in the light soils of Gujarat. In the Hunsur area, rotation of fingermillet with flue-cured Virginia tobacco was not only advantageous but also reduced the incidence of the root-knot nematode.

Anhydrous ammonia to supply 180 kg N/ha in conjunction with green-manuring could be used as a nitrogenous fertilizer in bidi tobacco. Manuring bidi tobacco either by broadcast or furrow application was equally effective. Though neemcake was as much effective as ammonium sulphate, it could not be recommended because of the yellow cast it imparted to the crop. Bidi tobacco seed crop should be manured @ 150 kg N/ha in Gujarat. Application of the oilcakes of mahua and pongam (karani) increased the yield of flue-cured Virginia tobacco in the light soils of central Gujarat, where the crop should be irrigated at 10-day intervals after the first priming.

In ‘Kanakaprabha’ the uptake of nutrients was maximum during the reproductive phase (60 to 90 days) followed by the active vegetative phase (30 to 60 days) in both light and heavy
soils. The uptake was more in heavy soils than in light soils at every stage of crop growth.

**AC 92,553 (ACCOTAB)** suckericide controlled axillary and ground suckers of bidi tobacco and did not leave any toxic effect on the plant. Rabbing of the nursery site was good for controlling weed population and increasing the number of transplantable seedlings. Antak 4 per cent spray and drip application of 25 per cent groundnut oil emulsion on natu tobacco controlled the suckers effectively and increased the cured-leaf yield significantly.

In flue-cured Virginia tobacco infested with *Orobanche*, the uptake of nutrients diminished by 50 to 80 per cent and the chemical and physical quality characters were adversely affected.

In Tamil Nadu application of half the N as top-dressing 45 days after transplanting and spraying 2 per cent urea 15 days later was found to be more beneficial than application of the entire quantity of N to the soil in 2 splits to chewing-tobacco.

*Nicotiana gossei* and *Nicotiana unbratica* were found to be highly attractant and toxic to white flies. Befin @ 0.2 per cent and FM spray @ 1.0 per cent were found to be very effective in controlling the damping-off and leaf-blight in flue-cured Virginia tobacco nurseries.

Bavistin and MBC @ 1 kg/ha controlled leaf-spots effectively in ‘White Burley’ tobacco grown in the agency area of Andhra Pradesh.

Three sprayings of the leaf extracts of *Basella alba* and *Bougainvillea spectabilis* at 10-day intervals after transplanting flue-cured Virginia tobacco reduced the incidence of the tobacco-mosaic disease, and increased the yields of green, cured, bright and total bright leaves. Soil application of Aldicarb 10 G @ 1.0 kg ai and Disulfoton @ 0.75 kg ai before planting flue-cured Virginia tobacco in light soils controlled the infestation of green peach aphid (*Myzus persicae*) very effectively. The pesticide residues in the cured leaf were well within the acceptable limits.

Ten spider predators were recorded for the first time in India feeding on larvae of *Spodoptera litura* (*Oxyopes wroughtoni*). *Cheyletus cruditus*, a mite, was recorded for the first time predating on the eggs of cigarette beetles (*Lasioderma serricorne*) on stored cigar-wraper tobacco in West Bengal.
A simple process was developed to isolate export-worthy solanesol concentrate from tobacco waste. The solanesol content in this concentrate was almost 80 per cent compared with 10-15 per cent in the crude extract now being exported. Since the chemical recovery was high (70 per cent) and the solvent loss low (8 per cent), the process holds great promise.

**LAC**

Besides *Croton oblongifolius* and *Desmodium pulchellum*, now under field study, a monoecious variety of *Milletia extensa* (Leguminosae) was identified as promising kusmi lac host. A few species of *Ficus* (locally known as *jheru, ghun* and *gular*) were found to be promising alternative hosts to kusmi lac.

Endosulfan and a thuricide could be used for controlling lac predators *Eubleemma amabilis* and *Holcocera pulverea*. They had no adverse effect on the vital attributes of the lac insects; in fact there was an improvement in fecundity in the laboratory.

The confirmation of the presence of pheromone in the female moth of *Eubleemma amabilis* would be helpful in controlling this major lac predator.

An endoparasite, *Pristomerus sulci*, was reared in the laboratory for investigating its usefulness in the control of the lac predator, *Holcocera pulverea*.

A 15-day delay in lac inoculation would avoid the synchronization of the emergence of predators, reducing infestation. About 30 per cent increase in lac production was recorded in the study conducted during the 1977 crop season.

Crosses of the *rangeeni* and kusmi lac insects produced a kusmi-type, superior-quality, lighter-coloured resin. The crosses maintained the *rangeeni* life-cycle behaviour, indicating that they could be propagated on *Butea monosperma* (palas), on which the bulk of the lac of commerce is produced.

When 40 ppm of gibberellie acid was sprayed on the foliage of lac hosts *Moghania macrophylla* and *Albizzia lucida*, their growth was enhanced and the gestation period reduced, which in turn gave more yield of lac. Since the depth and spread of the roots was better, the host plants could withstand drought.
Propagation of kusum

Success was achieved in inducing rooting in kusum (Schleichera oleosa) through air-layering with the aid of IAA+IBA at 100 ppm.

Components of lac resin

A new aldehydic acid was isolated from lac and some of its structural characteristics were established. It was tentatively assigned a molecular formula \( \text{C}_{15}\text{H}_{18}\text{O}_3 \).

Shellac-based urethane coatings

Urethane coatings from shellac having more flexibility, adhesion and resistance to chemicals and solvents were developed. First, shellac-based polyesters were prepared through chain extension by reacting shellac with ethylene glycol and a dicarboxylic acid such as adipic, phthalic, terephthalic or maleic; subsequently, these polyesters were reacted with 2 : 4 toluene diisocyanate to yield polyurethanes.

Plasticisers

Marked improvement in the flexibility, dielectric strength and heat resistance of shellac varnishes was noticed with the addition of dimethyl phthalate (20 per cent on the weight of shellac). The dielectric strength of shellac varnishes treated with dimethyl phthalate was 1.7 KV/mil (shellac 0.8-1.0 KV/mil). The plasticised shellac films were resistant to heat up to 100°C (shellac 70°C) and passed the test for flexibility as per IS: 352-1973.

A number of pattern enamels based on shellac or MF resin as binder were prepared. These compositions on application by brush produced hard, smooth, glossy and highly adherent films on wooden surface. They showed good drying and adequate resistance to humid conditions and to the action of wet sand and organic binders normally used for making sand moulds.

Adhesive for furniture

A thermoplastic adhesive composition from a mixture of shellac and synthetic monomer in the ratio of 70 : 30 was developed and found to be very satisfactory for fixing sunmica (decorative laminates) on table tops and for joining wood to wood surface. The bonded surfaces had set at room temperature within 48 hours without applying pressure. The performance of this composition in regard to bond strength and peeling test compared
favourably with the performance of the commonly used synthetic adhesive, ‘Fevicol’.

Operational Research Project

In 4 villages in the Ranchi district, 83 demonstrations of improved methods of lac cultivation (involving approximately 1,000 trees) were laid out with the baisakhi 1977-78 crop. The ari harvest data on jujube (ber) trees indicated that the stick-lac yield per tree obtained by the traditional method could be nearly doubled with the improved technology. Some farmers started following the improved practices on their own.

SUGARCANE

Twelve hybrid clonal selections possessing high yield potential, good juice quality, disease resistance and better physical attributes than the standards were released (‘Co 7801’ to ‘Co 7812’). Of these, 6 were early-ripening types and the rest mid-late. Planting materials of these varieties were supplied to 32 research centres in India. About 27 kg of fluff from a large number of crosses effected in the National Hybridization Garden were supplied to 15 centres to provide genetic material with a broad base for exercising selection at different locations.

With the release of ‘Co 671’, ‘CoA 760’ and ‘Co 7204’, the harvesting period was shortened to 8 months, and it is now possible to have 3 short-duration crops in 2 years as against only 2 crops of the mid-late ‘Co 6304’. A few inbred progenies were found to have 18 per cent more sucrose than the parent variety.

‘Co IK 7701’, a high-yielding variety with a yield potential of 80 to 100 tonnes/ha, was released. Mid-late in ripening, it had 16-18 pol per cent in December and February and was found to be a good ratooner, tolerant to drought and moderately resistant to red-rot and top-borer.

The pol per cent juice and purity of ‘Co IK 7801’, ‘Co IK 7802’ and ‘Co IK 7803’ were better than of the standard ‘Co 1148’ in late April. These varieties, whose tops were greener, appeared to be better suited for late harvest when the crushing season is prolonged.

Breeding for horizontal resistance to different red-rot biotypes in sugarcane made rapid progress and advanced lines were produced for testing in ‘hot-spots’. Through back-crossing and mutation breeding a number of smut-resistant clones were developed.
With the HSR 8626 method, the sugarcane yield of rabi crops could be increased by 41.6 per cent over the conventional methods. ‘Co 1148’ was better suited to late planting, yielding 27.8 per cent more than ‘Co 13B 6’.

For building up shoot population and increasing the planting density under moisture stress, it was found better to reduce the row-to-row spacing than to use higher rates of nitrogen. This was demonstrated in a study of package of practices with limited inputs.

Spraying 4 ppm of indole-3-butyric acid or naphthalene acetic acid significantly improved transplant survival in 8 varieties of sugarcane and reduced the replacement needs. The beneficial effect of the hormonal spray was traced to quick production of shoot-roots in the treated plants.

Drip irrigation was found to save about 40 per cent irrigation water without any great setback either in quantity or in quality of the produce. In some varieties restriction of irrigation at the critical flower-initiation period was found to control flowering.

Tests showed that ‘Polaris’ could be used on a large scale in difficult-to-ripen areas and the sucrose content increased by 6-19 per cent.

Applied @ 2 kg ai/ha, Dasanit, 0.0 diethyl-O (4-methyl sulfinyl-phenyl)-monothiophosphate, a systemic chemical, provided an effective control of parasitic nematodes and increased the yield by 23 per cent.

The attack of the third brood of the top-borer, which coincides with the grand growth period of sugarcane with the onset of the monsoon, was kept under check with soil application of Carbofuran 1.0 kg actual toxicant per hectare along the sugarcane rows. It reduced borer incidence to 4.4 per cent from 22.4 per cent.

The larvae of the stalk-borer, Chilo auricilius, proved to be the best laboratory host for rearing the dipterous parasite Sturmiopsis inferens, the maggots of which lost viability within 72 hours when stored at 7°C. Isotima javensis multiplied parthenogenetically during the hot weather.

**SUGARBEET**

It was found possible to produce good-quality seed at high altitudes.

Progress in the development of indigenous varieties with the available facilities have been made by way of intra and inter-population improvements. 'Pant S 1', 'Pant S 2', 'Pant S 3', 'Pant S 10', 'Pant Composite 1' and 'Pant Composite 6' showed encouraging performances. 'Ramonskaya', the only variety multiplied on a large scale in India, is being renovated. 'Anglo-Maribopoly', '68 MSH 126', 'Pant Composite 1', 'Hh Monitor' and '68 MSH 155' showed tolerance to Sclerotium root-rot, while 'Pant Composite 1', 'Polirom' and 'Maribopoly V' were tolerant to Cercospora leaf-spot.

The scope for raising sugarbeet in saline and sodic soils was established. Several hectares of barren saline and sodic soils can now be made use of.

Soil application of potash @ 80 kg/ha at sowing increased the per cent of sugarbeet roots in the first week of April and May, but the difference narrowed down in the last week of June.

Boron, zinc and manganese were found to play an important role in determining the yield and quality of sugarbeet. Sclerotium root-rot could be prevented by suitable rotation and use of Brassicol drenching @ 15 kg/ha.

The milk yield of cattle was found to increase when they were fed on sugarbeet top and pulp.

**PLANTATION CROPS**

*Cashew*

At the Fourth Workshop on the All-India Co-ordinated Spices and Cashewnut Improvement Project, held at Panaji, Goa, in September 1978, 15 cashew types were identified as the best performers at Vengurla, Bapatla and Mannuthy, based on high yield, early flowering, short flowering phase, high percentage of perfect flowers, high setting percentage, medium-sized nuts and good shelling percentage (Table 1). The universities of the regions were requested to release them in their states.

On the basis of progeny performance in comparative yield trial, 3 Vridhachalam selections, viz. 'M 76/1', 'M 10/4' and 'M 44/3', were recommended for pre-release multiplication.

16 M of A & I/78—5
Table 1. Performance of 15 cashew types

<table>
<thead>
<tr>
<th>Centre</th>
<th>Selection/ Hybrid</th>
<th>Parents</th>
<th>Yield/tree (1978)</th>
<th>Mean yield (5 years)</th>
<th>Shelling (%)</th>
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</thead>
<tbody>
<tr>
<td>Vengurla</td>
<td>'37/3'</td>
<td></td>
<td>43.52*</td>
<td>32.68</td>
<td>32.0</td>
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<tr>
<td></td>
<td>'Hybrid 11'</td>
<td>'Midnapur Red' × 'Venture 56'</td>
<td>23.18</td>
<td>18.10+</td>
<td>30.7</td>
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<td>'Hybrid 19'</td>
<td>'Midnapur Red' × 'Venture 36'</td>
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<td>18.56</td>
<td>32.2</td>
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<td>'Hybrid 24'</td>
<td>'Ansur Early' × 'Mysore Kotekar 1/61'</td>
<td>24.79</td>
<td>18.30</td>
<td>31.0</td>
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<tr>
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<td>'Hybrid 5'</td>
<td>'Ansur 1' × 'Venture 56'</td>
<td>17.24</td>
<td>13.35</td>
<td>27.6</td>
</tr>
<tr>
<td></td>
<td>'T No. 1'</td>
<td></td>
<td>50.6*</td>
<td>46.8</td>
<td>24.0</td>
</tr>
<tr>
<td></td>
<td>'T No. 273'</td>
<td></td>
<td>13.2</td>
<td>14.6</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>'3/3 Simhachalam'</td>
<td></td>
<td>15.1**</td>
<td>12.96</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td>'9/8 Epurupalem'</td>
<td></td>
<td>8.94*</td>
<td>9.40</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td>'Hybrid 2/11'</td>
<td>'T No. 1' × '273'</td>
<td>23.60*</td>
<td>17.10</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>'Hybrid 2/12'</td>
<td>'T No. 1' × '273'</td>
<td>22.50*</td>
<td>19.40</td>
<td>25.7</td>
</tr>
<tr>
<td>Mannuthy</td>
<td>'BLA 139-1'</td>
<td></td>
<td>37.80</td>
<td>33.89</td>
<td>27.99</td>
</tr>
<tr>
<td></td>
<td>'K 10-2'</td>
<td></td>
<td>17.76</td>
<td>13.18</td>
<td>26.96</td>
</tr>
<tr>
<td></td>
<td>'Hybrid H-4-7'</td>
<td>'T 30A' × 'Brazil 18'</td>
<td>13.65</td>
<td>11.4</td>
<td>25.20</td>
</tr>
<tr>
<td></td>
<td>'Hybrid H-3-17'</td>
<td>'T 30' × 'Brazil 18'</td>
<td>21.26</td>
<td>16.04</td>
<td>26.20</td>
</tr>
</tbody>
</table>

*Yield in 1977.
**Yield in 1976.
+Average for 4 years.

For the control of the blossom blight of cashew caused by the tea mosquito (*Helopeltis autonii*), endosulfan was found to be most effective when sprayed with high-volume or minimicron sprayers. Aerial spraying of 3 per cent endosulfan is cheaper and more effective than high-volume spraying at lower concentrations in reducing the shoot and panicle attack (Table 2). The cost works out to Rs. 59.60/ha for aerial spraying as against Rs. 75/ha for spraying through high-volume sprayers.
Table 2. Mean percentage of cashew shoot and panicle attack by the tea mosquito in 2 types of sprayings

<table>
<thead>
<tr>
<th>Type of attack</th>
<th>Aerial Spraying</th>
<th>Rocker Spraying</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot attack</td>
<td>4.6</td>
<td>8.6</td>
<td>16.8</td>
</tr>
<tr>
<td>Panicle attack</td>
<td>20.1</td>
<td>34.1</td>
<td>68.2</td>
</tr>
<tr>
<td>Cost of spraying one hectare</td>
<td>Rs. 59.58</td>
<td>75.6</td>
<td></td>
</tr>
</tbody>
</table>

There are many advantages of adopting aerial spraying of insecticides in large-scale plantations. As the build-up of the tea mosquito takes place quickly after the monsoon, coinciding with the emergence of new flushes, the spray operations are to be done in a short time; otherwise the pest severely damages the crop. Since spraying operations cannot be completed in large plantations within a short time, aerial spraying was taken up in the cashew plantations of the Kerala Plantation Corporation extending to about 2,000 ha.

Cardamom

Three cardamom types have been found to be superior, based on yield, quality of the capsule and suckering potential.

Yield of green cardamom capsules/clump (g), 1976-77

<table>
<thead>
<tr>
<th>Variety</th>
<th>'P 1'</th>
<th>'P 3'</th>
<th>'P 5'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mudigere</td>
<td>529</td>
<td>830</td>
<td>614</td>
</tr>
</tbody>
</table>

Pepper

Work done at the Panniyur Centre of the Kerala Agricultural University indicated that Bordeaux mixture and Bayer 5072 gave good control of the quick wilt of pepper.

Cumin

Research conducted at the Udaipur University showed that 3 aphids infect cumin—(a) Aphis gossypii, (b) Aphis (Myzus) persicae and (c) Hydaphis coryli. Application of Dimethoate 0.03 per cent or Formothion 0.025 per cent or Phosphamidon 0.025 per cent or Thimetan 0.025 per cent gave good control in the crop sown in the last week of October. Application of Phorate 100 or Aldicarb 10 g or Hephosphlon 50 @ 20 kg/ha at flowering as side-dressing also gave good protection.
**Fennel**

Three sprays of methyle demeton 0.025 litres/ha applied fortnightly from mid-March proved effective against aphids at Udaipur. Aphids generally cause a lot of damage.

**Cacao**

‘Forastero’ cacao appeared to be a promising intercrop in arecanut, as revealed from studies at the Konkan Krishi Vidyapeeth, Dapoli.

**Development Project**

The Kerala Agricultural Development Project aims at improving the productivity of major foreign-exchange-earning tree crops and pepper with emphasis on improving the economic status of the small farmer.

The Kerala Agricultural University finalized plans to strengthen the existing research activities and training facilities. Seven field trials were laid out on cashew, coconut, pepper and cacao.

The Central Plantation Crops Research Institute would intensify research on the wilt diseases of coconut and pepper. Application of manures and disease observations were carried out on many plots and a 2.8-hectare garden (600 palms) was selected in Krishnapuram for adoption of management practices.

A programme to check the spread of coconut wilt was inaugurated at Irinjalakuda in October 1978.

**FRUITS**

**Mango**

A high-quality hybrid between ‘Banganapalli’ and ‘Alphonso’ was isolated at the Indian Institute of Horticultural Research, Bangalore. The hybrid retained the flavour and general fruit characteristics of ‘Banganapalli’ along with the pulp consistency and sugar content of ‘Alphonso’.

A promising regularly bearing hybrid ‘No. 1179’ (‘Neelum’× ‘Alphonso’) was developed at the Konkan Krishi Vidyapeeth, Dapoli.
The earlier finding of spraying of 200 ppm of NAA in October followed by debloming at the bud-burst stage for controlling mango malformation, a serious problem, was confirmed by the work done at the Central Mango Research Station, Rehman Khera.

_Citrus_

Work conducted at the Citrus Die-back Scheme, Shirirampur, indicated _Citrus macroptera_ (‘Satkara’) to be free from greening, a serious disease of citrus.

With the objective of supplying virus-free budwood on a large scale to growers, a virus-free 'Sathgudi' sweet-orange nucellar-bud-bank with a potential to supply 200,000 buds a year was established at the Tirupati Centre of the Citrus Die-back Scheme, and about 16,000 'Sathgudi' virus-free buds were supplied to nurserymen and growers in 1978.

Similarly, a virus-free progeny block of 275 trees comprising ‘Kinnow’ mandarin, and ‘Blood Red’, ‘Jaffa’ and ‘Pineapple’ cultivars of sweet-orange was raised at the Punjab Agricultural University, Ludhiana, to supply virus-free budwood.

Trials conducted at the Tamil Nadu Agricultural University, Periyakulam Centre, Punjab Agricultural University, Ludhiana, and Punjabrao Krishi Vidyapeeth, Akola, indicated that Quinalphos (0.05 per cent) and Monocrotophos (0.05 per cent) controlled most of the insect pests attacking citrus, including vectors of virus and virus-like diseases such as citrus psylla, aphid, leaf-miner, leaf caterpillar and bark-eating caterpillar.

Hyperparasitism of _Podonectria cocicota_ on scale insects (green scales), serious in some citrus-growing areas, was noticed at the Horticultural Experiment Station, Chethalli. The fungus, recorded for the first time in India, can be exploited for biological control of scale insects.

Studies conducted at the Marathwada Agricultural University, Parbhani, revealed seedless ‘Kinnow’ to be superior in quality to and more resistant to canker than ‘Kagzi’ lime.

_Banana_

A new banana hybrid, ‘H 135’, derived from multiple cross of _Musa balbisiana_ (BB), ‘Ladan’ (AAB) and ‘Kadali’ (AA) was developed at the Tamil Nadu Agricultural University,
Coimbatore. The new variety resembled hill banana 'Virupakshi' in size, taste and flavour, and could be grown even in the plains.

To introduce nematode-free plants from a highly infested area, a technique was standardized at the Indian Institute of Horticultural Research, Bangalore, for obtaining banana plants through tissue culture. Rhizome tops of 'Robusta' banana measuring 3 cm could be developed into fully grown plants with this technique. Multiple plantlets from pieces of rhizome tips were also activated.

"Kottai Vazahai", a physiological disorder in 'Poovan' cultivar of banana, could be successfully controlled at the Tamil Nadu Agricultural University, Coimbatore, with 2,4-D applied @ 25 ppm soon after opening of the last hand.

Work conducted at the Konkan Krishi Vidyapeeth, Dapoli, showed that the incidence of the serious bunchy-top disease of banana could be minimized with the application of Thiodemeton (Solvirex).

Pineapple

Studies conducted at the Indian Institute of Horticultural Research, Bangalore, its Experiment Station at Chethalli, and the Kerala Agricultural University showed that a population density of 53,330 plants/ha with a spacing of 25 cm x 60 cm x 90 cm was the best for getting high yield and for the convenience in farm operations and ratooning.

The efficacy of NAA for the induction of flowering in pineapple was effectively increased when 10 ppm of it was combined with 20 per cent urea, which induced more than 90 per cent flowering compared with only 70 per cent in the control.

Papaya

Hybrids between *Carica papaya* and *C. cauliflora* evolved at the Indian Institute of Horticultural Research gave more yield.

Intervarietal crosses among different cultivars of *C. papaya* showed that heterosis could be exploited by suitable cross-combinations in this crop.

At the Tamil Nadu Agricultural University, depletion of 40 per cent moisture was found to be the best for 'Co 2' papaya from the point of view of yield.
Guava

The fruit-canker (*Pestalotia psidii*) of guava was found to be serious in orchards around Bangalore. Bavistin (0.1 per cent) was found to be effective in controlling it.

Grape

Trials at the Indian Institute of Horticultural Research have indicated that 'Gulabi' and 'Black Champa' grape varieties can be grown on the head system, which eliminates heavy initial investment required on bower or kniffin systems.

Datepalm

To boost the production of dates the Indian Council of Agricultural Research imported 500 suckers of datepalm of 4 outstanding cultivars, viz. ‘Halawy’, ‘Medzool’, ‘Zahidi’ and ‘Barhec’, from California under the UNDP Project and distributed to 4 centres of research (Jodhpur, Bikaner, Mundra and Hissar) for establishment and further multiplication.

Jujube (ber)

An easier technique for multiplication of budded plants in polythene tubes was developed at the Central Arid Zone Research Institute, Jodhpur. The method consists of raising seedlings of wild *ber* ('boradi') by sowing seeds during early April in 300-gauge polythene tubes, 25 cm long and having a diameter of 10 cm, open at both ends, and filled with a mixture of sand, clay and farmyard manure in equal proportions. The tubes are kept in sunken beds. Budding is done during July when the seedlings are 90 days old. Grafted plants become ready for transplanting in August. The grafts can be transported to long distances in tubes without damage to the roots. This method is less cumbersome and takes hardly 1½ years.

VEGETABLES

The promising new vegetable varieties identified by the All-India Co-ordinated Vegetable Improvement Project were: radish ‘Punjab Safed’ and ‘Kalianpur No. 1’; carrot ‘Selection 5’ and ‘Selection 283’; cucumber ‘Pusa Sanyog’ and ‘Poinsette’; cowpea ‘Sel 1552’; pumpkin ‘CM 12’ and ‘CM 37/9’; brinjal ‘S 16’; and tomato ‘Punjab Chhohara’, ‘La-Bonita’ and ‘Sweet 72’.

'Punjab Sunheri' are being marketed abroad by a Danish firm. These varieties were found promising when tested in trials in other countries.

In trials conducted at Jabalpur, 100 kg N + 60 kg P₂O₅/ha was found to be the optimum dose for okra, resulting in 133 per cent more yield than the control (31 q/ha) and giving a net profit of Rs. 1,386/ha.

At Rahuri, the fruit and shoot-borer of brinjal could be effectively controlled with the application of Methomyl @0.5 kg ae/ha. Fortnightly application of Monocrotophos (0.05 per cent) could control the fruit-borer of okra in the Sabour region of Bihar.

**Tuber crops**

Exotic seeds of cassava were received from the International Institute of Tropical Agriculture, Nigeria. Some species of tuber crops were collected from the forests of Gujarat. Two open-pollinated progenies of sweet-potato were put under mini-kit trials in Kerala.

Application of zinc increased the tuber yield, slightly reduced the HCN content and increased the starch content, without affecting the cooking quality of the tubers. The branching habit of cultivars was found to affect the tuber yield significantly.

The time taken for flower initiation in cassava and the sunshine hours during the first 4½ months of growth were found to be interrelated.

Fenitrothion or fenithion C 0.05 reduced the damage caused by the weevil in sweet-potato. The residues retained in the tubers were far below the tolerance limit.

Training on the production technology of tuber crops was offered to 185 farmers, including 15 tribals, and 150 junior agricultural officers of the Department of Agriculture, Kerala.

An International Workshop on Intercropping with cassava was held at Trivandrum from 27 November to 1 December, cosponsored by the ICAR and the IDRC, Canada. Under a coordinated project, 9 centres have been conducting work on cassava, sweet-potato, Colocasia, Amorphophallus and Dioscorea:

Intercropping tuber crops with okra (bhindi), soybean and short-duration pigeonpea was found to be profitable and an extra
source of income to farmers. Harvesting of cassava from 8 to 10 months gave yields ranging from 15 to 20 tonnes/ha.

White-tuberred sweet-potato 'S 30', a collection of the Andhra Pradesh Agricultural University, was found to be suitable for all the 3 seasons, yielding 12-20 tonnes/ha. The red-stained hybrid 'H 620' was also found suitable for year-round cultivation.

Treatment of sweet-potato crop with Sumithion @0.1 per cent produced tubers with lowest weevil population.

At Arunachal Pradesh cassava 'H 165' was the highest yielder (32.3 tonnes/ha).

Of the 13 sweet-potato varieties tried in the mid-hills of Meghalaya, ‘Pusa Red’ and ‘Coimbatore White’ were found to be promising, with yields of 18 and 13.8 tonnes/ha respectively.

**FLORICULTURE**

Rose varieties ‘Raja Surendra Singh of Nalagarh’, developed by Dr. B. P. Pal, and ‘Raktagandha’, developed at the Indian Agricultural Research Institute, produced blooms on long stems. Both these Hybrid Teas were found to be promising for the export of cut blooms.

The Indian Institute of Horticultural Research, Bangalore, developed attractive bougainvillaea cultivars ‘Dr. H. B. Singh’ and ‘Usha Sholay’, and promising gladiolus varieties and hybrids, ‘Watermelon Pink’, ‘Tropic Seas’, ‘Meena’ and ‘Sapna’.

The National Botanic Research Institute, Lucknow, developed a technique for the production of triploid F1 hybrids in marigold—an important step in the production of F1 hybrids in ornamentals in this country. In *Jasminum grandiflorum*, the recovery of concrete of superior quality was higher during May to August than in other months and there was a significant reduction in the recovery of concrete when the time of picking flowers was delayed beyond 11 a.m. In *J. sandwae* foliar application of 30 g N/plant was found to be adequate to secure normal yields and a higher recovery of concrete instead of the conventional soil application of 120 g N/plant. In *J. grandiflorum* the use of five-node succulent, leafy terminal stems in intermittent mist (one minute ‘on’ for five minutes ‘off’) in a medium of either sand or vermiculite, or a mixture of both, gave as much as 100 per cent rooting. IBA at 5,000 ppm promoted the rooting in the mist to 91 per cent, compared with 44 per cent in untreated control.
MEDICINAL AND AROMATIC PLANTS

**Solanum**

A new introduction of *Solanum laciniatum* (‘EC 114305’) from the USSR gave good performance at Solan (Himachal Pradesh). Its dry berries and leaves contained 5.0 and 3.25 per cent total glycosides (calculated as solasodine). At Anand (Gujarat), small plantlets of liquorice could be raised from callus tissue in 8 to 10 weeks. Physiological studies on *Catharanthus roseus* (*Lochnera rosea*; *Vinca rosea*) at Delhi showed that both detopping and deflowering would help increase root yield.

**Geranium**

Application of zinc and boron @20 kg/ha increased the herbage yield in geranium at Kodaikanal by 85.7 per cent. N application had a beneficial effect. When 15 kg of N was applied basally and 15 kg divided into 2 splits and given as foliar application, the herb yield increased by 47.5 per cent. The yield of herbage was 125 q/ha and that of essential oil 9.49 kg/ha.

2. FORAGE CROPS AND GRASSLAND

The improvement in livestock production is closely related to the improvement in the availability of nutritious forages. The present supply of forages in the country is less than half the total requirement. The major emphasis for the research being carried out at the Indian Grassland and Fodder Research Institute, Jhansi, and under the All-India Co-ordinated Research Project on Forage Crops has been to reduce this gap to meet the fodder requirements of the livestock.

**New varieties**

A number of high-yielding, disease-resistant nutritive varieties of forages were identified for cultivation. Berseem varieties ‘JB 1’, a selection from ‘Chhindwara Local’, ‘C 3-94’, a selection from ‘JB 1’, and ‘UPB 102’ were identified as the most promising varieties giving 12 to 20 per cent more yields than the existing varieties like ‘Mescavi’ and ‘S 99-1’. Other promising varieties like ‘UPB 101’, HG-A-B/101’ and ‘S 104’ were found to be fast-growing, succulent and nutritive.

In lucerne, the most productive varieties were ‘SS 627’, a selection from ‘Kuchh Local’, ‘Atir 9-503’ and ‘71-18’, which gave 6 to 10 per cent more forage than ‘T 9’. These varieties were fairly leafy, tolerant to rust and mildew, produced more seed, and had the capacity to regenerate uniformly and rapidly.
The single-cut oat variety '77-32' gave highest green forage yield of 462.3 q/ha. ‘S 3021’, ‘HFO 212 B’ and ‘OS 6’ were superior to the old variety ‘FOS 1/29’ and the newly released ‘HFO 114’. They were tall-growing, leafy, more nutritious and of medium duration. Among the 2-cut varieties, ‘UPO 94’, ‘UPO 160’ and ‘K 310’ were found most promising when the first cut was taken 60 to 65 days after sowing and second cut at 50 per cent flowering stage. Any delay in the first cutting reduced the regrowth owing to the enlargement of the growing point and its destruction during cutting.

Forage sarsun varieties ‘FS 902’ and ‘Sel 1’ gave a green-forage yield of 399 to 415 q/ha. The sweet forage of these quick-growing varieties should be mixed with berseem, oat and lucerne to increase the tonnage in the first cut.

Excellent work was done at Jhansi in the development of new hybrids of photosensitive pearl millet and Napier grass with ideal ideotypes having erect growth of bunchy plants. ‘Hybrid 3’ was suitable for intercropping with legumes like cowpea in alternate rows and the crops were complementary to each other’s growth, resulting in 50 per cent increase in forage of high quality. The hybrids had a very high proportion of leafiness not found in other hybrids developed earlier. ‘Hybrid 2’, with grassy habit and numerous tillers, was most suited for grazing.


Dinanath grass (Pennisetum pedicellatum) varieties ‘S 43-1’, ‘PP 3’, ‘JP 12’ and ‘PS 38’ (white) were superior to the existing variety, ‘T 15’, and gave higher yield than sorghum.

Management

Research showed that lucerne should be fertilized with 30 to 60 kg P\textsubscript{2}O\textsubscript{5}/ha to get the highest forage yield (10 per cent increase) over the control. For high yield of seed, the crop should be irrigated at an interval of 15 to 20 days after the last cut was taken for seed production at the end of February. Spray application of 2 to 4 per cent P\textsubscript{2}O\textsubscript{5} at flowering increased the seed yield.
considerably. Similar results were obtained in berseem-seed production. Irrigating the crop 3 times at 15-day intervals after taking the last forage harvest in the middle of March gave the highest seed yield of berseem.

The highest yield of forage was obtained when oat was supplied with 80 to 120 kg N/ha and only 3 or 4 irrigations. For getting quality seed, oat should be irrigated at least twice, first at the time of tiller initiation and the second at flowering. The total number of irrigations for high seed yield might vary from 3 to 5 depending upon the type of soil.

For obtaining good forage, cowpea should be sown @ 40 kg/ha at row spacing of 25 to 35 cm.

Silvipasture

In a fuel-fodder production system, a high fodder-yield was obtained when *Sesbania grandiflora* was intercropped with fodder pearl millet, which gave 50 to 55% more yield than when it was grown singly with the same amount of inputs. In addition, extra fuel and top fodder leaves could be obtained. This would have relevance to intensive dairy farming units established under operational flood programme.

Research showed that *Sesbania aegyptiaca* could be grown on field boundaries, along natural drains, on canal banks and along road sides for promoting fodder-fuel production from the land otherwise not used for crop production. The fodder produced under this system would be available during the scarcity period in summer.

Growing para grass along the slopes of the ponds, interplanted with *Sesbania*, showed considerable promise for the efficient use of sites otherwise unproductive.

The persistent growth of *Stylosanthes scabra* and *S. hamata* in natural grasslands in drylands indicated the possibility of using a pasture-legume component in natural grasslands. These observations received support from the results obtained in southern India, especially from the Hyderabad region.

*Transfer of technology*

The Indian Grassland and Fodder Research Institute was engaged in extending research findings of proven value to agencies engaged in forage and animal production through demonstrations,
mini-kit trials, operational research projects, kisan melas, exhibitions, publicity through press, radio broadcasts and correspondence. During the *kharif* and *rabi* seasons, 243 demonstrations on cowpea, maize, hybrid Napier, berseem and oats were carried out, and 1,635 mini-kit trials were undertaken on fuel-fodder fertilizer production of trees and shrubs in 19 states and union territories, using 3 varieties of fodder tree and shrub species *Leucaena leucocephala, Sesbania grandiflora* and *Sesbania aegyptiaca*. Similarly 200 mini-kit demonstrations in 14 blocks of Jhansi and Lalitpur were carried out with berseem ('S 99-1', 'Meskavi'), Japan sarson and oat ('Kent', 'S 3021' and 'S 2688'). Operational research was taken up at Ambabi and Pahadi villages on forage production, arable farming, silvipasture system, upgrading of milch animals, and animal health care.

The Institute played an important role in planning and implementation of demonstrations and other developmental programmes in the dryland development pilot project at Lalitpur in Uttar Pradesh, showing the impact of improved practices on sorghum, pigeonpea, rice, soybean, groundnut, sorghum-cowpea (fodder) and double cropping (fodder-fodder and fodder-grain system).

3. PLANT PROTECTION

Since plant-protection research is built into the activities of different crop institutes, the results are highlighted under the respective crops. However, information on some broad areas of plant-protection activities not covered elsewhere are reported below.

Three symposia were organized to take stock of the pesticide research in the country.

The first workshop on pesticide residues with special reference to sampling techniques was held at the Indian Agricultural Research Institute during 20-21 March 1978. It was suggested that all the pesticide schedules recommended by agricultural universities, state departments of agriculture and agricultural research institutes should be tested for the residues they leave on plant products. The existing laboratories that analyse pesticide residues should be strengthened and expanded, and there is the need to co-ordinate their work.

A symposium on pesticide residues in environment was held at the University of Agricultural Sciences, Bangalore, during 7-10
November 1978. Stress was laid on formulating practices that lead to minimum pollution of the environment.

At the workshop held during 29-30 June 1978 at the Indian Agricultural Research Institute, the important role of insecticides of plant origin in the country was discussed. This aspect of research should be strengthened and efforts should be directed to encourage the use of synthetic pyrithroids.

A review was made of the use of microbial pesticides, especially *Bacillus thuringiensis*, which is known to be very virulent against the silk-worm.

**Surveillance of diseases and pests**

The programme of research provided crucial information on the foci of infection of the 3 rusts of wheat and their spread to other areas. Based on this information, ‘Sonalika’ and ‘Girija’ were recommended for cultivation in hilly areas; ‘Arjun’, ‘HD 2122’, ‘HD 2177’ in the north-western plains; ‘Janak’, ‘HP 1102’ in Bihar and West Bengal; ‘HD 2189’ in Maharashtra; ‘CC 464’ and ‘HD 2135’ in the Nilgiri Hills; and ‘HD 4530’ in Rajasthan.

Under an all-India co-ordinated project, a production-orientated survey to monitor the performance of high-yielding varieties of rice against major pests and diseases revealed that ‘CR 157-392-41-212’, ‘CR 189-62-14’, ‘CR 189-62-15’, ‘RP 894-15-2-1-1’, ‘Pusa 5-2-3-6-2’ and ‘CR 10’ had a fair degree of tolerance to major pests, and ‘ARC 10646’ and ‘TR 2071-603-5-2-63’ were resistant to sheath-blight.

**Apple scab**

Apple scab, which adversely affected the apple industry in Jammu and Kashmir and Himachal Pradesh, drew considerable attention. On the basis of intensive surveys, endemic areas were spotted and an extensive programme of research initiated to fight this menace. As a follow-up action, scientists were entrusted with the job of finding a suitable method of forecasting the occurrence of this dreadful disease.

**Rodent pests**

A co-ordinated research programme on bait-shyness of and losses due to rats throughout the country showed that the cost-benefit ratio in rodent control operations ranges from 1 : 75 to
1 : 100. In view of the success of the programme, it was planned to add 4 more centres, and rodent management would be undertaken in a sizeable area over a cluster of villages in various regions. A training programme on rodent management was organized jointly by the Indian Council of Agricultural Research, agricultural universities and the Central Directorate of Plant Protection and state governments.

**Nematode pests**

The main emphasis on research in the All-India Co-ordinated Research Project on Nematode Pests of Crops was on the biology and host-parasite relationship of several species of nematodes in the various agroclimatic regions of the country. Research under this project is being continued at the 14 centres located throughout the country.

**Biological control of pests**

The All-India Co-ordinated Project on Biological Control of Crop Pests, launched in 1977, continued research at 13 centres located in the various agroecological regions of the country and recorded a number of parasites and predators of the pests affecting tomato, brinjal, okra, cabbage, capsicum, mango, citrus, rice, cotton, sugarcane, tobacco, coconut, cashew, coffee, apple and potato. Research conducted with *Pyrilla* and borers of sugarcane, coconut and arecanut indicated that biological control could possibly be utilized more fruitfully in coming years.

**Economic ornithology**

India is believed to have nearly 13% of the world’s bird species, but our knowledge on the economic aspects of birds—their beneficial as well as harmful effects on agriculture—is still fragmentary. Hence it was proposed to initiate an All-India Co-ordinated Programme on Economic Ornithology involving 8 different research centres, which will also assist in conserving useful birds.

**Seed pathology**

With an expansion in plant-protection activities and exchange of seed material through international research centres, complex problems of the spread of pests and diseases through seed and other propagating material was on the increase. Hence a project was formulated to provide much-needed support to the seed
industry in the country by way of production of healthy seeds and certification against diseases. The Danish Government offered support for intensifying research in the field of seed pathology.

The National Commission on Agriculture recommended the need of an all-India co-ordinated research project to strengthen bee research, a relatively new field in India. A project was formulated for the Sixth Plan with 14 centres, with the main co-ordinating centre at the Central Bee Research Institute, Pune.

White-grubs

White-grubs have assumed great importance and are a bottleneck in increasing groundnut production. Hence a co-ordinated programme of research at 5 centres was proposed to be taken up during the Sixth Plan.

4. SOIL AND WATER MANAGEMENT, AGRONOMY AND AGRICULTURAL ENGINEERING

Soil Survey and Land Use Planning

The National Bureau of Soil Survey and Land Use Planning started functioning from August 1, 1976 at the IARI, New Delhi. The headquarters of the Bureau was shifted to Nagpur in June, 1978. The Bureau undertakes progressive reconnaissance soil survey and mapping covering the different states of country. It also carries out research on characterisation of bench mark soils, their genesis, classification and interpretation, hydrological properties of soils, use of remote sensing techniques and interdisciplinary and inter-institutional research projects. The main findings of this Bureau during the current year are as follows:

Soil resource inventory and mapping

The Bureau completed the soil inventory and mapping of about 47 lakh hectares in the states of Punjab, Himachal Pradesh, Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Kerala, West Bengal and North-Eastern Region. The Soil Survey reports with soil maps and land-use plans were helpful in identifying problem and potential areas and furnishing the necessary basic information for planning and implementation of projects/experiments in the integrated rural development districts, hilly and backward areas, Bundelkhand Region (U.P.), agricultural university campuses, etc.
Interpretation of soil maps for available soil moisture

Studies to relate the Soil Units delineated on the map with available soil moisture taking into consideration the precipitation patterns in the semiarid region of Hissar (Haryana) made it possible to recommend crops for rainfed agriculture in *kharif* and irrigation needs in *rabi*. A rational crop calendar for varying textural families is given in Table 1.

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Available moisture (cm in 10 cm profile)</th>
<th>Rainfed</th>
<th>Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tohna (fine clay loam to clay)</td>
<td>21</td>
<td>Rice (<em>kharif</em>), Wheat and gram (<em>rabi</em>)</td>
<td>Rice (<em>kharif</em>), wheat (1 to 2 irrigations)</td>
</tr>
<tr>
<td>Hissar (fine loamy)</td>
<td>16</td>
<td>All climatically adopted <em>kharif</em> crops</td>
<td>Cotton (<em>kharif</em>), wheat (3 to 4 irrigations)</td>
</tr>
<tr>
<td>Juglara and Talwandi (coarse loamy)</td>
<td>11</td>
<td><em>Bajra</em> and <em>kharif</em> pulses</td>
<td>Cotton (<em>kharif</em>), wheat and gram (4 to 6 irrigations)</td>
</tr>
<tr>
<td>Thaska and Bandra (sandy)</td>
<td>8</td>
<td><em>Moth</em></td>
<td>Wheat, gram and mustard (6 to 7 irrigations)</td>
</tr>
</tbody>
</table>

Remote sensing

LANDSAT imagery analysis for the present drainage systems and buried channels in the deserts of Western Rajasthan coupled with geomorphic studies and ground truth data revealed that the dry beds of the prior and present drainage channels were potential zones for ground water exploitation.

Re-zoning of wheat regions

Keeping in view the need for micro-level zoning of wheat varieties for fitting them in with the eight agro-ecological regions adopted by the ICAR, the National Bureau made a detailed analysis of the existing wheat zones and rationalising the same according to soil and agro-climatic parameters. The nine wheat zones have been identified.

Land irrigability evaluation of Narmada Command Area, Gujarat

Out of 1.82 lakh hectares surveyed in Kutch (Bhuj), Rajkot and Surendranagar districts of Gujarat and classified under 33 levels — 6
Soil Series, it was observed that 45 per cent of the land possessed moderate to severe limitations, 20 per cent under the marginal class while the remaining 35 per cent temporarily classified as unsuitable. 90 per cent of the limitation was due to soil characteristic properties like soil permeability, structure, bulk density etc. and 10 per cent due to drainage and topographic problems.

**Hydrological soil properties of Ahmednagar district (Maharashtra)**

The hydrological properties of soils play an important role in the ground water assessment. The intake rates of soils of Ahmednagar district in many parts of irrigated area revealed that the sub-soils were somewhat impermeable, thus restricting the movement of water. There was a build up of hydrostatic pressure in the confined strata. Excessive irrigation ignoring the requirement of net irrigable depth for standing crops resulted in the rise of ground-water table to the level of the hydrostatic head in the wells above the saturated aquifers.

About 27 per cent of the well-water samples indicated high to very high salinity with medium sodium hazards; only 3 per cent of the waters could be used for normal irrigation. pH was high (8.1) and sodium per cent was high as compared with other cations. In view of these studies the quality control of irrigation water and provision of suitable drainage were stressed.

**Training**

During the year 1978, two regular six-month courses in Soil Survey were conducted at the Training Centre, Nagpur. Thirty-five candidates deputed from different states successfully completed the course.

**SOIL CONSERVATION**

The Central Soil and Water Conservation Research and Training Institute, Dehradun, and its six research stations located at Chandigarh, Kota, Vasad, Agra, Ootacamund and Bellary continued work on the problems of conservation of soil and water as natural resources and their management for higher production under various land-uses.

The main research findings of this Institute are as follows

**Runoff and soil losses**

At Kota, the experiments conducted on the runoff and soil losses under a micro watershed of 0.4 ha put under jowar + arhar
mixture (1 : 1) showed that the runoff varied from 4.9 to 39.8 per cent in different years (1974-75 to 1978) and soil loss from 0.39 to 8.19 tonnes/ha (Table 2).

Table 2: Rainfall, runoff, soil loss under jowar+arhar mixture at Kota.

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall (mm)</th>
<th>Runoff (%)</th>
<th>Soil loss (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-75</td>
<td>608.1</td>
<td>30.0</td>
<td>8.19</td>
</tr>
<tr>
<td>1975-76</td>
<td>762.4</td>
<td>22.4</td>
<td>3.55</td>
</tr>
<tr>
<td>1976-77</td>
<td>629.5</td>
<td>4.9</td>
<td>0.39</td>
</tr>
<tr>
<td>1977-78</td>
<td>710.0</td>
<td>17.3</td>
<td>1.37</td>
</tr>
<tr>
<td>1978</td>
<td>807.2</td>
<td>39.8</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Runoff and soil as influenced by soil conservation measures in tea plantations in steep slopes of the Nilgiri Hills at Ootacamund

At Ootacamund (Nilgiri Hills), five years research data revealed that soil and water conservation measures with mulch (15 to 25 tonnes/ha) and staggered contour trenches (4 to 6 m apart, 0.6 m wide at top, 0.3 m wide at bottom, 0.3 to 0.5 m deep) reduced soil loss from 16,000-40,000 kg/ha to 30-500 kg/ha and runoff from 9-16 per cent to 0.1-2 per cent of rainfall as compared with newly established tea plantation (control) without soil conservation measures (Table 3).

Table 3. Effect of treatment on runoff and sediment in tea plantation at Ootacamund (Av. of 1971—1975)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>%runoff to total rainfall</th>
<th>Soil loss (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With 90% canopy (Excellent)</td>
<td>0.1 to 1</td>
<td>30 to 500</td>
</tr>
<tr>
<td>With 65% canopy (Fair)</td>
<td>0.1 to 1</td>
<td>30 to 500</td>
</tr>
<tr>
<td>With 15% canopy (Poor)</td>
<td>1 to 2</td>
<td>500 to 1,000</td>
</tr>
<tr>
<td>Newly established (control)</td>
<td>9 to 16</td>
<td>16,000 to 40,000</td>
</tr>
<tr>
<td>Newly established (with mulch and drain)</td>
<td>0.1 to 2</td>
<td>30 to 500</td>
</tr>
<tr>
<td>Newly established (with mulch only)</td>
<td>0.1 to 2</td>
<td>30 to 500</td>
</tr>
<tr>
<td>Newly established (with drains only)</td>
<td>0.4 to 2</td>
<td>400 to 1,000</td>
</tr>
</tbody>
</table>

Effect of loss of top-soil on maize and wheat yields—Dehradun

An experiment was conducted in kharif 1977 and 1978, and in rabi (1977-78) to study the effect of removal of top-soil on the
yield of maize (var. 'Ganga-5') and wheat (var. 'HD-1553') under rainfed conditions. The yield of maize and wheat crops progressively and significantly decreased with the increase in the removal of top-soil, indicating that it was extremely important to conserve the top-soil if the agricultural production base was to be maintained and improved.

**Double cropping on reclaimed ravine land under rainfed conditions at Agra**

At Agra (semi-arid region), with an annual rainfall of 765 mm, single crop is the normal practice under rainfed conditions. With the availability of short-duration *moong* variety ('PS-16') maturing in about 60 days, it was possible to raise two crops in a year. A crop sequence of *moong* and mustard (i.e. a pulse and oil-seed crop) gave a yield of 722 kg/ha of *moong* grain and 1,252 kg/ha of mustard seed (Table 4).

**Table 4. Grain yield (kg/ha) of different crop sequences under rainfed conditions at Agra**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Khairf</td>
</tr>
<tr>
<td><em>Moong</em> ('PS-16')-Mustard ('Varuna')</td>
<td>722</td>
</tr>
<tr>
<td><em>Moong</em>—Barley ('Ratna')</td>
<td>736</td>
</tr>
<tr>
<td><em>Bajra</em>—Fallow</td>
<td>1769</td>
</tr>
<tr>
<td>Fallow-Mustard</td>
<td>—</td>
</tr>
<tr>
<td>Fallow- <em>Taramiri</em></td>
<td>—</td>
</tr>
<tr>
<td>Fallow-Barley</td>
<td>—</td>
</tr>
</tbody>
</table>

*Crop was affected by frost.

**Use of mulches for conserving soil moisture**

In Doon Valley, rainfed *rabi* crops have to be grown with the conserved soil moisture of the monsoon season. There is considerable soil moisture loss by evaporation during the months of September and October, when the *kharif* crops have been harvested. An experiment was conducted with different mulch treatments to conserve soil moisture for utilization by *rabi* crops and obtain maximum yield from the same quantity of soil moisture. Three years average data indicated that grass-mulch and mulching before sowing increased the yield of wheat grain from
2369 to 3314 kg/ha (i.e. 39.9 per cent increase over control). However, dust-mulch appeared to be most practical way for conservation of moisture for wheat.

Training

Professional training in soil and water conservation continued to be imparted under regular courses of 22-weeks duration. Officers deputed by different State Departments were trained at the Institute while the non-gazetted graduate assistants were trained at the training Centres at Kota (Rajasthan), Ootacamund (Tamil Nadu), Bellary (Karnataka) and the collaborating training Centre at Hazaribagh DVC (Bihar). A total of 44 gazetted officers (at Dehradun) and 110 non-gazetted (24 at Ootacamund, 36 at Kota, 16 at Bellary and 34 at Hazaribagh) assistant trainees received the professional training in soil and water conservation for managing the action programme in the states in 1978.

A short course in ‘Watershed Management’ for 10 days was conducted at the Institute Headquarters. Thirty senior officers from different state governments participated.

So far (up to September 30, 1978), Institute and its Research Stations trained 1,101 gazetted officers and 3,560 assistants in regular courses in soil and water conservation as given in Table 5.

<table>
<thead>
<tr>
<th>Centre</th>
<th>Trained up to September 30, 1978</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Officers</td>
</tr>
<tr>
<td>Dehradun</td>
<td>1015</td>
</tr>
<tr>
<td>Ootacamund</td>
<td>86</td>
</tr>
<tr>
<td>Kota</td>
<td></td>
</tr>
<tr>
<td>Bellary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,101</td>
</tr>
<tr>
<td>Hazaribagh (DVC)</td>
<td></td>
</tr>
</tbody>
</table>
Watershed management at Fakot (Dehra Dun)

An Operational Research Project of about 370 ha was selected in the middle Himalayas in Narendranagar Block at Fakot village in Tehri Garhwal District in 1974. The watershed is typical for the catchments of Tehri Dam. The watershed selected for operations is in hilly terrain varying in elevation from 650 to 2015 ft.

The yields of high-yielding varieties of crops grown in the farmers’ field in the watershed are given in Table 6.

<table>
<thead>
<tr>
<th>Crop</th>
<th>High-yielding variety</th>
<th>Variety</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabi 1977-78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>'HD 2021'</td>
<td>Local</td>
<td>44.27</td>
</tr>
<tr>
<td>Barley</td>
<td>'PL 56'</td>
<td>Do.</td>
<td>31.56</td>
</tr>
<tr>
<td>Toria</td>
<td>'T-9'</td>
<td>Do.</td>
<td>5.24</td>
</tr>
<tr>
<td>Kharif 1978</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>'P-33'</td>
<td>Local</td>
<td>52.0</td>
</tr>
<tr>
<td>Maize</td>
<td>'VL-52'</td>
<td>Do.</td>
<td>47.5</td>
</tr>
</tbody>
</table>

In addition to above, varieties of haldi and ginger were also tried.

Out of 12 varieties of haldi tried, var. ‘Dahghi’ yielded 178.5 q/ha as compared with local variety which yielded 41.7 q/ha. Among the 6 varieties of ginger tried, var. ‘Kumar-mangalam’ yielded 136.69 q/ha as compared with local variety which yielded 38.04 q/ha.

SOIL SALINITY RESEARCH AND RECLAMATION TECHNOLOGY

Gypsum fineness and sodic soil reclamation

Laboratory and field studies showed that for reclamation of highly sodic soils commonly found in Indo-Gangetic plains, it was not necessary to grind gypsum to very fine grades, e.g. 60 or 100 mesh as recommended earlier. Passing gypsum through 2.00 mm sieve resulted in a whole range of particle sizes with nearly 50 per cent below 0.25 mm size. Grinding gypsum to pass through 2.00 mm sieve would, therefore, result in reducing the overall cost of gypsum.
Fluorine content in sodic soils

Laboratory and pot-culture studies showed that water extractable fluorine in soils and its uptake by plants increased with increasing soil sodicity and pH (Fig. 1). Further, plants grown in sodic soils are likely to contain toxic concentration of fluorine. It will, therefore, be desirable to reduce soil sodicity/pH by application of amendments, e.g. gypsum. It was observed that the total fluorine content of the soil had little influence on water-soluble fluorine and, therefore, small amounts of fluorine added through gypsum would not result in increasing soluble fluorine in soil to any appreciable extent.

![Graph showing the relationship between water extractable F in soil and uptake of F by wheat straw.](image)

**Fig. 1.** Relationship between water extractable F in soil and uptake of F by wheat straw.

Exchangeable sodium percentage and yield of raya

Effect of exchangeable sodium on the yield, oil content and chemical composition of raya (Brassica juncea) was studied under field conditions. Exchangeable sodium percentage (ESP)
more than 23 delayed germination emergence of flower and pods but enhanced maturity. The grain and oil-yield were significantly reduced above ESP 23 (Table 1). Decrease in grain-yield was associated with a sodium content of 0.28 per cent and Ca/Na and K/Na ratio of 3 in the stem at maturity.

Table 1. Effect of ESP on grain-yield and oil content of *Brassica juncea*

<table>
<thead>
<tr>
<th>ESP</th>
<th>Grain yield (kg/ha)</th>
<th>Oil content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6</td>
<td>1,010</td>
<td>40.7</td>
</tr>
<tr>
<td>12.5</td>
<td>954</td>
<td>41.3</td>
</tr>
<tr>
<td>16.6</td>
<td>965</td>
<td>41.0</td>
</tr>
<tr>
<td>23.0</td>
<td>875</td>
<td>40.6</td>
</tr>
<tr>
<td>44.2</td>
<td>713</td>
<td>37.4</td>
</tr>
</tbody>
</table>

Relative tolerance of crops to exchangeable sodium

Crops differ in their tolerance to excess exchangeable sodium, therefore, knowledge of the relative tolerance of crops in this context will be helpful in proper selection of crops for cultivation in soils of varying sodicities. As a result of studies undertaken in the past few years at CSSRI, Karnal, some of the common crops can be listed according to their tolerance to exchangeable sodium (Table 2). These results showed that unlike tolerance to salinity, barley was only moderately tolerant to exchangeable sodium. Rice on the other hand, is very tolerant. Crops like gram, cowpea, lentil, etc. were sensitive to sodic conditions and, therefore, were not recommended to be grown in sodic soils during initial years of reclamation.

Table 2. Relative tolerance of crops to exchangeable sodium (alkali soils)

<table>
<thead>
<tr>
<th>Tolerant</th>
<th>Semi-tolerant</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermuda grass</td>
<td>Wheat</td>
<td>Cowpea</td>
</tr>
<tr>
<td>Para grass</td>
<td>Barley</td>
<td>Gram</td>
</tr>
<tr>
<td>Rice</td>
<td>Oats</td>
<td>Groundnut</td>
</tr>
<tr>
<td><em>Raya</em></td>
<td><em>Lentil</em></td>
<td></td>
</tr>
<tr>
<td><em>Senji</em></td>
<td><em>Mash</em></td>
<td></td>
</tr>
<tr>
<td><em>Berseem</em></td>
<td><em>Mung</em></td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td>Peas</td>
<td></td>
</tr>
<tr>
<td>Millets</td>
<td>Maize</td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>Cotton (at germination)</td>
<td></td>
</tr>
</tbody>
</table>
Use of saline water for wheat cultivation

Studies on the use of synthetically prepared saline irrigation water of varying EC (0.6 to 16 mmhos/cm) in lysimeter revealed that in dune sand wheat yield remained unaffected even at EC 16 mmhos/cm but in the absence of sufficient summer and winter rain this limit of EC, was reduced to 8. In case of heavier sandy loam soil, such safe limits of EC were found to vary from 8-12 mmhos/cm, depending on rainfall. Summer rainfall of 627 mm after harvest of the last crop resulted in complete removal of accumulated salts from the entire profile of dune sand against a net accumulation of varying degree of salt in sandy loam soil beyond EC of 8 mmhos/cm.

Role of magnesium in influencing the physico-chemical properties of salt-affected soils

In a laboratory study, the effect of different qualities of irrigation water containing varying Mg/Ca ratios (2, 4, 8 and 16) with an electrolyte concentration of 120 me/1 and SAR of 10 on the hydraulic conductivity of alluvial sandy loam soil from Karnal and heavy black clay soil from Indore was evaluated. The hydraulic conductivity decreased with an increase in Mg/Ca ratio in irrigation water in both soils, the extent of decrease being more in black soil as compared with alluvial soil (Fig. 2). Further, the hydraulic conductivity at Mg/Ca ratio of 2 was significantly lower as compared with control in both soils. In the same study, the effect of leaching with water having varying Mg/Ca ratios in the electrolyte concentrations of 20 and 89 me/1 with SAR of 10 on the relative adsorption of Mg and Ca on the exchange complex was also examined in case of alluvial soil. Mg/Ca ratios attained in the soil varied from 10.4 to 3.09 in case of electrolyte concentration of 20 me/1 and from 1.61 to 7.27 in case of electrolyte concentration of 80 me/1 at different Mg/Ca ratios. At a particular Mg/Ca ratio in irrigation water, the adsorption of Mg by the soil was more at higher electrolyte concentration.

Planning and updating of irrigation schedule for a canal minor command area

The results of various agronomic studies conducted in sodic soils showed that the best time of transplanting long-duration varieties of rice like ('IR-8', 'IR-8-68' and 'Jaya') at Karnal was from June 25 to July 7. In order to optimize the use of irrigation water, a mathematical model for determining the optimum planting schedule in command area of a minor canal was
Fig. 2. Effect of leaching with irrigation water having varying Mg/Ca ratios on hydraulic conductivity of two soils.

developed and tested with data from Kachwa Minor command area of Western Jammu Canal. The recommended transplanting schedule of rice (Fig. 3) would reduce the peak of tubewell withdrawals by about 25 per cent leading to a possible reduction in the number of tubewells required within the area and which is also the optimum time for transplanting the above-mentioned varieties of rice.

Selection of crops and varieties for coastal saline conditions of Sunderbans (Canning Town)

Barley. The results of a co-ordinated varietal trial on barley with 44 promising barley varieties and one wheat variety 'HD—
2009' in coastal saline soils of CSSRI Research Farm, Canning
(ECe during the crop period ranged from 2.6 to 18.1 mmhos/
cm) indicated that among barley checks, 'Jyoti' (1.86 tonnes/ha)
yielded more in comparison with 'Rama' (1.47 tonnes/ha), 'DL
3' (1.22 tonnes/ha) and 'RS 6' (0.99 tonnes/ha). Wheat variety
'HD 2009' yielded only 0.42 tonnes/ha. Therefore, it appeared
that barley had an edge over wheat in Sunderbans coastal saline
conditions.

Linseed. In an evaluation trial conducted at Canning Town,
with 22 promising indigenous and exotic linseed varieties/strains
grown in a randomised block design with 3 replications and
fertilized @ N₃₀ P₃₀ K₃₀ kg/ha (ECe 0-15 cm soils ranged
from 5.71 to 17.01 mmhos/cm during crop period), it was ob­
served that 'NP 71' is the best variety for saline soil conditions
as far as its productivity per unit area and time is concerned. The other high performing varieties worth name are '219-1-2' and '219-1-1'.

Transfer of technology: reclamation of alkali soils

Under the Operational Research Project, two clusters of villages—one of four and the other of three villages were selected in kharif 1975 and 1977 respectively to test and demonstrate the technology under farmers' conditions, to work-out its credit worthiness and to identify constraints in its large-scale adoption by the farmers. Up to 1978, 472 demonstrations (0.2 or 0.4 ha size) were conducted and a total of 722.1 ha of alkali land up to 1978 were brought under cultivation (Table 3). Further, additional 8,000 tonnes of foodgrains were produced during 1975-78 from these hitherto alkali lands which had been lying barren for decades. Besides, there was considerable improvement in soil properties of the land after these were brought under cultivation. The average pH (0-15 cm soil) and ECe before reclamation were 10.3 and 1.88 mmhos/cm which decreased to 8.9 and 0.67 mmhos/cm after one year of reclamation.

Table 3. Progress of reclamation of alkali soils under Operational Research Project (1975-78), in Karnal District

<table>
<thead>
<tr>
<th>Cluster of villages</th>
<th>No. of demonstr. plots During 1978</th>
<th>Grain yield (tonnes/ha)</th>
<th>Total area reclaimed (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 1978</td>
<td>Rice 1978</td>
<td>Wheat 77-78</td>
</tr>
<tr>
<td>Kachwa</td>
<td>70</td>
<td>4.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Sagga</td>
<td>34</td>
<td>4.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Bir Naraina</td>
<td>78</td>
<td>2.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Sambhli</td>
<td>34</td>
<td>4.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Gudha</td>
<td>78</td>
<td>4.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Begampur</td>
<td>34</td>
<td>4.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Dadlana</td>
<td>78</td>
<td>4.4</td>
<td>2.0</td>
</tr>
</tbody>
</table>

WATER MANAGEMENT

The Integrated Project on Water Management and Soil Salinity continued at 23 research centres with its co-ordinating unit at the CSSRI, Karnal. The salient research findings are as under:
Irrigation scheduling in crops for efficient water-use

Groundnut. On sandy loam soil at Bhavanisagar, delayed irrigation at \( \frac{I\text{W}}{C\text{PE}} \) ratio (\( I\text{W} = \text{Depth of irrigation water} \) and \( C\text{PE} = \text{Cumulative Pan Evaporation value} \)) of 0.6 with 5 cm irrigation depth produced as much pod yields as \( \frac{I\text{W}}{C\text{PE}} \) ratio of 1.05 and resulted in the saving of 6 irrigations. At Rahuri also, where the soil is black clay, the highest pod yield was obtained at \( \frac{I\text{W}}{C\text{PE}} \) ratio of 0.6.

- Gram. At Dharwar, with the increase in the frequency of irrigation on black clay soil, the grain yield increased significantly. The highest yield was obtained at \( \frac{I\text{W}}{C\text{PE}} \) ratio of 0.8. A 6-cm irrigation depth each time gave additional 2 q/ha of grain yield over 8-cm depth of irrigation (Fig. 4). The interaction between

![Graph showing grain yield vs. irrigation frequency at Dharwar and Rahuri](image-url)

**Fig. 4.** Effect of moisture stress on the grain yield of gram (q/ha) at Dharwar and Rahuri.
irrigation depth and $IW/CPE$ ratio was significant and accordingly
the highest grain yield was attained at $IW/CPE$ ratio of 0.8 with
6-cm irrigation depth. On black clay soil at Rahuri, very good
yield of gram was obtained with application of irrigation. The
optimum irrigation schedule with 6-cm depth of irrigation was
at $IW/CPE$ ratio of 0.75.

Urd. At Madurai, the grain yield of blackgram declined
significantly when irrigation was applied at soil moisture stress
higher than 75% available soil moisture measured in 0—30 cm
depth. Increase in irrigation frequency above 75% depletion of
ASM (Available Soil Moisture) was not of any benefit (Table 1.)

Table 1. Effect of moisture regime on grain yield of blackgram
during *rabi* season at Madurai.

<table>
<thead>
<tr>
<th>Depletion of ASM before irrigation</th>
<th>No. of irrigations</th>
<th>Depth of irrigation (cm)</th>
<th>Grain yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed</td>
<td></td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>75</td>
<td></td>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>7</td>
<td>36</td>
</tr>
</tbody>
</table>

Rainfall (cm) | 5 | — |

Sorghum. At Dharwar, during *kharif* season the grain and
fodder yields of sorghum were significantly higher with the appli-
cation of irrigation as compared with no irrigation treatment.
The highest grain and fodder yields were obtained with irrigation
at 50% depletion of available soil moisture from 0-30 cm soil
layer (Table 2). In *rabi* season, the yield of sorghum was more
than that obtained in *kharif* season.

Table 2. Effect of moisture regimes on grain and fodder yields
(q/ha) of sorghum in *kharif* at Dharwar.

<table>
<thead>
<tr>
<th>Depletion of ASM before irrigation</th>
<th><em>No. of irrigations</em></th>
<th>Depth of irrigation (cm)</th>
<th>Fodder yield (q/ha)</th>
<th>Grain yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>4</td>
<td>39.0</td>
<td>67.1</td>
<td>36.2</td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>42.5</td>
<td>68.8</td>
<td>38.0</td>
</tr>
<tr>
<td>75</td>
<td>3</td>
<td>46.1</td>
<td>65.5</td>
<td>35.9</td>
</tr>
<tr>
<td>Control (No irrigation)</td>
<td></td>
<td></td>
<td>52.7</td>
<td>32.2</td>
</tr>
<tr>
<td>C. D. at 5%</td>
<td></td>
<td></td>
<td>13.9</td>
<td>3.5</td>
</tr>
<tr>
<td>Rainfall (cm)</td>
<td></td>
<td></td>
<td>28.8</td>
<td></td>
</tr>
</tbody>
</table>

*One common irrigation was applied in all the treatments at sowing.*
With 6 irrigations each of 6-cm depth applied at IW/CPE ratio 0.6, about 61 q/ha of yield was obtained. Further increase in IW/CPE ratio did not increase the grain yield significantly. 8-cm depth of irrigation, on the whole, was inferior to 6-cm irrigation depth (Table 3). Unlike Dharwar not more than one irrigation was needed for optimum grain yield of sorghum during kharif season at Rahuri.

Table 3. Effect of different irrigation schedules on grain yield of sorghum at Dharwar (rabi) and Rahuri (kharif)

<table>
<thead>
<tr>
<th>IW/CPE ratios</th>
<th>Grain yield (q/ha)</th>
<th>Rahuri (kharif)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dharwar (rabi)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth of irrigation</td>
<td>6 cm</td>
</tr>
<tr>
<td>0.40</td>
<td>52.0(4) 46.9(3)</td>
<td>49.5(4)</td>
</tr>
<tr>
<td>0.60</td>
<td>60.9(6) 98.5(5)</td>
<td>59.7(6)</td>
</tr>
<tr>
<td>0.80</td>
<td>63.0(7) 59.4(6)</td>
<td>61.2(7)</td>
</tr>
<tr>
<td>0.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unirrig. (control)</td>
<td></td>
<td>39.6</td>
</tr>
<tr>
<td>Rainfall (cm)</td>
<td>1.5</td>
<td>17.6</td>
</tr>
</tbody>
</table>

Note: Figures in the brackets indicate number of irrigations.

Maize. The effect of different moisture regimes on grain and fodder yield of maize at Dharwar revealed that the highest grain yield was obtained with irrigation at 50% depletion of available soil moisture from 0-30 cm depth and this was significantly superior to rest of the treatments (Table 4). But in case of fodder yield the highest yield was obtained with irrigation at 25% depletion of available soil moisture.

Table 4. Effect of moisture regimes on the grain and fodder yield of maize during kharif season at Dharwar

<table>
<thead>
<tr>
<th>Depletion of ASM before irrigation (%)</th>
<th>No. of Irrigations*</th>
<th>Grain yield (q/ha)</th>
<th>Fodder yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>6</td>
<td>48.8</td>
<td>83.7</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
<td>54.6</td>
<td>75.7</td>
</tr>
<tr>
<td>75</td>
<td>4</td>
<td>43.3</td>
<td>67.7</td>
</tr>
<tr>
<td>Unirrig. (control)</td>
<td>0</td>
<td>30.8</td>
<td>52.0</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td></td>
<td>5.6</td>
<td>10.4</td>
</tr>
</tbody>
</table>

*Includes two common irrigations applied in first three treatments at sowing and 6 days thereafter.
Cotton. Studies on irrigation schedules of cotton in relation to mulches carried out at Madurai centre revealed that irrigation at IW/CPE ratio 0.75 coupled with sorghum-straw mulch produced the highest seed-cotton yield and this was at par with IW/CPE ratio of 0.90 without mulch. Thus, there was economy of 3 irrigations (18 cm depth), in the former treatment as compared with the latter. Sugarcane-trash mulch was somewhat inferior to sorghum-straw mulch.

**Water-management under high water-table conditions**

**Water-table depth**

The critical water-table depths for different field crops were found out by lysimetry under controlled conditions, and are shown in Fig. 5.
Tolerance of crops to salinity and alkalinity

Considering the prevalent practice of 50% reduction in crop yield as the criterion, the critical levels of salinity and alkalinity for some of the prominent varieties of crops were worked out at different centres as given in Table 5.

Table 5

<table>
<thead>
<tr>
<th>Centre (soil type)</th>
<th>Crop</th>
<th>Variety</th>
<th>Critical level of soil salinity ECe (mmhos/cm)</th>
<th>Variety</th>
<th>Critical ESP level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hissar (sandy loam soil)</td>
<td>Wheat</td>
<td>'P34A', 'PB-18' and 'WH-101', 'P 369', 'P499' and 'V-277'</td>
<td>8</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kanpur (sandy loam soil)</td>
<td>Rice</td>
<td>'IR-8', 'Mt. 1', 'Jaya' and 'Padma'</td>
<td>15</td>
<td>'Pokkali', 'Jaya' and 'IR-8' and 'Saket'</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Barley</td>
<td>'K-131', 'K-135' and 'Amber', 'Ratna' and 'Vijay'</td>
<td>20</td>
<td>'Ratna' and 'Jaya'</td>
<td>30</td>
</tr>
<tr>
<td>Indore (clay soil)</td>
<td>Maize</td>
<td>'Ganga-5'</td>
<td>5</td>
<td>'Chandan-2'</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Cotton</td>
<td>'KH-33/1146'</td>
<td>10</td>
<td>'KH-33/1146'</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Jowar</td>
<td>—</td>
<td>—</td>
<td>'61-1-1'</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Safflower</td>
<td>'IC-11972'</td>
<td>10</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Berseem</td>
<td>—</td>
<td>—</td>
<td>Local</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Mustard</td>
<td>'TH-17'</td>
<td>15</td>
<td>'TH-17'</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Barley</td>
<td>—</td>
<td>—</td>
<td>'DL-106'</td>
<td>—</td>
</tr>
<tr>
<td>Dharwar (clay soil)</td>
<td>Rice</td>
<td>'MR18', 'MR-21'</td>
<td>10</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>'CSH-5'</td>
<td>16</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Setaria</td>
<td>Local</td>
<td>18</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>—</td>
<td>—</td>
<td>'Deccan hybrid 101' &amp; 'Shakti'</td>
<td>20</td>
</tr>
</tbody>
</table>
Water management in high rainfall areas

Studies conducted at Shillong indicated that 76 to 85% of the incident rainfall is lost as run-off and deep percolation losses. In case of kharif potato and maize about 16% of the rainfall is used for crop production. Whereas the second crop of potato grown under receding moisture conditions utilised two-thirds of its total requirement from the stored moisture.

At Kalimpong, 3 irrigations of 7.5 cm each at CR1, jointing and booting stages produced the maximum wheat grain yield of 57.5 q/ha.

Under Palampur conditions, maximum yield of potato (120 q/ha) was obtained by scheduling irrigation at 50% available moisture from 0-30 cm. There was a positive response in yield to application of K up to 160 kg/ha. At Kalimpong, an yield of 120 q/ha could be obtained by applying 2 irrigations of 7.5 cm each at 50% plant emergence and stolon formation stages.

Mulching with pine needles was found to be beneficial at Palampur by increasing the kharif crop yields from 1% to 28% and from 24 to 36% in case of wheat. It also helped to reduce the run-off losses in wheat to the extent of about 50%.

Based on five years studies, the most economic crop rotation for Palampur appeared to be one in which maize is the kharif crop followed by wheat/berseem/potato in the rabi.

Use of saline water in agriculture

The experiment to examine the effect of various combinations of good (canal) and poor (well/tubewell) quality water was conducted with cowpea at Agra, ragi and groundnut at Bapatla and rice at Dharwar centres. In general, maximum yield was obtained under complete canal water treatment and lowest yield was obtained in complete tubewell water treatment (saline water). The reduction in yield of all crops was minimum when two irrigations of canal water were followed by one saline water irrigation and, therefore, conjunctive use involving two canal water irrigations followed by one tubewell water could be adopted with very small reduction in crop yields. The effect of conjunctive use of saline tubewell water and good quality canal water on
cowpea crop at Agra is shown in Fig. 6. As the proportion of canal water increased in the saline tubewell water, the yields of cowpea increased accordingly.

Fig. 6. Conjunctive use of saline tubewell water and good quality canal water on cowpea crop at Agra.

SOIL MANAGEMENT

Micronutrients in soils and plants

The Co-ordinated Scheme on Micronutrients in Soils and Plants continued its operation at 9 centres, namely, New Delhi, Ludhiana, Lucknow, Ranchi, Jabalpur, Coimbatore, Anand, Hyderabad and Hissar. The salient research findings achieved during the current year are as under:
At all the above centres 9,300 soil and 1,086 plant samples were analysed for zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) content. The results are presented in Table 6.

Table 6. Distribution of Zn-Fe-Mn and Cu-deficient soil samples in some states of India

<table>
<thead>
<tr>
<th>State (St)</th>
<th>No. of samples analysed</th>
<th>Per cent samples deficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zn</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>276</td>
<td>67</td>
</tr>
<tr>
<td>Bihar</td>
<td>1000</td>
<td>17</td>
</tr>
<tr>
<td>Gujarat</td>
<td>2815</td>
<td>30</td>
</tr>
<tr>
<td>Haryana</td>
<td>494</td>
<td>83</td>
</tr>
<tr>
<td>Karnataka</td>
<td>1500</td>
<td>15</td>
</tr>
<tr>
<td>Kerala</td>
<td>64</td>
<td>39</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>511</td>
<td>79</td>
</tr>
<tr>
<td>Punjab</td>
<td>1151</td>
<td>64</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>959</td>
<td>15</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>585</td>
<td>75</td>
</tr>
</tbody>
</table>

From the Table 6 it is observed that zinc deficiency is most widespread as compared with other micronutrients. In Tamil Nadu, 47 per cent of the soil samples were deficient in copper (Cu) whereas in Madhya Pradesh more than 50 per cent of the soils showed manganese deficiency and in Haryana about 34 per cent soil samples were deficient in iron.

Response of crops to micronutrients

Seven hundred and thirty-five (Table 7) and 256 greenhouse experiments were conducted to study the response of different crops to micronutrient application. Regardless of the crop or type of experiment, response to Zn addition was studied extensively. Remarkably, like the soil analysis data, its deficiency was also most widespread as was confirmed by the proportion of responsive soils to its application. The results are presented in Table 7.
Table 7. Extent of soils responding to micronutrient application (Field experiments 1976-77)

<table>
<thead>
<tr>
<th>State</th>
<th>Nutrient</th>
<th>Total No. of Experiments</th>
<th>Range</th>
<th>% soils responding</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bihar</td>
<td>Zn</td>
<td>30</td>
<td>10.3-43.7</td>
<td>70.0</td>
<td>Wheat</td>
</tr>
<tr>
<td></td>
<td>Cu</td>
<td>30</td>
<td>11.3-44.3</td>
<td>50.0</td>
<td>Paddy</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>30</td>
<td>11.6-50.0</td>
<td>66.7</td>
<td>do</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>30</td>
<td>12.2-33.8</td>
<td>40.0</td>
<td>do</td>
</tr>
<tr>
<td>Punjaban</td>
<td>Zn</td>
<td>26</td>
<td>10.0-23.6</td>
<td>38.5</td>
<td>Maize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>12.5-94.8</td>
<td>100.0</td>
<td>Rice</td>
</tr>
<tr>
<td>Punjab</td>
<td>Mn</td>
<td>26</td>
<td>11.6-50.0</td>
<td>66.7</td>
<td>do</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>30</td>
<td>12.2-33.8</td>
<td>40.0</td>
<td>do</td>
</tr>
<tr>
<td>Bihar</td>
<td>Zn</td>
<td>5</td>
<td>16-81.0</td>
<td>33.3</td>
<td>Wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130</td>
<td>10.3-53.8</td>
<td>43.8</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130</td>
<td>10.1-48.3</td>
<td>30.0</td>
<td>-do-</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>Zn</td>
<td>13</td>
<td>10.0-56.7</td>
<td>76.9</td>
<td>Wheat</td>
</tr>
<tr>
<td>Haryana</td>
<td>Zn</td>
<td>54</td>
<td>11.5-12.9</td>
<td>42.6</td>
<td>Wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37</td>
<td>10.2-11.8</td>
<td>43.2</td>
<td>Ragi</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>Zn</td>
<td>81</td>
<td>10.0-105.9</td>
<td>73.1</td>
<td>Rice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53</td>
<td>10-46.1</td>
<td>27.0</td>
<td>Kharif rice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110</td>
<td>10-116.0</td>
<td>28.2</td>
<td>Ragi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>10-81.8</td>
<td>54.5</td>
<td>Rice</td>
</tr>
</tbody>
</table>

Zinc response was significant in 43 per cent and 72 per cent of the field and greenhouse experiments respectively. A critical evaluation of the data showed that yield increases (more than 50 per cent) brought about by zinc treatment were not uncommon. Further, the data revealed that zinc deficiency was not only restricted to important crops like wheat and rice alone but it could be obstacle to higher yields in less important crops also.

In Andhra Pradesh, *ragi* responded to the application of zinc in more than 50 per cent of the 34 field experiments. Remarkably, at a few locations, the yield increase by zinc was more than 80%. Response to other micronutrients was confined to a few states only.

**Depletion of micronutrients**

The micronutrient depletion studies revealed that different soils were depleted differently of their Zn, Fe, Mn and Cu con-
tents. In general, more nutrients were removed from heavy-textured soils than from the light-textured soils.

Wide variations were observed in the nutrient-removing capacity of different crops in Andhra Pradesh. In spite of lower dry matter yield, sorghum removed more Fe than wheat. Similarly, cowpea depleted soils more of its Mo content than either wheat or jowar. In contrast, total uptake of Mn, Zn and Cu was higher by wheat.

Regardless of the crop, more nutrients were removed if the dry matter production was high either because of inherent soil fertility or as a result of N P K fertilization. This was supported by more uptake of Zn, Fe, Mn, Cu, Mo and S by a cropping sequence which out-yielded the other crop rotations. On these basis, micronutrient problems are expected to appear faster in intensively cultivated areas.

**Tolerance of crop varieties to micronutrient deficiencies**

Not only different crops but also the genotype of a crop exhibited differential tolerance to micronutrient deficiencies. The crop varieties which tolerated zinc deficiency better than others are presented in the Table 8. Cultivation of these varieties is expected to economise on the micronutrient-use.

**Table 8. Relative susceptibility of different crops in descending order to zinc deficiency**

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Relative susceptibility of different varieties in descending order to zinc deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ludhiana</td>
<td>Wheat</td>
<td>'WG 357', 'WG 377', 'WL 711', 'HD 2009', 'PV 18', 'Kalyansona'</td>
</tr>
<tr>
<td>Hissar</td>
<td>Pigeon pea</td>
<td>'Pant A-1, 'H 72-44', 'C-21', 'Pant A-2', 'Prabhat Pant A-3'</td>
</tr>
<tr>
<td>Coimbatore</td>
<td>Rice</td>
<td>'IR 8', 'RP 4-14', 'Cul. 13493', 'Co. 38', 'TANU 658', 'Bhavani'</td>
</tr>
<tr>
<td></td>
<td>Ragi</td>
<td>'Ragi 4849', 'Ragi 4847'</td>
</tr>
<tr>
<td></td>
<td>Rice</td>
<td>'IET 2656', 'IET 1785', 'Jaya', 'C-24263', 'C 7306', 'C 13206', 'C 29692', 'IET 1444', and 'C 32341'</td>
</tr>
</tbody>
</table>
Recycling of farm and city wastes

Use of efficient cellulose decomposing fungal inoculants in the rapid composting of organic wastes.—Efficient cellulose-decomposing strains of fungi were isolated and these are being used as inoculants for rapid composting of crop and animal wastes. A mixture of wheat-straw and chopped jowar-stalk (3 : 5) was composted at the IARI, Delhi, in one cubic metre earthen pits by inoculating the material with four efficient cellulolytic fungal cultures. The data show that the compost material was reduced to about 50 per cent of its original weight in 3 months of decomposition and a good quality of compost with C/N ratio 14.8 was obtained.

In a similar experiment at Pune, sugarcane-trash was cut to 2-to 3-cm size and was decomposed with fungal inoculants in one cubic metre cemented pits each containing 87 kg of the trash at 75.0 per cent moisture. The material in the pits was turned over at intervals and compost samples were analysed at monthly intervals.

The analytical data of the compost in respect of carbon and nitrogen content after 2 and 3 months of decomposition are prescribed. These data have indicated that all the inoculants had their effect on the decomposition with small differences between different cultures. At the end of the third month the material was substantially decomposed with significant decrease in the C/N ratio to as low as 23.0 from the initial 125.0 with the fungal culture of Trichurus spiralis.

In another experiment at Hissar, a mixture of grasses, leaves and cattle-dung in the ratio of 11 : 1 : 8 was allowed to decompose for 4 weeks at appropriate moisture content. The partially decomposed material was then divided into quantities of 10 kg in polythene carboys and inoculated with mixed fungal cultures. Loss in weight was measured after 2 and 3 months. It was observed that inoculation led to rapid loss of organic material (Table 9). A mixed inoculant of Trichoderma viride and Paecilomyces fusicporus was found to be most efficient.
Table 9. Effect of inoculation with mixed fungal cultures on the decomposition of organic wastes.

<table>
<thead>
<tr>
<th>Fungal inoculant</th>
<th>Decomposition period (months)</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% loss in weight</td>
<td>% loss in weight</td>
<td></td>
</tr>
<tr>
<td>1. <em>Trichoderma viride</em>-9414 + <em>Paecilomyces fuscanspor</em></td>
<td>36.13</td>
<td>56.75</td>
<td></td>
</tr>
<tr>
<td>2. <em>Trichoderma viride</em> + <em>Pestalotiopsis versicolor</em></td>
<td>46.75</td>
<td>56.75</td>
<td></td>
</tr>
<tr>
<td>3. <em>Aspergillus</em>-2 + <em>Penicillium</em>-3 + <em>Penicillium</em>-4</td>
<td>46.75</td>
<td>56.75</td>
<td></td>
</tr>
</tbody>
</table>

Influence of crop-waste incorporation on the crop yields and soil properties.—Sugarcane-trash cut to 2-to 3-cm size was incorporated in the soil at the experimental farm of the college of Agriculture, Pune, and was allowed to decompose for one month before planting of wheat crop (‘Sonalika’) in 4 m × 2.5 m plots in triplicate. The trash was treated with a mixed inoculum of four efficient fungal cultures (500 g/t) before incorporation. The wheat crop was fertilized with 120 kg N/ha.

Another experiment on the utilization of crop-waste in soil and crop improvement was conducted in an acidic soil (pH 5.3) at the college of Agriculture, Ranchi. A mixture of paddy-straw and water-hyacinth (50 : 50) cut to 8—10 cm size was incorporated in the soil one month before planting of wheat. Fifty percent of the total fertilizer nitrogen was added at the time of the waste incorporation and the rest was applied to wheat in two splits.

The results showed that there was a positive effect of paddy-straw water-hyacinth incorporation in the soil on the grain yield of wheat (Table 10).
Table 10. Grain yield of wheat (kg/ha) as affected by the incorporation in the soil of paddy-straw and water-hyacinth in an acidic soil (pH 5.3).

<table>
<thead>
<tr>
<th>Waste applied (tonnes/ha)</th>
<th>N₀</th>
<th>N₁₀</th>
<th>N₂₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1167</td>
<td>1300</td>
<td>1333</td>
</tr>
<tr>
<td>2.5</td>
<td>1933</td>
<td>2600</td>
<td>2833</td>
</tr>
<tr>
<td>5.0</td>
<td>2133</td>
<td>2783</td>
<td>3382</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>N.S.</td>
<td>N.S.</td>
<td>38</td>
</tr>
</tbody>
</table>

Management of black cotton soils

Studies on physical, chemical, mineralogical and micro-biological properties of black cotton soils.—These soils are moderately deep to very deep in nature and texturally they range from silty-clay to clay. Invariably pH and electrical conductivity (EC) and CaCO₃ content increase with depth, whereas organic carbon (OC) content decreases with depth. Normally the pH value range from 8.1 to 9.0. Electrical conductivity ranges from 11.9 to 418 micromhos/cm and OC from 0.21 to 0.90 per cent. Characterisation of other properties are in progress.

Black soils derived from diverse parent material were fractionated for inorganic forms of phosphorus. The results obtained so far revealed that soil derived from granite gneiss had Ca—P > Al—P > Reductant — P > Al — P > Soloid — P. In general Ca — P, Al — P and Fe — P increased with depth. In black soils derived from basalt parent material Ca — P was the most abundant fraction and in soils derived from granite and limestone parent materials reducant P forms the most abundant fraction. In black soil derived from schistose parent material soloid-P formed a major portion of the inorganic phosphorus.

Effect of exchangeable potassium percentage and soil physical properties.—The effect of different levels of exchangeable potassium percentage (EPP) on the physical properties of soil revealed that the width of cracks significantly reduced from 1.69 to 0.80 cm. All the K treatments significantly reduced the width of cracks over the control.

The results of the study indicated that the addition of potassium would reduce the extent of cracking, swelling and resulted in an increase in aeration porosity and infiltration. This is possibly due to partial conversion of ‘Smectites’ to mixed clays.
Studies on farm and factory-wastes on soil properties and yield of maize.—In a microplot experiment, factory and farm-wastes, such as wool-waste, cotton-mill-waste, paddy-husk, sheep-manure, maize-straw, FYM and gobar-gas-digested material, were added to the soil. The data thus obtained showed that gobar-gas-digested material, sheep-manure and maize-straw at 10 and 15 tonnes/ha and FYM at 15 tonnes/ha were significantly superior over the NPK treatment in increasing the grain yield. Maize-straw at 5 and 10 tonnes/ha gave higher yield as compared with 15 tonnes/ha.

Infiltration studies were carried out in microplots. An infiltration rate of 10.2, 6.2 cm/hr was recorded in plot that received maize-straw at 10 tonnes/ha and cotton-mill-waste respectively as compared with 0.87 cm/hr under NPK treatment alone.

Management of problematic areas by improvement of soil physical conditions.

The locally available crop residues such as powdered groundnut-shells, rice-husk, wheat-bhussa, maize-stalks and ena grass were mixed in the upper 20-cm layer under field conditions to improve the soil structure.

The mixing of slow decomposing organic materials reduced the bulk density of the soil and interposed the soil particles, with the result, hardening of red ‘chalka’ soil and crusting of alluvial sandy loam soil was reduced. The yield of groundnut, maize, jowar and wheat crops increased significantly.

The deep-mixing of rice-husk in slow permeable soil increased the infiltration rates and kept the soil loose for root proliferation.

The mixing of the rice-husk in paddy fields maintained better physical conditions of the soil at harvest of the paddy crop and produced 25 to 50 per cent higher yield of wheat crop.

Soil-test-crop response

Fertilizer recommendations for economic yield of crops.—On the basis of soil-test values of different soil types, the recommendations for efficient fertilizer-use for economic yield of agricultural crops were worked out for rice, wheat, soyabean and laha. The details are presented in Table 11.
<table>
<thead>
<tr>
<th>Centre/Soil Type</th>
<th>Crop/Variety</th>
<th>Average soil-test values (kg/ha)</th>
<th>Fertilizer doses (kg/ha)</th>
<th>Economic yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etawah (Alluvial)</td>
<td>Rice ('1R-24')</td>
<td>0.59% (OC)</td>
<td>N 38 P 558 K 200 N 67 P 80</td>
<td>7639</td>
</tr>
<tr>
<td>Palampur (Grey brown podzolic)</td>
<td>Rice ('Norin 18')</td>
<td>477</td>
<td>N 36 P 137 K 195 N 0 P 38</td>
<td>5544</td>
</tr>
<tr>
<td>Jabalpur (Medium black)</td>
<td>Wheat ('Patel 1')</td>
<td>293</td>
<td>N 10 P 261 K 218 N 35 P 51</td>
<td>4191</td>
</tr>
<tr>
<td>Ludhiana (Grey brown)</td>
<td>Wheat ('Sonalika')</td>
<td>244</td>
<td>N 18 P 178 K 200 N 150 P 0</td>
<td>4504</td>
</tr>
<tr>
<td>Jabalpur (Medium black)</td>
<td>Soyabean ('JS-2')</td>
<td>240</td>
<td>N 18 P 473 K 18 N 90 P 46</td>
<td>3400</td>
</tr>
<tr>
<td>Pantnagar (Tarai soil)</td>
<td>Laha</td>
<td>0.74% (OC)</td>
<td>N 37 P 198 K 123 N 152 P 130</td>
<td>2357</td>
</tr>
</tbody>
</table>
Critical limits of soil-test for response to potash fertilizers

Soil-test-crop response investigations showed that depending on the soil type, there are certain critical levels of soil tests above which only the positive effect of added fertilizer K on increasing the crop yield would become evident. It was essential to keep the soil status for potassium above these values so as to derive the maximum benefit from added fertilizer K. Such critical limits for soil potassium are given in the Table 12 which shows that the critical limit is very much soil type specific varying from 74 kg/ha in the brown hill soils of Almora to 190 kg/ha in the alluvial soils of Delhi.

Table 12. Critical limit of soil-test for response to potash fertilizer.

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil type</th>
<th>Crop</th>
<th>(Soil test) (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi</td>
<td>Alluvial</td>
<td>Cotton</td>
<td>190</td>
</tr>
<tr>
<td>Almora</td>
<td>Brown hill</td>
<td>Wheat</td>
<td>70</td>
</tr>
<tr>
<td>Nclhatti</td>
<td>Red</td>
<td>Rice</td>
<td>144</td>
</tr>
<tr>
<td>Ranchi</td>
<td>Red loam</td>
<td>Wheat</td>
<td>131</td>
</tr>
</tbody>
</table>

Soil-health-care scheme

In the two years of functioning of this Project, 185 soil-health-care workers were trained by the 10 agricultural universities. These workers were drawn at the grass-root level from the farming house-holds from a cadre of self-employed rural youth working in conjunction with the village-level worker.

The university keeps up regular follow-up programme with the trainees after the training period. These follow-up programmes revealed that the activities of these trainees by-and-large are satisfactory and encouraging.

The workers are acting as catalysts in promoting an awareness for soil-fertility improvement through soil-testing and appropriate fertilization, alongwith integrated use of organic sources of manures available in the villages. They are also making an impact on identifying local soil problems such as acidity, soil salinity, alkali-nity limiting crop yield and enthusing the farmers for taking proper corrective measures.
The Co-ordinated Project for Research on Dryland Agriculture continued at 23 research centres located under different agro-climatic zones of the country. The main findings are as under:

**Oilseeds and pulses in crop sequence**

In drylands receiving more than 800 mm rainfall and having a moisture storage capacity of about 200 mm, crop intensity could profitably be increased to 200 per cent. Oilseeds and pulses find an efficient place in such double-cropping systems.

**Table 13**

<table>
<thead>
<tr>
<th>Region</th>
<th>Crop sequence</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akola</td>
<td>Sorghum (‘CSV-3’)—Safflower (‘7-13-3’)</td>
<td>52.5±18.3</td>
</tr>
<tr>
<td>Hoshiarpur</td>
<td>Maize (‘Local’)—Raya (‘RL-18’)</td>
<td>26.4±17.1</td>
</tr>
<tr>
<td>Indore</td>
<td>Maize (‘Ganga-5’)—Safflower (‘JSF-1’)</td>
<td>32.6±13.9</td>
</tr>
<tr>
<td>Rewa</td>
<td>Rice (‘DR-192’)—Gram (‘Pink-2’)</td>
<td>40.8±10.1</td>
</tr>
<tr>
<td>Ranchi</td>
<td>Maize (‘GS-2’)—Linseed (‘T-397’)</td>
<td>38.0±5.6</td>
</tr>
</tbody>
</table>

**Evaluation of production inputs**

So far the improved packages, as a whole, were compared with the traditional practices for economic evaluation. Research efforts are now on to assess the effect of important production inputs at various research centres to develop graded technologies.

**Table 14**. Average relative yields due to production inputs.

<table>
<thead>
<tr>
<th>Production inputs</th>
<th>Yield of crop (q/ha)</th>
<th>Sorghum</th>
<th>Pearl millet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>14.6(100)</td>
<td>19.7(133)</td>
</tr>
<tr>
<td>1. Seed</td>
<td></td>
<td>10.9(100)</td>
<td>16.9(133)</td>
</tr>
<tr>
<td>(a) Traditional</td>
<td></td>
<td>7.5(100)</td>
<td>14.5(100)</td>
</tr>
<tr>
<td>(b) Improved</td>
<td></td>
<td>15.7(210)</td>
<td>19.7(192)</td>
</tr>
<tr>
<td>2. Management</td>
<td></td>
<td>11.0(100)</td>
<td>13.0(100)</td>
</tr>
<tr>
<td>(a) Traditional</td>
<td></td>
<td>18.8(171)</td>
<td>20.8(160)</td>
</tr>
<tr>
<td>(b) Improved</td>
<td></td>
<td>18.8(171)</td>
<td>20.8(160)</td>
</tr>
</tbody>
</table>
The results clearly indicated the importance of improved seed followed by fertilizer. Sound management, per se, increased yields by 30—50 per cent.

*Sorghum production technology in Hyderabad District*

About 9,600 hectares were covered under this programme. Crop cut data were collected from 8 villages with 450 farmers. Results are summarised below:

- Average yield of ‘CSH-5’ sorghum with improved practices 29.10 q/ha
- Standard deviation ±8.41
- Range in yield 11.83—55.04 q/ha
- C.V. (%) 27.2

The yield of sorghum under local management was about 15.0 q/ha.

*Critical irrigation helps boost yields in drylands*

Moisture stress is common in drylands during the crop growth. In *kharif* it would be cyclic and in *rabi* a receding moisture situation. The effect of a critical irrigation of about 4-5 cm on yields of crops is under evaluation at various centres. Some of the results are given in Table 15.

<table>
<thead>
<tr>
<th>Crop</th>
<th>No. of trials</th>
<th>Yield (q/ha)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
<td>With critical irrigation</td>
</tr>
<tr>
<td>Wheat</td>
<td>3</td>
<td>25.3(100)*</td>
<td>33.1(131)</td>
</tr>
<tr>
<td>Sorghum</td>
<td>2</td>
<td>12.7(100)</td>
<td>23.3(183)</td>
</tr>
<tr>
<td>Safflower</td>
<td>4</td>
<td>9.7(100)</td>
<td>13.8(142)</td>
</tr>
<tr>
<td>Tobacco</td>
<td>1</td>
<td>6.9(100)</td>
<td>12.5(181)</td>
</tr>
</tbody>
</table>

*Figures in parentheses indicate relative percentages.

The shallow-rooted sorghum responded most. The winter rains reduced the response in the case of wheat. Deep-rooted safflower crop also did not respond much.
Improved farm machinery improves yields

A bullock-drawn seed-drill was fabricated for testing and use in the Gangetic alluvial soil. At Varanasi, the seed-drill was found to be effective in obtaining higher plant stands and yields (Table 16).

<table>
<thead>
<tr>
<th>Seeding method</th>
<th>Crop yields (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wheat</td>
</tr>
<tr>
<td>Traditional (pora)</td>
<td>24.4</td>
</tr>
<tr>
<td>New seed-drill</td>
<td>27.0</td>
</tr>
</tbody>
</table>

At Anantapur Nobel Blade was found to be useful in recovering more (15 per cent) groundnut pods at harvest (Table 17).

<table>
<thead>
<tr>
<th>Method of harvest</th>
<th>Yield recovery (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional (bullock-drawn blade-harrow)</td>
<td>14.1</td>
</tr>
<tr>
<td>Noble blade (tractor-drawn)</td>
<td>16.2</td>
</tr>
</tbody>
</table>

Efforts are in progress to fabricate bullock-drawn drills incorporating the Noble Drill principles.

ARID ZONE RESEARCH AND DESERT TECHNOLOGY

The Indian arid zone includes 0.32 million km² of hot desert and 0.07 million km² of cold desert, which accounts for 12 per cent of the total geographical area of the country. The Institute continued to develop suitable agricultural technology for arid zone areas of the country. The main research findings are as under:

Uneconomic land-use practices and over-exploitation of water resources in Rajasthan Canal Projects area

Investigations on land-use carried out between 74° 45' to 75° 0' E and 29° 30' N to 29° 15' N just to the south of the old Ghaggar river bed (in Hissar District of Haryana) and southern Ghaggar canal revealed some interesting features.

The southern part of the region was waterlogged, flanked by sandy hummocks and sand-dunes as mapped by Survey of India during 1912—14. The reclamation of the waterlogged areas and the marginal lands by irrigation water converted them into
cultivated lands with high intensity of 80 to 100 per cent. But the cultivation of the marginal lands and sand-dunes have caused the shifting and deposition of sands further south near Jasana, Ramsara, Ratanpura, Rajkwra etc.

Recent survey conducted during September 1978 showed further increase of sands throughout the area which may be attributed to indiscriminate cutting of the shrubs and trees and cultivation of marginal lands. This had led to the deterioration of good agricultural lands and has increased the desertification intensity affecting about 30 per cent of the total area. The inundated areas which were waterlogged as early as in 1912 became saline and this particular problem is gradually increasing towards the south in recent years.

Land-use map of western Rajasthan based on the interpretation of Land Sat imageries

Based, primarily on the interpretation of 5 band land sat imageries (1 : 1,000,000) supplied by ISRO, a tentative land-use map of western Rajasthan was prepared. This is cartographed on the basis of tonal variation of the imageries aided by the study of convergence of evidence. Ground truth of the areas, already surveyed, are only considered.

Mapping units, with their area in per cent (in bracket), established are: (1) double and multiple cropping (2.0 per cent), (2) mono-cropping with intensity 60—80 per cent (19.5 per cent), 40—80 per cent (19.0 per cent), 30—50 per cent (10.3 per cent), 20—30 per cent (8.4 per cent), 10—20 per cent (9.3 per cent), below 10 per cent (4.2 per cent), (3) sandy waste (duny complex) and grazing land (12.7 per cent), (4) saline waste and salt lakes (0.8 per cent), (5) gravelly and rocky waste (5.6 per cent), and (6) hills (3.7 per cent).

Trace elements in forages of arid zone

Investigation carried out showed (Table 18) that all the naturally occurring grasses, shrubs and top-feed species of arid zone are rich in trace elements Fe, Mn, Zn, Cu (containing as much as twice the threshold value). Only exception is Calligonum polygonoides which was found low both in copper and zinc. This correlated well with the general status of these trace elements in the soils, which together with climate may explain better vigour and growth of animals in arid zone.
Table 18. Trace elements in the important grasses, shrubs and feed species in iso-soil conditions (red desertic).

<table>
<thead>
<tr>
<th>Name of the species</th>
<th>Trace element content (mean values in ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe</td>
</tr>
<tr>
<td>Cenchr us ciliaris</td>
<td>158.65</td>
</tr>
<tr>
<td>Cenchr us setigerus</td>
<td>169.60</td>
</tr>
<tr>
<td>Lasius sildicus</td>
<td>121.09</td>
</tr>
<tr>
<td>Eleusine compressa</td>
<td>128.32</td>
</tr>
<tr>
<td>Aristida funiculata</td>
<td>89.97</td>
</tr>
<tr>
<td>Panicum turgidam</td>
<td>103.30</td>
</tr>
<tr>
<td>Zizyphus jujuba</td>
<td>120.00</td>
</tr>
<tr>
<td>Zizyphus nummularia</td>
<td>146.60</td>
</tr>
<tr>
<td>Prosopis cineraria</td>
<td>300.50</td>
</tr>
<tr>
<td>Acacia senegal</td>
<td>124.79</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>191.60</td>
</tr>
<tr>
<td>Acacia nilotica</td>
<td>206.00</td>
</tr>
<tr>
<td>Tecomella undulata</td>
<td>199.90</td>
</tr>
<tr>
<td>Azadirachta indica</td>
<td>153.30</td>
</tr>
<tr>
<td>Caligonum polygonoides</td>
<td>131.00</td>
</tr>
</tbody>
</table>

Mean content of available nutrients in soil (ppm)

<table>
<thead>
<tr>
<th></th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>2.45</td>
<td>4.24</td>
<td>0.39</td>
<td>0.94</td>
</tr>
<tr>
<td>20-50</td>
<td>2.14</td>
<td>3.87</td>
<td>0.38</td>
<td>0.68</td>
</tr>
<tr>
<td>50-75</td>
<td>2.21</td>
<td>3.87</td>
<td>0.38</td>
<td>0.91</td>
</tr>
<tr>
<td>75-90</td>
<td>2.09</td>
<td>4.00</td>
<td>0.43</td>
<td>1.22</td>
</tr>
<tr>
<td>90-120</td>
<td>2.09</td>
<td>2.87</td>
<td>0.43</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Control of katra (Amsacta moorei)

For the control of katra or red hairy caterpillar (Amsacta moorei), the insecticides Methyl parathion 0.05 per cent, Carbaryl 0.1 per cent, Malathion 8.08 per cent and Quinaphos 0.05 per cent were found effective. Antifeedant triphenyltin acetate (0.06 per cent) was as good as insecticides. A combination of triphenyltin acetate with wettable formulations of insecticides, preferably also with 0.1 per cent wetting agent in the spray solution was recommended. The antifeedant triphenyltin acetate was also found effective against Myllocerus maculosus weevil in laboratory trials.

Pearl-r illet variety 'PHB-12' was found fairly resistant against damage by Tribolium castaneum and Rhizopertha dominica. Variety 'BJ 104', susceptible to both these insects, was not damaged much by Rhizopertha dominica if dried well before storage.

16A&I/78—8
Minor millets *Setaria italic* and *Panicum miliaceum* were not attacked by *Tribolium castaneum* in storage.

**Solar water heater-cum-solar steam cooker**

A solar water heater-cum-solar steam cooker was developed at the CAZRI, Jodhpur, comprising a flat-plate collector, a storage tank and a steam cooker. The absorber, optimized to give maximum efficiency at minimum cost, consists of an aluminium sheet (28 gauge thick) blackened on the exposed side and wrapped over set of seven G. 1 pipes (spacing 10 cm) of 19 mm diameter. This absorber plate (1.4 m²) painted black on the exposed side is placed in a mild steel box having two glass covers at the top and 5.0 cm thick fibre glass insulation on the rear side. This absorber is oriented towards south and inclined at an angle of 41 degrees from horizontal at Jodhpur. The storage tank is made of 20 gauge G.1 sheet with 10 cm wall spacing filled with fibre glass insulation and is kept on stand so that the bottom of tank is about 30 cm above the collector. The steam cooker fixed at the collector top position by a 25 mm pipe consists of a double-walled insulated lid at the top and a 25-mm-diameter pipe welded at the bottom of the inner tank which acts as an inlet of water to the absorber and also outlet of steam. Four gate valves are provided at appropriate points to operate the steam-cooker and the water-heater as and when desired.

It was observed that this solar water-heater could supply 100 litres of water at a temperature of 60°—70°C during winter afternoons and 50°—60°C in the morning the following day. Two cooking vessels could be placed side by side and 1.0 kg. of rice, *dal*, potatoes and other items could be boiled within 1.5 hours.

**Social aspects of desertification**

Studies on social aspects of desertification conducted at the CAZRI, Jodhpur, revealed devastation of natural vegetation by indiscriminate cutting and overgrazing, deterioration of the local grazing lands and increase in salinity causing decline in productivity. About three-fourths of the households reported 60—70 per cent decrease in tree vegetation except *khejri* (*Prosopis cineraria*) during the last 30 years. Highest percentage of households (52.12 per cent) in the saline tract as compared to 22.22 per cent and 4.07 per cent in the respective rainfed and pastoral tract reported deterioration of the grazing lands chiefly because of increase in salinity, growth of undesirable weeds and use of saline water for irrigation from Sardar Samand Dam.
Decline in productivity of land was mentioned by the majority of respondents in the three tracts, namely, pastoral (30.16 per cent), rainfed (62.22 per cent) and saline (56.25 per cent) during the last 20 years. The chief reasons of declining productivity in pastoral and rainfed tracts were opined to be decline in soil fertility (93.33 per cent and 75.00 per cent), incidence of crop diseases (26.66 per cent and 32.13 per cent) and emergence of new weeds like bissia, kukarli, dab, onikantala, messa etc. (26.66 per cent and 21.42 per cent) respectively. While in saline tract (66.66 per cent and 11.00 per cent) sample households expressed increase in salinity and emergence of new weeds as the reasons.

Performance of Rathi Breed heifers in Lasiurus Grasslands

Western Rajasthan abounds in Lasiurus sindicus a native grass of good forage value. Under protected conditions of Bikaner, Lasiurus grasslands provided an average dry matter yield of 3011 kg/ha. Performance studies carried out at the CAZRI on fifteen, 6 to 10-month-old Rathi breed heifers on Lasiurus grasslands allowing ad libitum grazing but without any concentrate supplement at Bikaner during this year, revealed that the animals recorded a sharp increase from their initial body weight of 134.1 kg/animal at the end of September to 176.4 kg/animal at the end of December. It means a phenomenal body-weight gain of about 42.3 kg/animal in a period of 90 days representing a growth rate of 470 g/animal/day which is considered good under tropical environment. It is significant that 7 out of 15, two and-half-year-old heifers developed heat and conceived which otherwise happens at over three years.

AGRONOMY

The research on agronomical aspects of crop production was conducted in various ICAR Research Institutes, Agricultural Universities and under the Co-ordinated Projects on Agronomy, Soil and Water Management, Long-term Fertilizer Use, Dryland Farming, Weed Control, Biological Nitrogen Fixation, Cereals, Pulses, Oilseeds and Commercial crops, etc. The salient findings are given below:

Production potential of intensive crop sequences under adequate input conditions

Based on the results obtained from the All-India Co-ordinated Agronomic Research Project, some of the crop sequences found promising at different centres are given in figure 7 and the same are described zone-wise below:
Fig. 7. Production potential of promising crop sequences at agronomic research centres 1977-78.
Northern zone. At Ludhiana, the productivity of 10.1 to 10.2 tonnes grain yield/ha per year was obtained in maize ('Ganga-5'), wheat ('Kalyansona'), moong ('G-65') rotation. The yield of maize and wheat was 4 and 5 tonnes/ha, respectively. At the same centre, the crop sequences of maize ('Ganga-5')—potato ('K.C. Mukhi')—wheat ('Kalyansona')—moong ('G-65') rotation gave a production of 8.3 tonnes grain with 20 tonnes of potato/ha.

At Pantnagar, grain yields of 10.5 tonnes/ha with 7.8 tonnes of potato were obtained by growing maize ('Ganga-2')—potato ('K.C. Mukhi')—wheat ('RR-21'). Only two crops of maize ('Ganga-2') and wheat ('RR-21') also produced 10.1 tonnes grain yield/ha.

At Varanasi all the crop sequences with rice ('Jaya') in kharif, wheat ('HD-1553') in rabi and cowpea ('Pusa Phalgungi') or moong ('P-Baisakhi') or cheena (local) or rice ('Suphala') gave a total production ranging from 9.9 to 12.0 tonnes/ha. The average yield of kharif rice was 46.5 q/ha and yield of wheat was 40.1 q/ha. During summer, moong yielded better (15.0 q/ha) compared with cowpea (8.0 q/ha).

Eastern zone. At Chipilima, the promising crop sequence with rice ('Ratna')—Knol-khol ('White Vienna') and ragi ('Dibhya Singh') gave a production of 7 tonnes of grain and 11.4 tonnes of vegetable/ha. The yield of rice was low (2.2 tonnes/ha) whereas the yield of ragi was better (4.7 tonnes/ha).

Central zone. At Navsari, the promising crop sequence was rice ('Ratna')—wheat ('Sonalika')—moong ('G-2-81') giving total production of 9.9 tonnes/ha. At the same centre, a grain production of 8.2 tonnes and green fodder production of 13.7 tonnes/ha was obtained by growing rice ('Ratna')—wheat ('Sonalika')—guar ('Pusa navabahar') in a sequence.

Southern zone. At Kariairuppa, the highest grain production of 13.2 tonnes/ha was obtained by growing maize ('Ganga-5'), rice ('IR-20') and pearl-millet ('KM-1-85') in a rotation. Grain production of 9.6 tonnes/ha with 9 quintals of cotton yield was obtained by growing ragi ('PR-202')—rice ('IR-20')—cotton ('MCU-5'). Among the rotations involving vegetables, bhindi, ('Pusa Sawani')—rice ('IR-20')—pearl-millet, ('K-tall') produced total grain yield of 8.2 tonnes with 13 tonnes of vegetable per hectare.

At Siruguppa, the highest grain yield of 9.4 tonnes/ha was obtained by hybrid jowar ('CSH-1')—wheat ('UP-301')—hybrid jowar ('CSH-1'). The next promising crop sequence was
cotton ('Varalaxmi') followed by hybrid jowar ('CSH-1') giving a grain production of 2.9 tonnes and cotton yield of 2.89 tonnes/ha.

At Tanjavur, the grain production ranged from 9.1 to 9.7 tonnes/ha by growing rice ('ADT-31')—rice ('IR-20'), followed by groundnut ('TMV-2') or greengram ('CO 3') or ginjelli ('TMV-3') or bhindi ('Pusa Sawani'). The yields of summer crops were generally low, except bhindi which gave a production of 3 tonnes/ha.

Production potential under resource constraints

The studies conducted under the All-India Co-ordinated Agronomic Research Project revealed that at Pura Farm (U.P.), after a normal crop of kharif rice, wheat was found good in rabi under adequate irrigation and fertilizer inputs, while Bengalgram was found good under limited fertilizer and irrigation resources. Similarly at Jabalpur (M.P.), gram and linseed performed better in rabi following a rice in kharif, under limited irrigation and fertilizer inputs. At Bhubaneswar (Orissa) and Anantharajapet (Andhra Pradesh), the crop of groundnut was found good under resource constraints in rabi following a rice crop in kharif. The yield of wheat, grown after rice in kharif in most of the places wherever tried was reduced with the reduction in the level of irrigation and fertilizer.

With sorghum as the kharif crop grown with normal inputs, the crop of gram gave satisfactory yields at Rahuri and Akola (Maharashtra), in rabi with limited fertilizer and irrigation. At the same places, the crop of safflower, however, required adequate inputs for good yields.

After maize grown as kharif crop, the crops of mustard and peas could be grown successfully in rabi with limited irrigation resources. At Purnagar, gram and rai were successfully grown under limited irrigation. At both these places, the reduction in fertilizer level, however, reduced the yield. The crop of wheat following maize required adequate fertilizer and irrigation inputs for its good growth.

At Bichpuri (U.P.) and Hisar (Haryana), gram and mustard could be grown in rabi with limited irrigation following a crop of sorghum grown with normal inputs in kharif. It was, however, observed that reduction in fertilizer dose reduced the yield of gram and mustard.
The other crop rotations recommended under rainfed conditions are as below:

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<th>Place</th>
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<th>Rabi</th>
<th>Summer</th>
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<td>Maize</td>
<td>Wheat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>Peas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soybean</td>
<td>Wheat</td>
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</tbody>
</table>

Coordinated Dryland Agriculture Project Centre at—
(i) Akola (Maharashtra) . . . Soybean Safflower
(ii) Hoshiarpur (Punjab) . . . Maize Raya
(iii) Indore (M.P.) . . . Maize Safflower
(iv) Rewa (M.P.) . . . Rice Gram
(v) Ranchi (Bihar) . . . Maize Linseed

N.E. Research Complex Centre at—
Tripura . . . Rice Sweet-potato
Rice Regi Cowpea
Rice Rice Cowpea
Maize Rice Cowpea

**Intercropping and mixed cropping**

The studies conducted under the All-India Coordinated Agro-nomic Research Project revealed that intercropping cotton with *moong* without additional fertilizer gave satisfactory yields of both the crops (Fig. 8). Yield of cotton without fertilizer was 6.4 q/ha and that with recommended fertilizer, it was 8.1 q/ha. With two rows of inter-cropped *moong*, in the absence of additional fertilizer, the yield of cotton was 8.9 q/ha and the additional yield of *moong* was 9.6 q/ha. With 100 per cent fertilizer to both the crops, the yield of cotton was suppressed, whereas the yield of greengram remarkably increased. *Moong* was a better intercrop as compared with cowpea.

At HPKVV, Palampur, intercropping of soyabean in maize and pearl-millet with *moong* gave good results. The studies conducted at Navasari (Gujarat) revealed that 10 rows of wheat intercropped with 2 rows of mustard produced 20.4 q/ha of wheat which was comparable to a pure crop of wheat producing
Fig. 8. Effect of intercropping of moong and cowpea in cotton at Akola.
21.8 q/ha. The yield of intercropped mustard was 3.6 q/ha. (Fig. 9). The intercropping practice was found better than mixed cropping so far as the production of wheat as main crop was concerned. In mixed crop, the mustard yielded better while the growth of wheat was reduced.

![Graph showing yield of crops](image)

Fig. 9. Studies in mixed cropping of wheat and mustard at Navsari 1977-78

The studies of NE Research Complex, Shillong, revealed that maize and soybean and potato and ragi could be grown as intercrops at high altitudes (above 1,300 m), whereas maize and blackgram and maize and cowpea could be grown as intercrops in low and mid-altitudes (up to 900 m).

In a fuel-fodder production system developed at IGRIP, Jhansi, cultivation of Sesbania grandiflora intercropped with fodder crops like fodder bajra, higher fodder yields were obtained. The fodder bajra, gave about 50-55% increase than when grown singly at a similar level of inputs. In addition, extra fuel and top fodder leaves were obtained. This may have more relevance to intensive dairy farming units being established under Operational Flood (Phase II).
Fertilizer response studies

A large number of experiments on cultivators’ fields under the All-India Co-ordinated Agronomic Research Project revealed valuable information on the response of foodgrain crops with the application of fertilizers. The average response of a few crops is given in Table 1.

With the use of fertilizers based on soil test in long-term fertilizer experiments, yield levels per hectare of over 11 tonnes of wheat + rice at Pantnagar, 7 to 8 tonnes of rice + rice, ric + wheat, wheat + maize and wheat + soyabean along with 2 to 3 tonnes/ha of dry matter of fodder and fibre (jute) could be maintained during last 5 to 6 years at Hyderabad, Barraekpore, Ludhiana, Palampur and Jabalpur without any deterioration in soil fertility. There has been a general improvement in the organic matter and available nitrogen status of the soil with the application of farmyard manure and a rise of more than 2-3 times in P content with the application of fertilizer phosphorus was noticeable. Available potassium in the soil, generally decreased, in the absence of application of potassium.

The data obtained in the long-term fertilizer experiments clearly showed that the response to the inorganic fertilizer is dependent upon the soil characteristics. At Pantnagar, no response to the application of P and K was observed as the soil was well supplied with respect to these nutrients. But at Ludhiana continuous application of N alone depleted the soil of phosphorus and potassium and for maximum efficiency, an application of both phosphorus and potassium was essential. Similar data were obtained for wheat at Palampur and for ragi at Coimbatore and Bangalore. At these stations, application of nitrogen alone resulted only in slight increase in yield but when P was applied along with N spectacular increases in yields were obtained.

At CPRI, Simla, it was found that K should be applied in furrows before planting of potatoes in the acidic brown hill soils. The second dose of N may be given if needed at the time of final earthing up. The soaking of seed tubers in 1.5% single superphosphate solution and 0.05% FeSO₄ and ZnSO₄ solution prior to planting for 4—6 hours was beneficial. The responses to micronutrients particularly zinc were obtained at different places. High application of P depressed Zn uptake. ‘Kutri Chandramukhi’ was more responsive to Zn than ‘Kufri Jyoti’ and ‘Kufri Sindhuri’.
<table>
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<tr>
<th>Place (State)</th>
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<th>No. of trials</th>
<th>Av. yield of unfertilized plants</th>
<th>Response to nitrogen N(_{20})</th>
<th>N(_{50})</th>
<th>N(_{120})</th>
<th>Response to phosphorus P(<em>{20}) over N(</em>{40})</th>
<th>P(_{40})</th>
<th>Response to potassium K(<em>{20}) over N(</em>{40})</th>
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<th>K(_{60})</th>
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</table>
| Kurukshe
ta (Haryana) | 'Jaya'      | 28            | 3820                            | 1016                            | 2006    | 2582    | 247                             | 164     | 104                             | 91      | 26     | 50      | 256     |
| Gu
daspur (Punjab)  | 'RR. 106'   | 23            | 3439                            | 668                             | 1301    | 1762    | 145                             | 64      | 458                             | 220     | 111    | 47      | 271     |
| Fa
labad (U.P.)   | 'Saket-4'   | 29            | 2515                            | 622                             | 1099    | 1236    | 929                             | 1435    | 2069                           | 1060    | 1638   | 2269    | 171     |
| Jaunpur (U.P.)    | 'Saket-4'   | 23            | 1761                            | 455                             | 808     | 1099    | 670                             | 1082    | 1689                           | 824     | 1201   | 1914    | 116     |
| Pur
ea (Bihar)   | 'IR-8'      | 40            | 1932                            | 1188                            | 1862    | 2502    | 1503                            | 2257    | 3108                           | 1611    | 2484   | 2426    | 69      |
| Muzaffarpur (Bihar) | 'Jaya'      | 40            | 1802                            | 448                             | 878     | 1321    | 769                             | 1459    | 1989                           | 1048    | 1658   | 2444    | 58      |
| Bad
ghat (M.P.)  | 'Kranti'    | 15            | 2793                            | 488                             | 791     | 1041    | 323                             | 387     | 581                             | 81      | 0      | 378     | 377     |
| Tiru
elveli (T.N.) | 'ADT-31'   | 27            | 4134                            | 732                             | 1406    | 1758    | 592                             | 314     | 535                             | 134     | 187    | 503     | 315     |
| Tumkur (Karnataka) | 'Vari'      | 30            | 3018                            | 464                             | 899     | 1380    | 352                             | 579     | 622                             | 321     | 199    | 498     | 286     |
| North Arcot (T.N.) | 'IR-20'     | 40            | 2765                            | 518                             | 830     | 1120    | 250                             | 354     | 385                             | 235     | 169    | 307     | 128     |
| Krish
ga (A.P.)  | 'Masuri'    | 32            | 1905                            | 396                             | 1221    | 1968    | 295                             | 331     | 352                             | 220     | 243    | 340     | 78      |
<p>| East Godavari (A.P.) | '8002'     | 39            | 3711                            | 493                             | 944     | 1290    | 463                             | 345     | 528                             | 350     | 589    | 499     | 189     |
| Rabi Rice Irrigated |             |               |                                 |                                 |         |         |                                 |         |                                 |         |         |         |
| Kanyakumari (Kerala) | 'IR-20'   | 12            | 4021                            | 335                             | 573     | 703     | 477                             | 261     | 521                             | 268     | 596    | 652     | 180     |
| Tirunelveli (T.N.) | 'IR-20'    | 32            | 4960                            | 683                             | 1078    | 1358    | 527                             | 352     | 199                             | 297     | 365    | 822     | 248     |
| Madurai (T.N.)    | 'IR-20'    | 45            | 3554                            | 446                             | 743     | 1076    | 130                             | 108     | 262                             | 132     | 181    | 151     | 140     |
| North Arcot (T.N.) | 'ADT-31'   | 36            | 3649                            | 297                             | 553     | 800     | 241                             | 293     | 274                             | 324     | 329    | 467     | 164     |</p>
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<td>394</td>
<td>561</td>
<td>728</td>
<td>87</td>
<td>419</td>
<td>364</td>
<td>521</td>
</tr>
<tr>
<td>Agra (U.P.)</td>
<td>'Manpuri'</td>
<td>7</td>
<td>820</td>
<td>396</td>
<td>851</td>
<td>1200</td>
<td>143</td>
<td>185</td>
<td>222</td>
<td>60</td>
<td>63</td>
<td>69</td>
<td>128</td>
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<tr>
<td>Hissar (Haryana)</td>
<td>'BJ-104'</td>
<td>15</td>
<td>1283</td>
<td>295</td>
<td>598</td>
<td>692</td>
<td>12</td>
<td>20</td>
<td>216</td>
<td>213</td>
<td>37</td>
<td>69</td>
<td>131</td>
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<tr>
<td>Agra (U.P.)</td>
<td>'Manpuri'</td>
<td>13</td>
<td>752</td>
<td>283</td>
<td>708</td>
<td>1139</td>
<td>234</td>
<td>321</td>
<td>346</td>
<td>51</td>
<td>88</td>
<td>29</td>
<td>104</td>
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<tr>
<td>Tumkur (Karnataka)</td>
<td>'Indef-5'</td>
<td>19</td>
<td>1161</td>
<td>163</td>
<td>354</td>
<td>623</td>
<td>204</td>
<td>402</td>
<td>538</td>
<td>182</td>
<td>329</td>
<td>431</td>
<td>157</td>
</tr>
</tbody>
</table>

**Rabi Maize (Irrigated)**

**Kharif Bajra (Irrigated)**

**Kharif Bajra (Irrigated)**

**Summer Ragi (Irrigated)**
It was further revealed that available P and K for potatoes in acidic brown hill soils of Simla and alluvial soils of Jullundur were nearly double than that of cereals. P and K should be applied to potatoes in a crop rotation based on soil-test values. Rapid methods, based on oxidation of organic compounds by chromic acid were developed to determine total as well as available N in soils and total N in plants. The levels of 0.4 to 0.6 ppm available zinc (DTPA extractable) in soil was the critical limit for potatoes. Nearly 75% soils of Simla district (H.P.) were deficient in zinc for potatoes.

Studies with slow-release nitrogen fertilizer, nitrification retarders and modified area compounds

Recovery of nitrogen applied to the soil is generally low due to leaching, denitrification, etc. One of the ways to reduce the losses is to utilize fertilizer material with slow release properties which may be to have larger granules for proper placement or use of nitrification retarders. To increase the efficiency of applied nitrogen, experiments are being conducted under the All-India Co-ordinated Agronomic Research Project at various centres. Salient observations are as below:

(a) Rice (Kharif). At Tanjavur, the urea briquettes of 0.75 g size (IFFCO) were compared with ordinary urea in single and split doses at 40, 80 and 120 kg N/ha on ‘IET-2881’ variety of rice. At all levels of application, urea briquettes produced higher rice yields over ordinary urea. On an average, urea briquettes produced 58.7 q/ha yield as compared to 47.0 q/ha with urea in split doses and 42.5 q/ha with urea in single dose.

At Bhubaneswar, urea briquettes of 2.9 g size with sulphur-coated urea (TVA) were compared with ordinary urea in single and split application at 40, 80 and 120 kg N/ha on rice (‘Jaya’). On an average, sulphur-coated urea produced significantly higher yield (37.0 q/ha) over urea briquettes of 2.9 g size (34.9 q/ha) when both were applied in one dose at planting. The yields with urea in one dose at planting and urea by split application were respectively 30.9 and 33.5 q/ha. No significant residual effect was observed on rice crop during rabi season.

(b) Rice (rabi). The urea briquettes of 0.75 and 2.5 g size (IFFCO) were compared with ordinary urea applied on splits during rabi season, on rice (‘IR-20’) at Tanjavur. On an average, there was no significant difference in yield between the sources but urea briquettes of 2.5 g size produced higher yield (40 q/ha) compared to urea briquettes of 0.75 g. size (36.5
and urea in split application (32.4 q/ha). Highest yield (49.4 q/ha) was obtained with application of urea briquettes of 2.5 g size at 120 kg N/ha as compared to other treatments (24.8 to 40.5 q/ha).

At Mangalore, urea briquettes of 1.0, 1.9 and 2.9 g size with sulphur-coated urea (TVA) were compared with urea at planting and urea in split application of 'Jaya' rice. None of the slow release materials produced significantly higher yield over urea in split application (39.4 q/ha). The yield with urea briquettes of 1.0, 1.9 and 2.9 g size were significantly low (30.8 to 34.3 q/ha), compared with urea in split application.

(c) Wheat. At Ludhiana, urea briquettes of 0.75 g size (IFFCO), with and without neem-cake coating, and sulphur-coated urea (TVA) were compared with ordinary urea at planting and in split application, on 'WL 71' wheat. On an average, there was no significant difference between the sources.

Studies on efficiency of nitrophosphate as a source of phosphorus

Phosphate in water soluble form is generally considered superior to insoluble or citrate-soluble forms. But, production of water soluble phosphates is costly. Nitrophosphates with varying water solubilities are being tested with water soluble phosphate (WSP) fertilizers on different soils at various Agromonomic Research Centres.

Nitrophosphate of 30, 50 and 80% WSP were compared with triple superphosphate (TSP) at 20, 40, 60 kg/P2O5/ha. The nitrogen dose was adjusted to 120 kg N/ha. Potash was applied at 60 kg K2O/ha. The results obtained at Hissar and Indore are as below:

At Hissar, the experiment conducted with pearl-millet ('PHB-14') in kharif and wheat ('Kalyansona') in rabi, revealed that the responses to application of TSP and diammonium phosphate (DAP) were significantly superior to that of nitrophosphates of 30 and 50% WSP at all levels, while nitrophosphate 80% WSP was on par with TSP at 60 kg P2O5/ha level. In the studies on residual effect with wheat crop also, the response to TSP and DAP was significantly higher over nitrophosphates of 30 and 50%, WSP at all levels of application.

At Indore, the experiment conducted with sorghum ('CS-3541') in kharif and wheat ('Kalyansona') during rabi revealed that the response to P2O5 in sorghum was significant only at 60
kg/ha level. Nitrophosphates of 50 and 80% WSP were superior to nitrophosphate of 30% WSP and on a par with TSP. Significant residual effect of nitrophosphates applied to kharif sorghum was also observed on wheat crop. At 60 kg P₂O₅/ha, nitrophosphates 80% WSP produced the same residual response (14.7 q/ha) as that of TSP (14.6 q/ha) over control (30.6 q/ha).

Relative efficiency of rock phosphate as source of phosphorus

In view of high cost of producing water and citrate-soluble phosphate fertilizers, it is essential to find out the possibility of using rock phosphates for crop production in acid soils. Experiments conducted under All-India Co-ordinated Agronomic Research Project revealed that at Pantnagar, in the studies on direct effect with wheat ('Sonalika'), significant response over control was obtained by application of missouri rock phosphate (MRP) at 120 kg P₂O₅/ha (9.7 q/ha) and MRP at 60 kg P₂O₅ + 10 tonnes FYM/ha (7.0 q/ha). In the studies on residual effect with soybean ('Bragg') during kharif, significant yield response of 7.7 q/ha was obtained with application of 120 kg P₂O₅/ha in the form of SSP + 10 tonnes FYM/ha to the previous crop over control (26.4 q/ha).

In the studies on residual effect with rice ('Jaya') at Titabar during kharif, application of phosphate at 60 and 120 kg P₂O₅/ha in the form of single superphosphate (SSP) and MRP produced significant residual effect ranging from 6.4 to 11.6 q/ha over control (31.25 q/ha).

In the studies on direct effect with wheat ('S-308') at Palampur, the responses to 60 kg P₂O₅/ha in the form of SSP (16.2 q/ha) and MRP (20.2 q/ha) were promising over control (13.0 q/ha). The latter was significant over the former. At 120 kg P₂O₅/ha, low responses were recorded with both the sources. Combinations with FYM were also not promising though 10 tonnes of FYM/ha alone produced a significant response of 11.4 q/ha over control.

With wheat ('Kalyansona'), at Sehore, significant response of 11.7 and 12.4 q/ha over control (29.3 q/ha) were obtained by application of 60 kg P₂O₅/ha in the form of SSP and MRP. Application of 10 tonnes FYM/ha produced the same response (11.7 q/ha) as 60 kg P₂O₅/ha in the form of SSP. However, combination of FYM with SSP and MRP at both levels did not produce further yield increase.
The experiment to compare the efficiency of super-phosphate at 60 and 120 kg P\textsubscript{2}O\textsubscript{5}/ha Peruvian rock phosphate at 90, 120 and 150 kg P\textsubscript{2}O\textsubscript{5}/ha and basic slag with varying mesh sizes of 20, 40, 60, 80 and 100 at 120 kg P\textsubscript{2}O\textsubscript{5}/ha was conducted on kharif rice (‘Jaya’) at Kharagpur. All the sources and levels of P\textsubscript{2}O\textsubscript{5} produced significantly higher yield over N+K (18.6 q/ha). Highest response of 35.4 q/ha was obtained by application of 120 kg P\textsubscript{2}O\textsubscript{5}/ha in the form of SSP. Basic slag of 100 mesh size produced practically the same response (34.1 q/ha).

At Hissar, the experiment was conducted to study the relative efficiency of superphosphate and Missouri rock phosphate at 60 and 120 kg P\textsubscript{2}O\textsubscript{5}/ha with and without 10 tonnes FYM/ha and at 0, 500 and 1,000 kg pyrites/ha. The levels of pyrites and its interaction with sources of P and FYM were not significant. Application of FYM and P\textsubscript{2}O\textsubscript{5} at both levels and sources and their combinations with FYM produced significantly higher responses over control (30.3 q/ha). Application of MRP at 60 and 120 kg P\textsubscript{2}O\textsubscript{5}/ha and its combination with FYM produced significantly low response (3.9 to 19.5 q/ha) compared with SSP (10.0 to 29.9 q/ha).

Cultural practices

(a) Time of planting and age of seedlings. At Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, it was found that different varieties of rice need to be transplanted with different aged seedlings. Variety ‘China-988’ and ‘Norin’ gave maximum yield when transplanted with seedlings of 25 days and 40 days age, respectively, while variety ‘IR-579’ and ‘RXT-42’ performed equally well when transplanted with seedlings of 25 to 40 days old. It was also reported that the age of seedlings at transplantation should not exceed 55 days in case of latter two varieties.

At Vivekananda Parvatiya Krishi Anusandhan Shala, Almora, it was found that 3rd week of June was optimum for direct seeding of paddy and the yield declined considerably when the sowing was delayed beyond this period. It was further reported that for transplanted rice with early-maturing varieties ‘VL Mandua-204’ the optimum age of seedlings was 30-40 days, while it was 40-50 days in case of medium maturing varieties like ‘VL Mandua-101’. The studies conducted at N.E. Research Complex, Shillong, revealed that the planting of rice (‘Khonorulu’) should not be delayed beyond 20th of June for obtaining good yield.
In the North-Western plains Zone, the optimum time for sowing of wheat was reported to be as first fortnight of November for long-duration varieties and second fortnight of November for short-duration varieties under the All-India Co-ordinated Wheat Improvement Project. The best time for sowing of wheat in other zones of the country except Karnataka was first fortnight of November. At VPKAS, Almora, it was found that wheat variety 'VL-401' could be sown in early October, while variety 'VL-421' could be sown in last week of October to first of November which is normal sowing time.

(b) Legumes in crop rotation and intercropping systems: In the irrigated cropping systems programme, the role of legumes in crop rotation was further investigated at IARI, New Delhi, and it was confirmed that grain legumes, e.g. groundnuts, cowpeas, lathyrus and Bengal-gram benefited cereal crops to the extent of 40 kg N/ha, whereas fodder legumes like berseem and cowpea are capable of contributing between 40 to 60 kg N/ha. For the small and marginal farmers, enhanced utilisation of the limited land resource is a major challenge and in this context, the role of grain of fodder legumes intercropped with kharif cereals assumes added importance. By changing the geometry of the crop to a paired row system in crops like maize and sorghum, it is possible to introduce short-duration legumes like mung, black-gram, grain and fodder cowpea, and groundnut as intercrops and these intercropping systems increase the land utilisation ratio by 35 to 40%. The Regional Station of IARI at Hyderabad also carried out studies on intercropping systems involving pigeon pea (arhar) as the intercrop and sorghum or groundnut or castor as the main crop. In case of sorghum intercropped with arhar, the total grain production was increased from 15 to 25%; in the case of arhar intercropped with groundnut, there was an increase of 100-150% in total production; and in arhar-castor intercropping, the total yield increased by about 40%.

(c) Fertilizer use in crop rotations. It was noted at IARI, that it is not essential to apply the entire recommended dosages of N and P to all the crops grown in sequence. Thus, the phosphorus needs of a cereal—cereal rotation should be adequately met if the phosphatic fertilizer is applied at the rate of 60 kg/ha to the cereal grown in the winter season and the next cereal crop is able to give good yield without any additional application of phosphorus. The leaching or denitrification losses of nitrogen could be substantially reduced by the use of slow-release N materials, and urea or ammonium sulphate
mixed with neem-cake. Urea thus mixed with neem-cake and applied to the rice crop not only increased its yield but also reduced the nitrogen requirement of the succeeding wheat crop.

(d) Cropping systems under rainfed conditions.—Dust-mulch and straw-mulch applied to grain sorghum increased its yield by 4.6 and 6.7 quintals, respectively, over no mulch (yield 53.3 q/ha) at IARI, Delhi. The differences were significant. Application of atrazine (120 g/ha), phenyl mercuric acetate $1 \times 10^{-4}$ M and Kaolin (6% suspension) through foliar spray (applied just before flowering) significantly increased the yield of sorghum by 12.4, 11.3 and 10.6 q/ha, respectively, over no anti-transpirant treatment which yielded 48.9 q/ha. Application of Mobileaf and CCC also increased the grain yield of sorghum significantly.

Anti-transpirants were also tested on dry land wheat using the cultivar 'Kalyansona' at IARI, Delhi. The wheat-growing season was characterised by no rainfall during the entire period of the growth of wheat crop. The moisture conserved from the previous fallow amounted to 140 mm of available water up to a depth of one metre. The application of Kaoline, CCC and PMA increased the yield of wheat by 23.5, 20.4 and 11.8%, respectively, over the control.

(e) Farming system.—The wide-spread farming system presently in vogue, in the North-Eastern region is a wasteful system leading to soil erosion, loss of fertility, low productivity and it does not permit use of modern technology. The system can be immediately replaced by the alternative system, which aims at stopping loss of soil and its fertility as well as improving production without shifting and any disturbance in the socio-cultural life of the people. The alternative system as developed by the N. E. Research Complex, Shillong, is given below:

*Alternative system of Farming to replace Jhuming (Shifting Cultivation)*

<table>
<thead>
<tr>
<th>Slope</th>
<th>Approx % of total area</th>
<th>Land use</th>
<th>Conservation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower portion</td>
<td>33.5</td>
<td>Agriculture</td>
<td>Bench terracing</td>
</tr>
<tr>
<td>Mid portion</td>
<td>33.5</td>
<td>Horti-pastoral</td>
<td>Half-moon terraces for horticulture with spreading legume in between.</td>
</tr>
<tr>
<td>Top portion</td>
<td>33.0</td>
<td>Forestry</td>
<td></td>
</tr>
</tbody>
</table>
**Weed control**

The experiments conducted at Hanumangarh under All-India Co-ordinated Agronomic Research Project revealed that in pearl-millet, application of Lasso at 0.5 litres/ha just after sowing produced significantly higher response (6.5 q/ha) compared with manual weeding (4.9 q/ha). There was no significant residual effect of weedicide treatments on the succeeding wheat crop.

At HPKVV, Palampur, in case of wheat, it was reported that application of Avadex (Pre-sowing) @ 2.5 litres/ha and Tok-B-2 (Pre-emergence) @ 5 litres/ha and 2, 4-D (Post-emergence) @ 1 kg/ha controlled all kinds of weeds effectively and the crop yielded on par with that of two manual weedicings.

An All-India Co-ordinated Project on Weed Control sanctioned with PL-480 grant has started functioning with effect from kharif season of 1978. There are six centres, viz. PAU, Ludhiana (Punjab), GBPAT, Pantnagar (U.P.) IIT, Kharagpur (W.B.), JNKVV, Jabalpur (M.P.), and UAS, Bangalore (Karnataka) with a co-ordinating cell at CRRI, Cuttack (Orissa). Following are the major objectives of this Project:

(i) To evolve effective, easy, economical and safe methods of weed control in diverse farming and multiple cropping practices:

(ii) To evolve suitable chemical, mechanical and cultural methods of weed control and finding out their effectiveness alone and in combination under different agro-climatic conditions;

(iii) To evolve effective weed control schedules for each of the different types of weeds, classified as aquatic, semi-aquatic, parasitic and arable;

(iv) To improve crop productivity and soil fertility through different weed control methods;

(v) To assess the value of weeds on the basis of their utilisation for food, feed and medicine; and

(vi) To study the effect of herbicides on the dynamics of weed growth and on crop productivity and soil fertility.

In addition, herbicides research in multiple cropping sequences in situations requiring minimum tillage in aquatic environments and parasitic weed control are to be taken up on an All-India basis so that techniques for production are worked
out under different cropping situations. Further, experiments will be conducted for studying the side effects or the cumulative effects of herbicide application on the quality of the environment, namely, the persistence and movement of herbicides in soil, plant, water, animal and human systems.

Soil microbiology

(a) A new non-symbiotic nitrogen-fixing micro-organism *Spirillum lipoferum* is a bacterium capable of entering into “associative symbiosis” with wheat, rice, sorghum, maize and some weeds. The bacterium has been detected in the root hairs, roots and stems of rice and wheat in carefully conducted experiments under artificial inoculation at IARI, Delhi. Some of the strains are capable of fixing 36 mg N/g substrate, which is quite high as compared with the nitrogen-fixing ability in other bacteria. A suitable carrier for bacterium has also been prepared for large-scale production and inoculation of the organism. Field trials with wheat, rice, and forages have been laid out at various locations in the country to test the efficacy of the organism with and without graded doses of urea.

An isolate of *Spirillum lipoferum* from the root region of variety ‘Co-1’ of sugarcane from Coimbatore fixed as much nitrogen as 46.6 mg N/g of carbon source under laboratory conditions.

(b) Use of blue-green algae in rice fields. A technique for production of blue-green algae for inoculation in rice fields was worked out at CRRI, Cuttack. Use of fresh algal inoculation was found to be better than application of dried algae. Inoculated blue-green algae gave additive effect of grain yields under conditions of application of 20—30 kg N/ha as chemical fertilizer.

In Tamil Nadu, it was also shown that application of free-living blue-green algae brought about a saving of at least 20—25 kg of nitrogen in rice cultivation. The IARI, has developed cement tanks for cultivation of blue-green algae successfully.

At IARI, efficient isolates of blue-green algae such as *Anabaena* and *Nostoc* were used for preparing algal inoculants which are capable of effectively reducing the normal requirement of nitrogenous fertilizers in paddy cultivation.

(c) Application of Azolla in rice fields. It was possible to cultivate *Azolla* at the CRRI, Cuttack, throughout the year under field conditions with annual harvest of 333 tonnes/ha green material corresponding to about 840 kg N. Besides beneficial effects of incorporation of *Azolla*, dual culture of *Azolla* in
a field of growing rice and inoculated with small amounts of the fern after transplanting of rice was found to meet the nitrogen requirement of the crop at later growth stages.

Several field experiments conducted at the CRRI, Cuttack, clearly demonstrated that incorporation of Azolla in rice soil at the rate of 10 t/ha increased the grain and straw yield of rice plants from 20 to 40 per cent over control and saved nitrogen applications to the extent of at least 30 kg N/ha.

The use of Azolla was also tried at some of the centres of the All-India Co-ordinated Agronomic Research Project. It was found that use of 10 t/ha of Azolla gave a response of 10.6 q/ha at Bhubaneswar, 25.5 q/ha at Kharagpur and 6.8 q/ha at Titabar as compared with control plots. The response was equivalent to addition of 60 kg N/ha at Bhubaneswar and Titabar, whereas it was equivalent to 30 kg N/ha at Kharagpur.

(d) Role of Azospirillum in nitrogen fixation. It was found at CRRI, Cuttack, that different rice cultivars harboured the nitrogen-fixing organism Azospirillum in the rhizosphere. The nitrogen-fixing capacity of the organism varied with the cultivars of rice from which they were isolated.

Recent experiments at IARI, have also clearly demonstrated the utility of Azospirillum inoculant as a new bacterial fertilizer for wheat, barley, rice and oats. Special extensive field trials showed that Azospirillum inoculation could be done at all levels of urea application and still obtain additional increases in grain yield. From several field experiments, it could be concluded that Azospirillum inoculation could save urea application up to 20 kg N/ha for wheat, barley, oats and rice.

(e) Biological Nitrogen Fixation. The All-India Co-ordinated Project started functioning since kharif season of 1978 at 10 centres. viz. IARI, New Delhi; HAU, Hissar (Haryana); UAS and IIS, Bangalore (Karnataka); TNAU, Coimbatore (TN); CRRI, Cuttack (Orissa); M. S. University, Baroda (Gujarat); JNKVV, Jabalpur (MP); BCKVV, Kalyani (WB) and MAU, Parbhani (Maharashtra). Following are the major objectives of this Project:

(a) To identify research on biological nitrogen fixation in a co-ordinated manner;

(b) Survey, ecology evaluation, benefits of inoculation and interactions with host germplasm, pesticides and inorganic fertilizers;
Genetical studies to enlarge host spectrum by mutation, conjunction, transduction and transformation;

Somatic hybridisation, tissue culture techniques and fusion of protoplast using host plants and nitrogen fixing bacteria; and

Physiological studies to exploit knowledge at the fundamental level of nitrogen fixing and related enzymes to the applied side.

**Bacterial and Algal Nitrogen.** The work on non-symbiotic nitrogen fixation with emphasis on recent developments and molecular biology of bacterial nitrogen fixation processes was reviewed at National Symposium on Bacterial and Algal mediated non-Symbiotic nitrogen Fixation, held on March 27, 1978, at IARI. Various photosynthetic nitrogen fixers, genetics of nitrogen-fixing blue-green algae; and nitrogen fixation and the pathway of nitrogen metabolism as revealed by the use of radioactive nitrogen and ammonium were discussed. Response of crops to applications of *Azotobacter, Azolla* and bacteria from water-hyacinth were also discussed.

**AGRICULTURAL ENGINEERING**

Emphasis during the year has been on research and development and operational research on farm power and machinery, energy requirements in crop production, wells and pumps, post-harvest technology of cereals and pulses, solar energy for agricultural purposes and biogas technology. The work was carried out at the CIAE, Bhopal, and under 4 All-India Co-ordinated Plan Schemes, one operational research project sponsored by the International Development Research Centre, Canada, and 20 *ad-hoc* schemes under the Scientific Panels of Agricultural Engineering and Post Harvest Technology. Work was also started at Bhopal and CRRI, Cuttack, under the Regional Network for Agricultural Machinery of the Economic and Social Commission for Asia and the Pacific.

**Survey**

* Implements in hilly areas. A survey of the existing practices and implements in hilly regions for their evaluation and improvement was taken up. Hand-tools and bullock-drawn implements in the Almorah area of U. P. were procured and were being field evaluated at the CIAE, Bhopal.  

Tribal area and villages. A survey was undertaken in the Bastar District (Madhya Pradesh) and the nearby villages of the CIAE, Bhopal, to identify cultivation practices, farm management problems, implements and tools and their performance, post-harvest practices and constraints in introducing modern technology.

Farm Power

Lack of power on the farms was one of the important constraints in increasing agricultural productivity. Progressively, the supplies of fossil fuels are getting depleted and alternative energy sources have to be developed. Concurrently, the utilisation efficiency of existing sources of power such as manual and animal have to be enhanced.

ENERGY REQUIREMENTS

Field experiments were conducted at the five research stations to determine the energy requirements for raising important crops under the crop rotations of the regions. Different energy treatments comprising man, machine and power sources were studied at all the centres. Another part of the study included field surveys at the farmers' fields. At each research station 26 farmers were included in the study.

It was observed that tractor technology was cheaper for paddy production compared with bullocks. The power-tiller was found to be still cheaper but energy requirements were more than for tractor or bullocks. Irrigation was the major energy-consuming item for raising the crop, the second major operation being harvesting and threshing. The component of total energy used for sowing/transplanting and interculture was small. At all the centres it was noticed that even bullock-farming depends on mechanical power sources for their energy needs from 49.1—86.8 per cent for paddy-wheat and 50.1—87.1 per cent for crops other than paddy-wheat crop rotations. The component of manual energy in crop production was slightly lower for tractor treatment than for bullock. The field survey at Ludhiana indicated that working of the soil after paddy harvest was difficult with bullocks and farmers were hiring tractors for preparing the seedbed. The total energy requirements for raising different crops is given in Table 20.
<table>
<thead>
<tr>
<th>Centre</th>
<th>Energy treatments</th>
<th>Paddy</th>
<th>Wheat after paddy</th>
<th>Other crops</th>
<th>Wheat after other crop</th>
<th>Sugarcane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ludhiana</td>
<td>(a) Bullocks with improved implements</td>
<td>2303.4</td>
<td>413.7</td>
<td>913.0</td>
<td>997.8</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(b) 35-H.P. tractor with conventional implements</td>
<td>2537.4</td>
<td>417.4</td>
<td>1110.4</td>
<td>1086.1</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(c) 35-H.P. tractor with implements of future</td>
<td>2591.3</td>
<td>387.6</td>
<td>1108.0</td>
<td>1000.8</td>
<td>..</td>
</tr>
<tr>
<td>2. Jabalpur</td>
<td>(a) Bullocks with improved implements</td>
<td>692.4</td>
<td>564.4</td>
<td>775.2</td>
<td>648.8</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(b) 8-H.P. Power-tiller with conventional implements</td>
<td>..</td>
<td>540.0</td>
<td>..</td>
<td>605.2</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(c) 35-H.P. tractor with conventional implements</td>
<td>780.7</td>
<td>964.5</td>
<td>1805.8</td>
<td>976.0</td>
<td>..</td>
</tr>
<tr>
<td>3. Kharagpur</td>
<td>(a) Bullocks with improved implements</td>
<td>464.7</td>
<td>597.2</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(b) 8-H.P. power-tiller with conventional implements</td>
<td>664.2</td>
<td>611.7</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(c) 35-H.P. tractor with conventional implements</td>
<td>524.8</td>
<td>624.1</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>4. Paninagar</td>
<td>(a) Bullocks with indigenous implements</td>
<td>..</td>
<td>183.8</td>
<td>737.6</td>
<td>926.9</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(b) Bullocks with improved implements</td>
<td>..</td>
<td>147.6</td>
<td>620.4</td>
<td>875.9</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(c) 20-H.P. tractor with conventional implements</td>
<td>..</td>
<td>222.0</td>
<td>656.4</td>
<td>910.4</td>
<td>..</td>
</tr>
<tr>
<td></td>
<td>(d) 35-H.P. tractor with conventional implements</td>
<td>..</td>
<td>160.6</td>
<td>628.5</td>
<td>882.5</td>
<td>..</td>
</tr>
</tbody>
</table>

* Under the column of other crops and wheat after other crops, the other crops should be read as groundnut for Ludhiana, soybean for Jabalpur and maize for Pan Nagar.
Solar Energy

Solar-air heater. Under the PL-480 Solar Energy for Agriculture Project, three basic configurations of flat plate solar-heaters were studied at the CAZRI, Jodhpur and PAU, Ludhiana to raise the air temperature above ambient by about 5°—10°C, 15°—25°C and 25°—35°C at average efficiency of about 50 per cent. The complexity of construction and intensity of use of insulation materials increased with air heaters which yield higher temperature.

For drying of crops the solar-air heater raising the temperature of air by 15°—25°C was found most suitable since crops with wide variations of initial 20—50 per cent and final 8—14 per cent moisture content, wet basis, could be dried. Two different configurations of air heater raising air temperature from 15°—20°C have already been studied experimentally at Ludhiana.

Drying chamber. After identifying the cost affecting configurations, experiments were performed with 3 different types of drying chambers designed to determine the best overall system for a given cost and performance.

Solar-water heater. A solar-collector for 200 litres capacity was designed at Bhopal. The unit is under testing for its performance, heat-use efficiency and economics of operation.

Biogas (‘Gobar’ Gas)

Kinetics of biogas production. The investigations carried out at 6 research centres, the optimum temperature for biogas production by the anaerobic fermentation of cow dung was found to be 35°C. Although, at higher temperature the gas production was slightly more, at lower temperature the gas production practically ceased. Calcium ammonium nitrate used as an additive to the cellulosic material accelerated the production of methane and also total quantity of gas. Water-hyacinth was also found to be a good source, either alone or in combination with dung, for the production of gas. Of the other materials treated such as poultry-excreta, pig-dung and cattle-dung, the pig-dung was the richest source material for the production of gas both in the total amount and the quality of the gas.

Scrubbing of carbon dioxide. A simple technique was developed for scrubbing of carbon dioxide from gobar gas by bubbling it through 100 per cent aqueous solution of monethanolamine.
By single bubbling through a plain column of 6 cm height, the CO₂ content of the biogas was reduced to 0.5-1.0 per cent by volume from the initial content of about 40 per cent.

Microbiological investigations. A simple new method for obtaining an absolute anaerobic reducing environment which is an essential prerequisite for isolating Methanobacterium sp. was developed. Using this technique enriched cultures of methanobacteria from cowdung slurry were obtained by serial transfers.

Kinetics of biogas production and microbiology of anaerobically digested cowdung slurry were studied in relation to different inoculation levels. Effect of inoculum (extract of predigested slurry) on N : C ratio changes, total N levels, microbial ecology (fluctuations in the total anaerobic and cellulolytic bacteria and methane production) were studied with a view to identifying factors to improve efficiency of methane production by increasing overall fermentability of cowdung. Inoculation increased total anaerobic bacteria and cellulolytic population over un inoculated control. Increase in the rate of application of inoculum hastened the establishment of both these groups of microorganisms in the digesting slurry and also increased the cellulolytic bacterial component of the total anaerobic population. Inoculation had no effect on aerobic bacteria whose population was found to be very low. With increase in the rate of inoculum application the amount of total methane gas produced also increased.

Development of low-cost burners. Simple and comparatively cheaper biogas burners were designed in different sizes. They include 50 mm and 75 mm cast iron body burners and those made from conventional G.I. pipe reducers (75 mm to 12 mm and 100 mm to 12 mm). These burners had suitable bore size jets and an intake pores to give proper gas/air ratio for total combustion. The efficiency of these burners was observed to touch a maximum of 77 per cent and varied from 60 per cent—77 per cent at varying gas pressures from 2 cm to 10 cm of water column. The flame temperatures reach up to a maximum of 72°C. The gas consumption was 2 to 4 cft. per hour.

It was found that a conventional 75 mm to 12 mm pipe fitting reducer could be conveniently used by getting the top 75 mm covered with an M.S. sheet (16 C.W.G.) by welding and providing about 30 holes of 3 mm diameter on the circumference 75 mm side. The 12 mm side could be used for fitting 12 mm nipple (about 150 mm in length), the other end of which could accommodate a jet. Holes for air could be made in the nipple.
The cast-iron burner could be arranged in various ways like single burner, double domestic burner etc. The G.I. pipe fitting burners could be very well utilised for group cooking like messes and hotels.

**Biogas plant:** Work on development of biogas plants was taken up at Bhopal with the main objectives, namely, effect of temperature, and pH of slurry on quantity and quality of gas produced, determination of extent of matter converted into biogas.

**Bio-electrical battery:** A battery with 36 cells of cowdung electrolite and metal electrodes, developing 2.2 volts, and 10 milliamperes of electrical power was developed at Bhopal and found successful to power transistor radios and electronic calculators. Further investigations regarding the mechanism of electricity generation, extent of retention of charge and effect of selected catalysts to maximise power generation in different capacity batteries are in progress.

**Farm equipment**

**Kharif technology for black soils:** This project was initiated at the CIAE, Bhopal, to develop a reliable technology which might bring appropriately 60 lakh hectares of fallow land under cultivation in Madhya Pradesh. Continuous and excessive rains or failure of monsoon during kharif does not give ample time to the farmers to prepare and sow the land by conventional methods. Accordingly they do not take the kharif crop and depend solely on the rabi (winter) crop for their livelihood. The project was aimed at developing suitable technology with proper implements and tools. Results of the trials conducted during the kharif season of 1978 followed by the rabi season gave valuable information regarding special tools and implements for this technology.

**Design and Development:** Under the Co-ordinated Project on Farm Implements and Machinery, animal-drawn 3-5 row seed-drills for sowing groundnut, sorghum, bajra, maize, cotton, etc. were developed at Coimbatore and demonstrated successfully on the farmers’ fields. The two models suitable for heavy and light bullocks cost Rs. 1500 and Rs. 825 respectively. The ‘Jyoti’ seed-cum-fertilizer drill developed at the Pune centre costing Rs. 720 was found successful in six districts of Maharashtra for sowing wheat, sorghum and sunnhemp. Long-handled weeder, 8 cm hoe, 12 cm holder-weeder and V-blade weeder were found
promising for the hill region of Shillong. The animal-drawn potato digger developed for the Nilgiri district of Tamil Nadu was found suitable for the region and saved up to 50 per cent cost in the harvesting operation. The power-tiller-mounted moving-canvas type harvester developed at Coimbatore was selected for field evaluation in 6 Asian countries under the Regional Network for Agricultural Machinery Programme of the Economic and Social Commission for Asia and the Pacific of the United Nations. A low cost power-tiller using a light weight diesel engine of 45 H.P. was developed. Its estimated cost is about Rs. 7,500. A set of matching implements, plough, ridger and bund former were also developed and the unit is under laboratory and field testing. In harvesting wheat sickles developed by the Maharashtra Agro-Industries Corporation based on the Japanese design and sickles from Punjab were tested around Bhopal in Madhya Pradesh and found to be superior in performance compared with the local designs. The models from Maharashtra and Punjab have serrated cutting edges, whereas the local one is of a plain edge. The sickle from Punjab is observed to be more economical in operation with lighter yield crops of 30-50 q/ha and the serrated sickle of the Japanese types were more effective with heavier yield crops of 50-70 q/ha.

Regional Network for Agricultural Machinery (RNAM)

The United Nations Development Programme sanctioned the Regional Network for Agricultural Machinery programme in 1976. The project is being executed by the Economic and Social Commission for Asia and the Pacific (ESCAP) and India is one of the participating countries. The CIAE, Bhopal, has been designated as the National Institute in this project. The project has 4 sub-network activities on Paddy Transplanter, Cereal Harvester, Power Weeder and Manufacturing Technology. Under this project work was initiated to test and evaluate the following prototypes:

Transplanters: (a) Two wheel tractor mounted root-washed seedling type transplanter, Momethora UP-2 from Japan. (b) Self-propelled root-washed seedling type Tong Feng 2-S 10-row model from Malaysia.

Cereal Harvester: Self-propelled hand guided two-row reaper binder Sato make from Japan. Under this programme a National Farm Mechanization Committee is to look after the
mechanization programme of the country and co-ordinate with the RNAM.

SOIL AND WATER ENGINEERING

The Co-ordinated Project on ‘Optimum Utilisation of Groundwater through Wells and Pumps’ has been functioning at five main centres, namely, Ludhiana, Pantnagar, Vadodara, Poondi and Hyderabad. In addition, there were three ad-hoc centres of research located at Jabalpur, Hissar and Bhubaneswar.

The Hyderabad centre concentrated on field studies. In the hard rock regions in Andhra Pradesh, and the Poondi centre developed mathematical models and conducted laboratory studies for predicting the performance of open wells in the hard rock areas. Criteria for locating open wells in different types of rock formations and their geometry including depth in relation to the weathered formations in different rock formations were obtained.

Investigations on corrosion and incrustation problems in tube-wells as a function of the entrance velocity were conducted at the Vadodara centre. Useful information on the entrance velocity in tube-wells as a function of the area and size of perforations was obtained. The centre also developed and conducted studies on the metallurgy of tube-wells for prolonged life. Information on groundwater recharge was obtained from the studies at Poondi and Vadodara.

The Pantnagar centre studied the hydraulic performance of coir rope-wound and nylon fabric mesh-wound well screens. Better performance was obtained from the nylon fabric than the rope-wound screens. The durability of the nylon-mesh was also more than that of the rope. It was observed that nylon-mesh could be used in place of rope as a wrapping material for such screens.

A propeller pump of 22.5 cm diameter casing was designed and fabricated at the Pantnagar centre. The testing of this pump is being carried out. It is substantially cheaper than those available in the market for the same range of discharge rate. It is simpler in construction and is expected to offer lesser operational problems.

The Pantnagar centre tested the performance of a manually-operated International Rice Research Institute, Manila-designed diaphragm pump fabricated by M/s. Assam Industries, Nowgong.
The reported capacity of the pump of 1.20 litres per second per man at 2 metre head was found reasonable. The pump appeared to be satisfactory and promising for low heads and low discharge if its cost could be kept within reasonable economical limits.

The Jabalpur centre concentrated on studies on water lifting devices commonly used in selected Adivasi areas in the State of Madhya Pradesh. Based on the information, a suitable bullock drawn four-cylinder positive displacement pump was developed and tested at the centre. Prototypes of two other pumps—a pedal operated one and a vacuum pump—are under development.

All the centres conducted studies on sick and failed tubewells and open wells. Detailed field investigations on the cause of well failures were conducted, based on which farmers were advised on how to overcome these problems.

The Poondi centre conducted intensive studies on the durability of different types of wells' screens made of locally available material.

The Ludhiana centre developed a low cost safety device, for diesel engines used in pumping sets, which automatically stops the engine in case of a disconnection of the engine cooling system. Basic equations on spacing of wells under situations of fully and partial penetrating water bearing formations were developed. Nomographs were also prepared to determine the discharge of wells.

**POST-HARVEST TECHNOLOGY**

Drying of vegetables: In collaboration with the National Seeds Corporation work on drying of vegetables was taken up at Bhopal to develop a fluidised bed drier for drying vegetable seeds and to determine time-temperature relationship, the equilibrium moisture content and storability in different types of packaging materials like brown paper, polythene etc. A design of the drier was worked out and the first prototype was under fabrication.

Improvement of local storage structures: This work was taken to improve the structural and functional design of local grain storage structures such as 'bindi' and 'kothi', for reducing the losses due to insect pests, avoiding deterioration of quality of grain stored and reducing cost of storage. Six local bins, 3 with neem leaves and 3 as control were under investigation.
Rice flakes: Rice flakes (‘chura’/‘puha’) are quite commonly used in Madhya Pradesh and Maharashtra. A project was taken up to carry out studies on existing small-scale rice-flakes producing units suitable for rural areas, from the technical performance and economics of operation points of view. Information about existing types of units was collected and is under analysis.

Coordinated investigations

Research on harvest and post-harvest problems of cereals and pulses was continued under the All-India Co-ordinated Scheme for Post-Harvest Technology at 10 centres, namely, Akola, Bhopal, Coimbatore, Cuttack, Jabalpur, Kharagpur, Ludhiana, Pantnagar, Raichur and Udaipur and also at PPRC, Thiruvarur under ad-hoc scheme on Pre-harvest Chemical Spray on Paddy Crop. Studies were conducted on post-harvest operations related to harvesting, drying, storage, processing and utilisation of agricultural wastes. The salient results of research are:

Harvesting studies

To determine the optimum date of harvesting paddy and its effect on yield, milling and nutritional qualities, studies were conducted at Cuttack, Kharagpur and Thiruvarur. (a) Experiments conducted at Cuttack with 2 rice cultures, viz. CR--94-M.R.-155 and CR-149-198 showed that both varieties could be harvested between 31-40 and 31-43 days respectively after 50% flowering without any significant loss to head yield (maximum 44.6 and 58.8% respectively). Similar studies are in progress at Raichur for sorghum ‘CSH-1’. (b) At Kharagpur centre, study with ‘Sonaliaka’ wheat indicated maximum yield when crop was harvested after 26 days of heading and grain moisture in the field reaches about 19% (w.b.). (c) By spraying common salt solution of 15-20% concentration at the end of biological maturity of the paddy crop, reduction in moisture content of grain as well as straw, quick change in colour of both grain and straw from green to yellow and early harvest at least by a week yielding higher recovery of paddy during first threshing operation were observed at Thiruvarur.

Drying

At Bhopal centre, investigations carried out for determining the effect of various surfaces on the drying-rate of chillies in the sun revealed that tarpaulin surface, jute mat, black polythene and concrete surfaces reduced the drying time by 4, 3.5, 3
and 2 days respectively in comparison with usual mud and floor which needs 13 days to reduce the moisture content from 80 to 15%. The benefit-cost ratio in using tarpaulin and jute mat surfaces was 2.44 and 2.38 respectively.

The Cuttack centre while determining the effect of staggered drying on milling quality and storability of paddy, noted that long exposure to sun over less number of days made the grain susceptible to insect attack, than short exposure (during morning hours) over number of days. The effect of these treatments on milling quality is being analysed.

One-tonne capacity solar grain-drier: This comprises a one-tonne cylindrical metal bin, an unshielded solar collector on the south facing bin wall and a 0.5 H.P. electrical blower was developed at Jabalpur. It gives 9°C air temperature rise at 38 cubic metres/minute of air flow at 15 mm water static head pressure. The cost of the dryer is Rs. 2,500.

Horizontal solar-blower: This is a modification over the vertical solar-blower and was developed at Jabalpur centre to increase the rate of drying of moist grains and perishable product by forced ventilation.

Portable tray-type grain-dryer: This dryer using agricultural wastes like peat and stalks as fuel was designed and developed at Raichur with a drying capacity of 300-350 kg (paddy)/hr to reduce moisture level by 10% (from 25%—15%) in drying temperature of 50°-65°C. The cost of this equipment is Rs. 1,500 and drying cost is Rs. 0.30/q. A similar unit using farm-wastes such as cotton stalks and jowar stubble was developed at Akola for drying of cobs before threshing and drying freshly threshed sorghum grains before storage. The rates of cob and grain drying obtained were 6-8 q/day and 10-15 q/day respectively in a temperature range of 55°—60°C. The capacity of the drying bin was 150 kg of cobs and 300 kg of grains. The cost of the whole unit is Rs. 6,500 and drying costs/q of cobs and grain are Rs. 3.86 and Rs. 2.81 respectively.

Husk fired furnace and continuous grain-drier: This unit was designed and developed at the Pantnagar centre and is ready for release for commercial production.
Storage

Studies were conducted at all the centres to evaluate indigenous and improved storage structures. Three structures namely Aluminium bin, Nanda bin (made of burnt earthen rings) and ‘Pucca’ bin (made of brick, masonry and plaster) were evaluated at the Cuttack centre for their storage performance. These structures recorded losses between 9-11.6% due to exposure from heavy rains, being outdoor structures. A bed-cum-storage bin structure was developed at Cuttack which utilises three walls of a room thus saving cost of construction. It is a multi-purpose masonry structure and could be used as a bed and also for keeping utensils, bags etc.

At Akola, improved PKV bins costing Rs. 150 were tried for storage of sorghum both with and without polythene embodiment as an indoor and outdoor structure. The indoor improved bin without polythene showed good performance and is now being tested on operational basis in rural areas. In a similar study at Coimbatore, plywood bin and Hapur bin proved better for sorghum storage than any other structure. ‘Gumme’, the popular indigenous storage structure in Karnataka was modified at Raichur by providing a rodent proof platform for its erection, an outlet chute for easy removal of grains and polythene sheet lining (700 G) for safer storage.

In another study to evaluate some synthetic chemicals and plant products as paddy grain protectants, Allitin, a synthetic compound showed good potential against Sitotroga cerealella. Acorus calamus proved to be a promising non-toxic grain protectant for sorghum grain at Akola, when mixed in 0.1% concentration. Covering the gunny bags with grain by husk-ash and cowdung-ash reduced the grain damage by 2% at Cuttack. Impregnated gunny bags with Velexan for storage of ‘CSH-6’ sorghum at Coimbatore was found to be the best among different chemicals tried. While determining the effect of storage on milling qualities of paddy, it was noted at Kharagpur that milling qualities improved significantly after 6 months of storage. The head yield of rice of raw paddy increased from 46.3—56.4% and of parboiled paddy from 74—76%. Cooking quality as judged by optimum time of cooking and water uptake and solids leached showed an improvement due to storage.
Processing

A comparative evaluation studies were conducted at Bhopal on hand-grinder, mini-grain mill and commercial flour mill for their performance for wheat milling. The mini mill was found satisfactory for both wheat-milling and pulse-splitting and in grinding of split pulses into flour (besan) by making some minor adjustments, while determining the effect of processing equipment under varying agronomic practices on rice, groundnut, sorghum and pulses. Three different threshers, viz. Podgilwar, L.C.T., Bhuvneshwar, and Vilan were evaluated with ‘Co-21’ sorghum earheads. The L.C.T. thresher with an output of 450 kg/hr and 88-99% threshing efficiency and 91% winnowing efficiency and Rs. 17.70/tonne threshing cost was found to be ideal for threshing sorghum grains. Crippen and Petkus models of seed cleaner-cum-graders gave 37 and 64% grading efficiencies at outputs of 250 and 400 kg/hr respectively and cleaning-cum-grading cost of Rs. 39.35 and Rs. 18.75/tonne. At Udaipur, some modifications were made on an ergot-bajra separator to improve its efficiency and performance. The cost of this machine is Rs. 300 and its operating cost is Rs. 2.08/hr.

Recycling of agricultural-waste products

A survey of agricultural waste products and their present utilization pattern was conducted at all the 10 centres. The study revealed a wide variety of useful materials such as flyash, mango-kernels, maize-cobs and maize-stalks, paddy-straw, sesame-cake etc. which have inherent potential for utilization in various sectors. The data are being analysed to determine the economic gains which could be had from such waste materials.

Marketing

To understand the existing pattern of practices followed in handling and storage of agricultural produces in the grain markets (‘mandies’), to work out their economics of operation and to develop suitable processing systems to enable the farmers to get higher returns, a study of the ‘Krishi Upaj Mandi’ at Bhopal was conducted. This revealed that farmers get only 70% out of the selling price in case of cereals, millets and whole pulses, and 60% in the case of split pulses ‘dal’ and the rest of the amount goes to the market functionaries. About 11% of the produce is lost in handling at the market. In the light of the data collected, provision of a co-operative drying, cleaning and processing unit at the market is considered beneficial.
Operational Research in Post-Harvest Technology

The Operational Research Project in Post-Harvest Technology sponsored by IDRC, Canada functioned at its ongoing five centres; PKV, Akola; CIAE, Bhopal; TNAU, Coimbatore; CRR, Cuttack and University of Udaipur, Udaipur. The technologies developed under the Co-ordinated Scheme for Post-Harvest Technology and other sources considered of importance in a particular context are being field tested and desired modifications incorporated to suit the local needs. The following are the important achievements under the project at different centres:

Akola Centre: The agricultural-wastes-fire dryer was field-tested in Akola district. Finding of harvesting hybrid sorghum arrived at earlier at 21—24% were field tested in five villages and an average of 16% more yield was obtained compared to traditional practice. More number of PKV bins and use of A. calamus powder as grain protectant were field tested.

Bhopal Centre: Coaltar drum bins 1.5 q capacity and Hapur 'Kothics' 2, 5 and 7.5q capacities were put on operational research in three villages and were found superior to the traditional mud 'Kothi'. Farmers responded very favourably to these bins. Work was carried out for field trial of mini grain-mill in the village to assess its introduction to create grain processing industry in the villages.

Coimbatore Centre: The TNAU dehusker-cum-sheller costing Rs 7,500 was field tried and shelling 940 kg cobs/hr at a unit cost of Rs 8.40/tonne was obtained. It saved time by 95% and the cost by 85% as compared with the manual method. The TNAU winnower with scalper was found well suited for winnowing sorghum and paddy, giving a winnowing efficiency of 97% with a unit cost of Rs. 0.5/q for sorghum and Rs. 0.35/q for paddy. A solar-batch dryer developed at TNAU using glass shielded flat-plate-solar collector, centrifugal blower and rectangular aeration was field tried at a seed processing plant. The solar-dryer gave 20% economy in cost as compared with the kerosene-fired dryer.

Cuttack Centre: Nanda bins, Bed-cum-Bin and 'Pucca Kothi' were field researched for storage of paddy. Nanda bins and Bed-cum-Bin were reported to have received good response from the farmers. Improvement brought about over the conventional parboiling technique at CRR, Cuttack was also laid out in the field.
Udaipur Centre: More number of Udaipur storage bin and Chittore stone Bin were installed/erected in five villages. Maize stored in the Udaipur Storage Bin, enabling fumigation due to airtightness gave Rs 40-45/q of additional income by virtue of storing the grain over a long period without significant deterioration in the quality. Maize dehusker-cum-sheller was scaled up and field tried. It shelled 1.5 q cobs/hr at a unit cost of Rs. 4/hr. Modifications on the solar-heat-treatment Machine and Ergot-Bajra Separator were pursued.

Documentation of information

To improve documentation of research information in the field of Agricultural Engineering which was very much lacking, work on the preparation of a directory of the research workers, the abstracts of research papers published and technical bulletins on different categories of equipment produced in the country was in progress. Two technical bulletins, ‘Weeding Tools and Implements’ and ‘Evaluation and Field Performance of Tools for Harvesting of Wheat Crops’ were published.

5. ANIMAL SCIENCES

Research on different species of economic livestock was pursued for raising animal production and providing effective health cover to them to ensure better productive performance.

CATTLE

Breeding

Efforts were continued at the central institutes and under the All-India Co-ordinated Research Project to develop dairy animals having higher milk production, and optimum and better feed-conversion efficiency. Under the Co-ordinated Project, which has the objective of evolving new strains of dairy cattle by crossing indigenous breeds (Hariana, Ongole and Gir) with 3 exotic dairy breeds, viz. Holstein-Friesian, Brown Swiss and Jersey, further progress was made. Half-bred Jersey, Holstein-Friesian and Brown Swiss were obtained for the production of three-breed crosses comprising 75% exotic inheritance in combination of two exotic breeds. The number of female half-breds in the Co-ordinated Project was about 2,580 and of female 3-breed crosses 1,186. The performance of 3-breed crosses at some of the centres of this Project is now
known. At Rahuri Centre, the age at first calving in these crosses was considerably less than of the half-bred crosses. The average age at first calving was recorded as 713 days in \( \frac{1}{4} \) Jersey \( \times \frac{1}{4} \) Holstein-Friesian \( \times \frac{1}{4} \) Gir when compared with 800 and 755 days in Friesian \( \times \) Gir and Jersey \( \times \) Gir half-breeds respectively. At Rahuri an experimental cow, 'Rajeshri' (\( \frac{1}{4} \) Jersey \( \times \frac{1}{4} \) Holstein-Friesian \( \times \frac{1}{4} \) Gir), calved at the age of 703 days yielding 3,639 kg of milk in 300 days in her first lactation. The encouraging performance by 3-breed crosses indicated the possibility of developing a synthetic breed of dairy cattle. A Jersey \( \times \) Gir cross-bred cow yielded 4,028 kg in 300 days at Rahuri. At Hissar, a Holstein-Friesian \( \times \) Hariana cross-bred yielded 4,673 kg in a lactation of 314 days with a daily average of 14.9 kg of milk. The fat percentage of 5.2 in Jersey \( \times \) Hariana cross at Hissar was considered slightly higher.

Under the young sire selection programme, based on the performance of the dam's and the sire's progeny test, superior three-breed cross sires were selected for inter-se mating programme.

Cross-breeding programme with Deoni cows using Holstein-Friesian semen was continued at the Marathwada Agricultural University, Parbhani. At the Konkan Krishi Vidyapeeth, Dapoli, Rathi and Hariana were crossed with Holstein-Friesian, though some Rathi \( \times \) Jersey half-breeds were also produced. The cross-breeds had better growth, reproductive performance and milk production than the local parents.

At the National Dairy Research Institute, Karnal, the high-yielding Karan Swiss gave an average of 3,249 litres of milk in 305-day lactation, an improvement of 60% over the contemporary Sahiwal averaging 1,988 litres in 305-day lactation. The new combination of Holstein-Friesian and Tharparkar with 50% inheritance from each averaged 3,380 litres in 305 days in the first lactation, indicating a better combination for further development.

**Nutrition**

Supplementation of immunoglobulins by injecting intravenously freeze-dried first-day colostrum reduced remarkably the calf mortality. Studies on cattle serum in Brown Swiss \( \times \) Sahiwal calves revealed that immunoglobulin level in the first day
colostrum was 65.8 mg/ml, which dropped to 19.9 mg/ml on the second day and 1.0 mg/ml on the fifth day. The survivability, growth rate and body weights were higher among the calves with higher level of immunoglobulins in their blood serum.

The pattern of feeding followed by cattle owners located in the high ranges of plains of Kerala State differed significantly. The study yielded confirmatory evidence on residual effect of feeding over the whole lactation. Proteins had a greater impact than energy on lactation among the cows under study. When local hay alone was fed the dry-matter (DM) intake came down to around 1.30 kg/100 kg of body weight and the animals lost some weight. However, when a mixture of 20 kg of green guinea grass and local hay was fed ad lib. the DM intake improved up to 2.3 kg/100 kg body weight and the animals gained in weight; 30 kg of guinea grass, 4 kg of local hay and mineral mixture without concentrates sustained milk production up to 3 kg of milk yield per animal per day.

The fat in the diet of Karan Swiss cows when protected by formaldehyde treatment resulted in increase in unsaturated fatty acid content and decrease in saturated fatty acid content of milk-fat.

The experiments conducted using S\textsuperscript{35} indicated that ammonia and sulphur from ammonium sulphate are utilizable by the rumen microbes. The release of volatile ammonia from ammonium sulphate was less than that from urea. Work was continued to find out a suitable combination of urea and ammonium sulphate to give a 10 : 1 ratio of nitrogen to sulphur for growth and milk production. Incorporation of S\textsuperscript{35} into microbial protein was significantly greater when biuret diets were fed than when urea-based diets were fed. \textit{In vitro} experiment revealed that 10 : 1 nitrogen to sulphur ratio was the best to incorporate maximum sulphur for microbial protein synthesis.

The concentration of cystine and methionine in microbial protein was significantly high with nitrogen to sulphur ratio of 10 : 1. A substantial, intake of C-14 citric acid was through rumen wall. This indicated its absorption from the rumen, resulting in greater papillary development in the rumen.

A calf-starter containing fish ensilage (20% and 30%) as an ingredient was assessed for its utility. The starter was palatable to the calves and was consumed without any difficulty.
Its inclusion in the calf-starter had no untoward effect for 6 months. This protein-rich ingredient is economical.

Conventional oilcakes are not available for incorporation in cattle feed in required quantity. The utility of rubberseed-cake was assessed. The cake contained 29% crude protein, 7% crude fibre, 21% digestible crude protein (DCP) and 71% total digestible nutrients (TDN). The study indicated that the cake can be successfully used in the place of linseed-cake or coconut-cake in the ration of milch cattle for obtaining optimum returns.

Efforts were made to promote fodder production, particularly under dry-farming condition. Horsegram fodder is an ideal dryland crop. Its DCP and TDN contents were 8 and 51% respectively. The nutritive value of hay was 6% DCP and 43% TDN. The fodder which is a short-time crop can provide palatable and nutritive fodder both as green and as hay.

Sargassum, a sea-weed belonging to brown algae family, is available in sizeable quantity along the coastline of the country. Processed sargassum contained 9.83% crude protein, 12.72% crude fibre and 4.62% calcium. Sargassum at 20 and 30% could be included in the daily ration of cattle.

Studies carried out at the Kerala Agricultural University showed that colostrum in excess of the requirements of the suckling calf can be stored at room temperature for 10 days and fed to other calves. The feeding of sour colostrum was beneficial and economical.

Soil, fodder and blood samples collected from Tarai area in Uttar Pradesh when analysed at the Indian Veterinary Research Institute, Izatnagar, indicated the possibilities of zinc deficiency in milk in the area. In spite of adequate amount of available copper in the soil, in general, all the fodders except legumes contained inadequate levels of copper for the proper upkeep of the animals. This was reflected by sub-normal and low levels of copper in blood of most of the animals of the area. Iron and magnesium deficiency did not appear to be a major problem in this area.

The study carried out on optimum fodder (para grass) and concentrate feeding for growth and milk production in cows at the Tamil Nadu Agricultural University gave encouraging results. Cows yielding up to 5 kg of milk per day, on an average, could
be sustained by feeding 30 kg of para grass in addition to 1 kg of lucerne per day. The cost of milk produced was much less. This resulted in the saving of feeding concentrates fed to medium- and high-producing types of cows.

At the Gujarat Agricultural University, Anand, studies were conducted on the feasibility of replacing cottonseed-cake with rubberseed-cake in concentrate mixture for Kankrej calves. Different levels of rubberseed-cake in concentrate mixture did not show any marked effect on the growth of calves. There was no adverse effect on body measurements, viz. girth, height and length; digestibility of proximate nutrients; balance of nitrogen, phosphorus and calcium; and cost of feeding per kilogram gain in body weight. It was concluded that rubberseed-cake can be incorporated in the concentrate ration of growing calves up to 30% level. Milk of cows fed concentrate mixture containing 25 to 30% of rubberseed-cake did not have any adverse effect on flavour or smell.

**Physiology**

The work done at the Kerala Agricultural University indicated that dry and non-pregnant cows could be artificially brought into lactation by means of hormonal treatment. The animals treated with hormones tended to have normal reproduction cycle thereafter. Both natural and synthetic oestrogen along with progesterone were effective.

Karan Swiss cross-bred cows were found to be better converters of feed and forages than buffaloes. Total butterfat production was 116.5 kg on 300-day lactation basis in cross-breds and 115.8 kg in buffalo cows.

Studies were carried out on the long-term effects of environmental heat on endocrine functions of cross-bred heifers at the Indian Veterinary Research Institute. Blood samples collected from the experimental animals before, during and after the exposure at 37°C were being analysed for tri-iodothyroxine uptake, glucocorticoid activity and progesterone.

**BUFFALO**

**Breeding**

Considering the importance of buffaloes in the agricultural economy intensive efforts for the improvement were continued in a co-ordinated manner under the All-India Co-ordinated
Research Project on Buffalo Breeding. The efforts were mainly directed towards the improvement of Murrah and Surti breeds. It was proposed to take up research programme on Bhadavari, Nagpuri and Jaffarabadi breeds of buffalo also. The studies carried out at the National Dairy Research Institute, Karnal, and the Punjab Agricultural University, Ludhiana, indicated that phenotypic and genetic correlations between service period and dry period were very high, and either of these traits could be considered for selection. Selection based on index incorporating service period or dry period and milk production increased the lifetime production of buffaloes. At the different centres under the Co-ordinated Project milk production significantly increased in Murrah and Surti buffaloes. The average milk production was about 1,800 kg per lactation in Murrah buffaloes and about 1,250 kg in Surti buffaloes. At the research centres Murrah buffaloes yielding more than 3,000 kg and Surti buffaloes yielding more than 1,800 kg of milk were identified. These will be utilized for developing an elite herd of buffaloes.

Work was initiated to establish a germplasm centre at the Indian Grassland and Fodder Research Institute, Jhansi, to raise surplus male buffalo calves from the various centres of the Project with specific emphasis for meat production. To transfer the benefits of the Project directly to the farmers, field units have been established at the project centres, so that the elite sires could be evaluated for their transmitting ability and simultaneously to improve the buffaloes.

Studies at the National Dairy Research Institute, Karnal, indicated that Citric Acid Whey (CAW) was a better diluent for freezing buffalo semen than the other traditional diluents. The work carried out at the Punjab Agricultural University, Ludhiana, however, indicated that ‘TRIS’ reagent was superior to CAW. This needs to be confirmed by further extensive trials.

Buffalo semen has 800 to 1,000 mg fructose/ml as free sugar and glycoprotein as bound sugar. Choline plasmalogens are the major phospholipids of buffalo semen which in addition contain glyco-lipids. Buffalo semen, samples having initial motility of spermatozoa had the capacity to produce cyclic adenosine monophosphate, an enzyme which affects motility, capacitation, maturation and fructolysis. The research work carried out at the All-India Institute of Medical Sciences, Delhi, indicated that human seminal plasma contains a ‘P’ factor, which has the capacity to increase the motility and hence improve the fertilizing capacity of buffalo semen. Field trials
carried out at the Haryana Agricultural University, Hisaar, indicated slightly better results on the percentage of conception when buffalo semen containing ‘P’ factor were used. The emphasis on future work will be to develop a technique for the synthesis of the ‘P’ factor as an additive not only to improve buffalo bull semen but also the semen of other species by improving their motility and fertilizing capacity.

Studies at the National Dairy Research Institute, Karnal, indicated that infant cattle and buffalo calves with higher gamma-globulin in blood had lower mortality. Based on this information management practices were developed, including administration of gamma-globulin intravenously to reduce calf mortality. The milk replacer developed reduced feed cost in the first 4 months from Rs 685 to Rs 400 per animal. Calves kept on milk replacer prepared from wheat, fish-meal, linseed-oil, coconut-oil, linseed-meal, citric acid, molasses, mineral mixture, and vitamins A, B and D had almost the same growth rate as milk-fed calves, and did not have any adverse after-effects even after calving.

**Nutrition**

Studies were conducted on the rumen microflora of cattle and buffaloes at the University of Agricultural Sciences, Bangalore, in respect of the general composition of the bacterial population, isolation, characterization and identification of bacteria, conditions required for maintenance of bacterial isolates; biochemical changes such as pH, ammonia, total volatile fatty acids, microbial protein content in rumen fluid under different feeding time intervals; and biochemical and enzymatic changes in the rumen fluid of cattle at different time intervals at different levels of urea supplementation. The results indicated that there was a significant increase in bacterial population, microbial protein and total volatile fatty acids in the rumen under urea-supplemented feeding regime.

At the Punjab Agricultural University, Ludhiana, it was observed that ‘Uromol’, a feed prepared by heating urea-molasses mixture, could be used as a good substitute for groundnut-cake in the animals yielding 10 kg milk/day. ‘Uromol’ concentrate mixtures cost less than cake-based rations. Adoption of this practice would spare the expensive oilcakes for non-ruminant livestock and reduce the cost of feeding. In another study, it was observed that malt husk could also be used in the rations of milch buffaloes.
Efforts were made to improve the feed value of low-quality roughages by impregnating them with suitable levels of urea and molasses at Dharwar. The findings suggested higher dry-matter intake in buffaloes and better digestibility of refractory components of fodder when maize straw was impregnated with 1% urea and 5% molasses than when fed untreated straw with 1 kg concentrate mixture. Studies at the National Dairy Research Institute indicated that by better feeding and individual care, the age at first calving in buffaloes could be brought down by 10 months, thus saving on rearing cost and also making the animal productive during that period. The maintenance energy requirements of milking buffaloes in early lactation was estimated at 158.54 Kcal ME/kg W0.75/day. The metabolizable energy required for the production of 1 kg of 4% fat-corrected milk was 1,863.63 Kcal. The digestible crude protein (DCP) requirement for maintenance in milch buffaloes was estimated at 3.20 g/kg W0.75/day. The DCP requirements for the maintenance of buffaloes in early lactation were also higher than Sen and Ray standards. The results confirmed that liberal provision of nutrients, especially energy, in the ration of milch buffaloes has to be made for the optimum production of milk.

Investigations at the National Dairy Research Institute, Karnal, suggested that the feed efficiency utilization decreased with increasing live weight. This may be because with the increase in size associated with advancing age, the energy requirement for maintenance increased resulting in the reduction of the total efficiency of growth. Considering the dry-matter requirements and energetic efficiency of growth in buffalo calves, it was seen that the law of diminishing returns started functioning at an appropriate level of intake, beyond which addition of energy to otherwise computed ration did not result in benefit to the growing animals in terms of efficiency of feed conversion and cost of nutrition per 1 kg gain in weight.

The energetic efficiency of different feeds and fodders, viz. kharif (wet season) fodders, green berseem, pearl millet, oat, concentrate-based ration, wheat straw, poultry-droppings-enriched ration, wheat bran, rice bran and deoiled rice bran, was evaluated at the Punjab Agricultural University, Ludhiana. The data collected on the various fodders when fed to male buffaloes at their maintenance level of nutrition was used for predicting the energetic worth of the fodders if their chemical composition was known. Negative correlations were observed
between crude fibre and TDN, digestible energy (DE) and metabolizable energy (ME) contents of the fodder. The multiple regression coefficients for TDN, DE and ME to that of chemical constituents were 0.735, 0.796 and 0.948 respectively.

At Anand Campus of the Gujarat Agricultural University metabolic trials were conducted on growing Surti buffalo male calves, under the All-India Co-ordinated Project on Utilization of Agricultural By-products. The animals could consume 2.75% dry matter from the ration consisting of pods of Prosopis julifera and mature pasture hay. The digestibility of crude protein was 50 to 60%, with the average of 56.24%. The average digestibility of ether extract, crude fibre, nitrogen-free extract and organic matter was 70.19, 80.40, 78.71 and 74.22% respectively. Thus, pods provided 7% DCP and 75% TDN on dry-matter basis. The nitrogen and calcium balances were positive while phosphorus balance was negative suggesting that pods should be fed along with phosphorus-rich concentrates or mineral mixture.

At the Southern Regional Station of the National Dairy Research Institute, Bangalore, extensive studies on the utilization of agro-industrial and marine by-products indicated that their nutritive value was satisfactory and that these could be incorporated in the rations of livestock.

**Physiology**

Basic investigations on hormonal changes were undertaken during the reproductive cycle in the buffaloes using radio-immuno assay. The result should help in detecting heat in buffaloes and initiating oestrus by administering drugs and synchronizing with ovulation for better conception. In a study on seasonal variation in oestrogen and progesterone level in milch cattle and buffaloes at Hissar, a method was developed to diagnose pregnancy as early as 20 days by estimating progesterone in blood. This is based on the concept that when the animals fail to conceive, the corpus luteum regresses and the blood progesterone concentration falls towards the end of the cycle. On the other hand, the corpus luteum and progesterone concentration are maintained if the animals conceive. Thus by determining the serum progesterone level, 13 pregnancies were accurately determined in the 14 buffaloes tested.

A study on the post-partum ovarian activity in buffaloes at the Punjab Agricultural University, Ludhiana, indicated that
the season of calving and level of production had no influence on follicular development, and the time between first post-partum oestrus and fertility varied significantly in different seasons. The study further suggested that autumn and winter were favourable for early estimation of ovarian activity and fertility, and that wallowing was the most effective method for increasing the reproductive efficiency. At the Rajendra Agricultural University, Patna, histological and histochemical studies on the endocrines, productive and excretory systems in buffalo bulls provided salient features for application in the field for improved reproduction in buffalo.

Studies carried out at the Indian Veterinary Research Institute, Izatnagar, indicated various types of reproductive disorders in rural buffaloes. Studies carried out under the All-India Co-ordinated Project on Buffalo Breeding indicated that ovulation of uterus was completed on an average in 35 and 45 days in normal and abnormal calvings respectively. First post-partum oestrus was observed after 50 days in normal calvings in buffaloes and 60 days in the rest of the animals. Only a few breeding females exhibited mucous discharge during summer. In winter mucous discharge was thick at periodic intervals. Frequent urination was an additional feature during autumn. In winter there was intensive activity accompanied by bellowing by the animals and there was thin copious mucous discharge with frequent urination. The alkaline-phosphatase activity increased in animals with fertile heat. Low level of plasma ascorbic acid was associated with poor fertility. Cholesterol level of plasma and cervical mucus showed a decrease with the progressive stage of oestrus.

Technology

A technique for preparing heparin from buffalo lungs was developed at the Bombay Veterinary College. The activity and the properties of the final purified product were comparable with the standard heparin. At the Patel Chest Institute, Delhi, the insulin was prepared from pancreas of buffaloes on a pilot scale. A number of private industries have shown interest in this technique.

Health

Basic and applied research on a number of disease problems in priority areas were conducted at the Indian Veterinary Research Institute, Izatnagar, and agricultural universities. The
epidemiological studies on the foot-and-mouth disease were conducted under the All-India Co-ordinated Research Project. Valuable epidemiological data for planning and implementation of foot-and-mouth disease control programme were obtained from 1,110 outbreaks and based on the epidemiological research studies made at different centres of this project. Out of the field materials collected from these outbreaks about 1,050 virus isolations were made. Of these 985 virus isolates were typed as follows: type 'O', 520; type 'A', 130; type 'C', 25; type 'Asia 1', 227; and cross-reacting isolates, 83.

The Centre produced the following quantity of type-specific reference sera (millilitres): type 'O', 180; type 'A', 1,892; type 'C', 100; 'Asia 1', 110; and subtype 'A', 100.

The work on subtyping virus isolates of different types was considerably intensified. This helped in comparing epizootic wild virus strains with seed virus types of present vaccine. The data on subtype 'A' provided useful information in relation to vaccine production.

At the Foot-and-Mouth Disease Vaccine Production Centre, Bangalore, important advances were made in developing technology for the production of more efficient vaccine against foot-and-mouth disease by using BHK21 suspension cell-lines. A large number of experimental (pilot) batches of vaccine were produced and tested in guineapigs and cattle in the laboratory as well as in the field. The vaccine was efficient and safe. Field trials conducted in the states of Karnataka, Uttar Pradesh, Haryana and Delhi also confirmed the efficacy and safety of the vaccine.

Research was continued on anaplasmosis at the Indian Veterinary Research Institute, Izatnagar, University of Agricultural Sciences, Bangalore, and Haryana Agricultural University, Hisar. At the Indian Veterinary Research Institute further progress was made in the development of vaccine, and a suitable one will be brought out soon. For rapid diagnosis of anaplasmosis a reliable test was standardized with the capillary-tube-agglutination test. At Bangalore of the 197 sera samples obtained 37 were positive. At the Haryana Agricultural University, Hisar, this test employed with spleen antigen gave very encouraging results in detecting the clinical cases in carrier animals. The study confirmed that buffaloes are also susceptible to this infection. This finding has a bearing on the control of the
disease. Chemotherapeutic research studies indicated that new drugs like chloramphenicol, rolitetracycline and diminazene aceturate are effective for treating clinical carrier animals.

In pursuance of the work carried out during the previous years, investigations were conducted to identify and solve the reproductive problems in cattle and buffaloes in rural areas. The efforts were aimed at rendering gynaecological services to farmers, especially marginal and poor, so that they get rid of sterile, unproductive and uneconomical animals. To augment the breeding activities and train the field veterinarians 18 camps were organized in Himachal Pradesh for gynaecological investigations.

In the discipline of veterinary surgery, several new advances were made to ensure speedy recovery of animals suffering from various important surgical conditions. At the Indian Veterinary Research Institute experimental studies with a synthetic material for immobilizing fractures showed that methylmethacrylate when used as adjunct to intramedullary fixation provided rigid immobilization with minimal callous formation, rotation and damage to the medullary cavity. The material does not produce any complications or side effects. The healing of bones was evaluated by X-ray angiography, medullography and histopathological examination of biopsy material.

A new technique for spinal angiography was successfully utilized for evaluating neurological disorders in sheep, goat, dogs, calves and rabbits. This procedure has added advantages over the conventional technique of myelography.

Investigations were carried out on theileriasis, an important protozoan disease of livestock, at the Punjab Agricultural University, Ludhiana, the Tamil Nadu Agricultural University, Madras, and the Indian Veterinary Research Institute, Izatnagar. Different species of ticks suspected to be vectors of the disease were identified and studied. At Ludhiana, it was observed that the tick Hyalomma detritum commonly infested cattle and transmitted Theileria annulata. At this Centre, important advances were made towards immunization of cattle against theileriasis. The results indicated that: (a) cattle can be successfully vaccinated by infection-treatment method, (b) attenuated schizonts in tissue-culture fully protected cattle against severe tick-introduced re-infection, and (c) vaccination conferred full protection against severe homologus infection and full clinical
cross protection against severe infections with other strains of the parasite.

Investigations were carried out on salmonellosis at the Haryana Agricultural University, Hissar. A total of 553 animal and human sera were examined for the presence of agglutinins against the commonly occurring salmonella serotypes. Out of 161, 83 and 117 serum samples from sheep, buffaloes, buffalo calves and human beings, respectively, 117 (72.67%), 38 (45.7%) and 83 (71%) contained haemagglutinins (HA) against antigens of commonly occurring salmonella. The HA titre of these sera ranged from 1:40 to 1:640. A number of salmonella strains commonly used for preparing antibiotics were tested for their sensitivity and useful data obtained.

MILK AND MILK PRODUCTS

Bacteriology

Work in dairy processing in the Divisions of Dairy Technology and Dairy Engineering at the National Dairy Research Institute, Karnal, is supported by basic work in Dairy Bacteriology and Dairy Chemistry. An outstanding research in Dairy Bacteriology was the study of biosynthesis of diacetyl which is mainly responsible for the pleasant aroma and taste of dahi. Several new mutants of bacterial organisms capable of producing the desirable flavour components were developed. Flavour concentrates were prepared from these organisms by adding them to products like curd, yoghurt and table-butter. Another area of work in Dairy Bacteriology was the production of acidophilus milk which has curative property for several intestinal disorders and has great therapeutic value. Lactobacillus acidophilus, the principal organism in this case gets implanted in the intestines and exhibits antibacterial activity against Staphylococcus aureus and E. coli. Rennet substitutes from microbial sources were successfully developed. The organisms used for rennet production were Bacillus subtilis K-26 (bacteria) and Absidia ramosa WBC-1 (mold strain). Blending of animal rennet and bacterial rennet in equal proportion yielded cheese with maximum score.

Chemistry.

Basic studies were done on the synthesis of milk protein. A heat-stable factor which stimulated protein synthesis by the mam-

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mary gland during lactation was detected in liver tissue of goat and rabbit. Basic research was carried out in the Department of Biochemistry at Ahmednagar College on the isolation and purification of α-lactalbumin and galactosyl transferase proteins, which constitute the lactose synthetase enzyme system present in milk and mammary glands of Jaffarabadi breed of buffaloes. This information would help to elucidate the regulation of function of mammary glands and milk secretion.

With sterilized milk coming into market, the effect of sterilization on milk products was studied. The effect of calcium ions and N-ethylmaleimide (NEM) on the denaturation of whey protein was investigated. NEM supplementation protected denaturation of protein in both cow and buffalo milk, whereas calcium chloride caused greater denaturation. Studies were carried out on mineral balance of buffalo and cow milk, since minerals in milk are involved in the heat stability of milk and quality of products. Buffalo milk had distinctly high concentration of calcium and magnesium, but less of sodium, potassium and chloride. Phosphates and citrates were similar in both the milks. Though calcium and magnesium content was high in buffalo milk, soluble calcium and magnesium content was low. Ionic modification of buffalo milk by electrometathesis reduced some of the difficulties encountered during processing and manufacturing of its products. The heat stability of buffalo milk at 120°C generally increased with the progressive replacement of calcium from about 120 minutes to about 500 minutes with 46 per cent of calcium replacement. However, further replacement of calcium decreased the heat stability of buffalo milk sharply to less than 80 minutes. There was no significant alteration in viscosity, specific gravity and ash content of buffalo milk when subjected to electrometathesis.

The antioxidant property of ghee was observed to be due to combining effect of the lipid constituents and also the non-lipid constituents like amino acids, sugars and their interaction products with protein and phospholipids. Incorporation of sediment isolated from desi butter to butteroil induced most pronounced flavour of ghee into butteroil when the latter was heat-treated at 110°C.

Technology

A major activity in Dairy Technology was the utilization of whey proteins for human nutrition. Processes were developed
for the isolation of proteins from caseins, rennet and paneer whey, using various polyvalent ions, hexametaphosphate (HMP), ferric chloride, ferripolyphosphate (FPP) and cow-milk casein by gel-filtration techniques. It was possible to recover 75 to 95 per cent of whey proteins. Whey protein isolates (WPI) prepared in the spray-dried form had 48 to 98% of proteins. These products are utilized for improving nutritional quality of processed cheese, replacing egg in cake-mix formulations, improving protein profile of buffalo milk and simulating human milk for infant feeding. The PER value of the resultant infant product was 3.05 and the NPR value 4.10. In India, particularly in the poorer sections of the community, the child though in critical health is weaned from mother's milk without adequate nutritional supplementation. A process for the manufacture of soya-whey weaning food (SWWF) was standardized by eliminating antinutritional factors present in raw soyabean by suitable heat treatment and increasing the solubility of the product. The protein efficiency ratio value of the product developed was 3.34 and the true digestibility 86 per cent when compared with 95 per cent of skim-milk powder. Trials conducted at the Punjab Agricultural University showed the acceptability of SWWF and its value as a supplementary diet for pre-school children. To a child of 1 to 4 years of age 100 g of the product supplied the minimum daily requirements of all nutrients except calories, and its cost was Rs. 5 per kg excluding the cost of packaging.

**Nutritive value**

At the newly established Division of Human Nutrition at Karnal work was conducted on the nutritive value of milk products with reference to Indian dairy products, milk and milk products in Indian diets, and nutritional problems in the utilization of sub-standard and contaminated milk and milk products. The sub-standard milk could be used to supply liquid milk to needy segments of population by way of using recombined and toned milk in place of whole milk. This milk did not differ significantly in nutrition from whole milk. Further, toned milk was superior to double-toned milk. When the energy and fat-soluble vitamin contents of double-toned milk were restored to levels of single-toned milk, the nutritive value became as good as that of toned milk.
Dairy economics

The economics of cross-bred cattle was conducted in Idukki and Alleppey districts of Kerala, using multistage stratified samples of 350 households, 225 from the project area and 125 as control from non-project areas. Three groups of farmers were studied—cattle owners in plains, settler farmers in the high ranges and tea-estate labourers in the high ranges. The cross-breds gave higher milk yield than local (desi) cows in all the 3 groups. The cost of feeding to produce a litre of milk varied from Rs. 11.21 in the plain to only Re. 0.15 with tea-estate labourers. This clearly showed that it was more economic to produce milk where fodder is available than transporting cattle to the areas where consumption of milk is concentrated. The net income per cow was highest from animals fed predominantly farm-grown forage, and the profit per cow per day increased with increase in milk production levels. A comparison of nutrient requirement with nutrient availability from feeds fed revealed that the young stock were considerably underfed. In terms of protein, less than even 50 per cent of the requirement was fed. Particularly, under-feeding was more pronounced in young stock maintained by tea-estate labourers. This was reflected in delayed maturity and less-than-optimum productivity after obtaining breedable age.

A socio-economic survey of dairy enterprises around Karnal indicated that a great potential for milk production existed on the premises of marginal and small farmers, and also landless agricultural labourers. These milk producers contributed about 60 per cent to the marketed surplus of milk in the Karnal milkshed. A very interesting finding was that their milk stock was more productive and better managed than those of the affluent farmers. They also obtained higher fodder yield per unit of land.

A study on the pattern of expenditure on milk and milk products for different income and occupation groups in Karnal showed that expenditure elasticity of milk was higher for small and lower-medium income groups than for large income groups, indicating that the growth and demand for milk was bound to be rapid as per caput income increased. Employed people had greater expenditure elasticities than business people.

An investigation on the cost of collection, transportation and chilling of milk was undertaken in the milk-shed area of Vijaywada. The average cost of collection of milk per litre was
10.18 paise, chilling 6.22 paise, quality control 0.45 paise, miscellaneous 2.61 paise, transportation from collection centre to chilling centre 8.46 paise, and from chilling centre to the dairy plant 5.07 paise. The total cost worked out to 33.08 paise per litre. The optimum scale of operation to minimize the procurement cost was about 10,000 litres of milk per day in a chilling centre, which brought down the procurement cost to 28.8 paise per litre.

The operational research project involving the scientists in integrated and crop-production improvement programme in 21 villages in Karnal district with a major thrust on cross-breeding of indigenous cattle through dairy Vikas Kendras was very successful. In about 3 years more than 1,500 cross-bred cattle were raised. Mini dairy units with high-producing cross-bred cattle were set up on the premises of more than 25 farmers entirely at their cost through bank loans and their own investment. Nine Harijan landless families were settled on 12 ha (30 acres) of Panchayat land obtained on lease, bringing about a net annual income of Rs. 5,000 to each family.

SHEEP

Breeding

Much emphasis on sheep breeding at the Central Sheep and Wool Research Institute, Avikanagar, was on studying the performance of new strains of sheep evolved for fine wool, mutton and dual purposes. In Avivastra, a strain evolved by crossing Rambouillet and Chokla, the lambing percentage was 67 on the basis of the ewes bred. The pre-weaning lamb and adult survival for this strain was 63 and 89 per cent respectively. The 6 monthly greasy weight of the fleece was 1.03 ± 0.037 kg for adults and 0.0753 ± 0.035 kg for hoggets. The average fibre diameter and medullation percentage was 19.43 ± 0.380 and 18.90 ± 1.920 respectively. The lambing percentage in the new strain Avikalin, specially evolved for superior carpet wool production, was 58. The 6-monthly greasy-fleece weight was 0.88 ± 0.022 kg and 0.68 ± 0.032 kg for adults and hoggets respectively. The average fibre diameter was 21.18 ± 0.520 and medullation percentage was 20.53 ± 2.680.

Under the All-India Co-ordinated Project on Sheep Breeding for Fine Wool, a significant increase of 28 and 27% in fleece yield of Nali crosses with Rambouillet and Merino over Nali was observed. The wool quality of cross-bred was signi-
significantly better than of native breeds. The improvement in fleece weight and fleece quality in Chokla crosses was not so marked as in Nali crosses. The improvement in body weight of cross-bred ewes over local sheep ranged from 10 to 20%. Similar improvement in fleece weight and quality of the cross-bred sheep at Sandyanallah unit and at Tal Unit was noted.

Under the All-India Co-ordinated Project on Sheep Breeding for Mutton improvement in body-weight gain, efficiency of feed conversion and carcass yield in crosses of Suffolk and Dorset with Malpura and Sonadi over the indigenous breeds was recorded. The meat quality of these crosses was superior in terms of protein percentage and intramuscular fat with lower moisture content than of the local breeds. Cross-breeding of Deccani breed with Dorset and Suffolk was in progress at the Mahatma Phule Krishi Vidyapeeth, Rahuri. At the Livestock Research Station, Palamner, the half-breds were superior to native sheep in growth as well as meat characteristics. Some cross-breds attained more than 30 kg body weight at 6 months of age. The dressing percentage ranged from 50 to 60 in half-breds when compared with 40 to 50 in pure local sheep. The overall performance of Dorset crosses was superior to Suffolk crosses.

Work on evolving dual-purpose breed through crossing Corri- riedale rams with Coimbatore sheep at Mannavanur Research Station gave encouraging results with regard to body-weight gain and fleece quality. Greasy fleece weight indicated superiority of $\frac{1}{2}$, followed by $\frac{1}{3}$ and $\frac{1}{4}$. However, the survivability of half-breds was superior to the other grades.

At the Central Sheep and Wool Research Institute, Bikaner Campus, the Karakul sheep were studied in respect of average body weight, gain in weight at 3 and 6 months of age, and survivability in different age groups. The overall lambing percentage was 92.6. The average greasy fleece weight was 0.968 kg for rams and 0.930 kg for ewes. Out of the 111 lambs born 20.72 per cent were of jacket type, 18.02 per cent of ribbed type, 9.91 per cent of flat type and 51.35 per cent of caucasian type.

Nutrition and physiology

At the Tamil Nadu Agricultural University slaughtering of sheep at the age of 9 and 15 months was found to be most
profitable, the margin of profit being 19.54 and 19.62 per cent respectively.

Canary colouration in wool during autumn poses problems for the woollen manufacturers on account of the uneven fading of the colour, particularly when used for bright and pastel shades. The studies carried out at the Central Sheep and Wool Research Institute, Avikanagar, and at the Wool Research Association, Bombay, indicated that dry heat in April did not affect the wool fibre. With the increase in humidity from July onwards the wool developed canary colouration. The suint became alkaline (pH 9.5 to 10.5) and the chemical modification of the fibre was maximum. The phenomenon of yellowing started disappearing from August. To know the nature of colouring matter and its mode of linkage to the fibre, the colouring matter from wool hydrolysate and from suint concentrate was isolated at the Sri Ram Institute for Industrial Research, Delhi. The colouring matter contained 3 colourless and 2 coloured fractions. On storage, the colour of the extract changed from light yellow to orange-red and finally to dark red, which was responsible for the defects produced in the woollen clothings.

The intensity of canary colouration was correlated to the micro-organisms present in the fibre at the Bikaner Veterinary College. The isolation and characterization of the micro-organisms indicated that different wools contained Bacillus group of organisms capable of producing antibiotic substance. Such organisms do not allow other wool bacteria to grow, giving an indication that there is a possibility of preventing the growth of chromogenic bacteria in the wool. Similarly, it was observed that sweat contained some substances which suppress the growth of micro-organisms. These observations were confirmed by in-vitro experiment by incorporating suint in the synthetic medium.

Wool science

Studies carried out at the Central Sheep and Wool Research Institute, Avikanagar, on the evaluation of end-use suitability of Indian and cross-bred wools indicated that Avivastra sheep could be exploited for the production of 56's quality wool for manufacturing 'serge' fabrics. The mill-scale trials on such wool conducted at M/s. Shri Dig Vijay Woollen Mills Ltd., Jamnagar, further confirmed this observation.
Wool technology

The basic work carried out at Avikanagar enabled the development of improved management practices for change in the shearing of sheep from March and September to February and June, which enabled reduction of canary-coloured wool during autumn season.

At the Wool Research Association, Bombay, attempts were made to develop improved bleaching-cum-dyeing techniques. Dyeing of wool to various bright and pastel colours was successfully done in the presence of metabisulphite at sub-boil temperature of 70°C. A computerized instrumental match-prediction method was also developed for obtaining receipts for various shades of colours.

Studies carried out at Bombay indicated that the absence of epicuticle on canary-coloured wool could be taken advantage of in its utilization in cigarette filters without any chemical treatment. Canary-stained woollen filters absorbed more total particulate matter, nicotin and carbon-monoxide gas formed during the smoking operations than the traditional filters made from cellulosic materials.

A small-scale mechanical deburring device was developed at the Cotton Technological Laboratory, Bombay, by using laboratory model gin for the removal of vegetable matter present in raw wool. This technique may enable reduction in the cost of deburring of wool.

GOAT

Breeding

Research work was continued at the National Dairy Research Institute, Karnal, for the development of high-yielding strains of goats by crossing Alpine and Saanen with local Beetal breed. The average expected producing ability was 205 kg for the Beetal flock (51 does), 269 kg for Alpine×Beetal (56 does), 310 kg for Saanen × Beetal (22 does), and 311 kg for Saanen × Alpine × Beetal (7 does). The average milk-fat percentage was 4.26 ± 0.13 in Beetal, ± 4.07 ± 0.08 in Alpine and 4.20 ± 0.02 in Alpine × Beetal.

The Alpine × Beetal crosses attained 15 kg body weight at 132.7 ± 28.1 days of age. First kidding in this group of ani-
mals was at the body weight of 45.8 ± 5.4 kg and at an average age of 68.8 ± 16.4 weeks. The overall mortality rate in the goat herd at the National Dairy Research Institute, Karnal, in 1977 was 7.9 per cent.

Under the All-India Co-ordinated Research Project on Goats, the average lactation yield of Malabari cross-breds in Kerala was 135 kg per doe when compared with 41 kg in native goats. The half-breds produced at Rahuri by crossing Sangamneri does with Angora bucks did not produce any mohair. However, goats with 75 per cent Angora blood at kid stage yielded up to 0.3 kg and in adults up to 1.0 kg. The staple length increased from 3.2 cm in 50 per cent Angora to 5.3 cm in 75 per cent Angora females. The fibre diameter reduced from 29 to 21.8 μ and the medullation percentage reduced from 35.2 to 22.1.

Studies on dilution, preservation and storage of buck semen at the Indian Veterinary Research Institute indicated that 1 : 10 is the best dilution rate for the preservation of buck semen. The egg-yolk coagulating tendency was observed in buck semen. Buck semen could retain good viability at 5°C up to 48 hours after collection.

Nutrition

Under the research scheme entitled "Economics of Goat Farming" at the Allahabad Agricultural Institute, rations containing high protein and high energy gave better results for growth than rations containing normal protein and normal energy. The carcass of goats on high protein and high energy ration was rich in protein and energy value. The Beetal goats (male and female) gained higher weight, consumed less feed and gave better feed conversion than Jamnapari goats. Mortality was more in Beetal goats, especially in males. Under the eastern Uttar Pradesh conditions, the Jamnapari goats were more stable than the Beetal goats.

The studies carried out at the above Institute on quality meat production in goats indicated that the total edible meat and the dressing percentage of the Saanen × Barbari cross was the highest and that of pure Barbari was the lowest. The Alpine × Barbari cross reached the required slaughter weight earlier, i.e. 210 days, but was not very significantly different from the other crosses.
The requirement of digestible crude proteins for maintenance was 116.89 g/100 kg live weight on the basis of endogenous urinary nitrogen and metabolic faecal nitrogen balance.

**Health**

Sheep husbandry in the country has been receiving severe setback due to scourge of sheep-pox. At the Indian Veterinary Research Institute, Izatnagar, for the first time, a suitable vaccine was prepared by growing the virus in lamb-kidney cells. This vaccine was very effective, particularly in cross-bred and exotic sheep. To date 1 million doses of this vaccine were prepared.

At the Haryana Agricultural University, Hissar, investigations were carried out on C. ovis in sheep with special reference to epidemiology, pathogenesis, diagnosis and immunity. Material from 326 sheep and 189 goat carcasses of varying ages, and both sexes were bacteriologically tested; 3.6 per cent sheep and 1.05 per cent goats were found infected. The isolated strains of C. ovis were characterized on morphological, cultural and biochemical characters.

Lungworm infestation is of major significance in sheep. An irradiated vaccine conferring a high degree of protection against this disease was developed at the Indian Veterinary Research Institute. At the Regional Research Station of the Institute at Srinagar, more than 0.1 million doses of vaccine were produced and supplied for vaccination of sheep and goats in Jammu and Kashmir State.

**PIGS**

**Health**

At the Kerala Agricultural University, investigations were carried out on porcine enteroviruses. From the 165 specimens in which isolation trials were completed, 37 viral agents were isolated (22.4 per cent). Of these isolations 14.0 per cent were from normal specimens (8 isolations from 51 samples) and 26.8 per cent from specimens of discard animals (29 isolations from 108 samples). The discard animals gave higher percentage of viral isolates than the normal ones. The characterization studies indicated that the viruses belonged to enterovirus groups. RNA was the nucleic acid content of 10 isolates.
Nutrition

A study was carried out at the Allahabad Agricultural Institute, Allahabad, to develop economic rations for pigs. Rations containing different levels of protein and energy in the diet with maximum inclusion of industrial waste were fed to study the growth rate, feed efficiency and carcass quality. In Large White Yorkshire males, the ration of normal protein and normal energy as per Morrison standard proved better than high or low protein level; in females, however, the high protein with normal energy proved better. In Landrace males and females normal protein and energy levels in the rations proved superior to other levels. No significant difference was noted in the feed conversion irrespective of breed and sex. The normal protein and energy levels proved better for growth rate, feed consumption, feed conversion and carcass quality.

Studies carried out at Kattupakkam, Tamil Nadu, on the comparative utility of ordinary maize, lysine-rich maize and tapioca in pig rations indicated no differences in the growth of pigs. Hence tapioca can replace maize in the diet partly or fully, provided the protein percentage in the ration is met by adding increased quantity of groundnut-cake available at a cheaper rate.

Technology

At the Central Dairy Farm, Aligarh, smoking, cooking and chilling losses in the most commonly prepared uncanned products in the factory were studied. The loss in different products was almost identical to that in products prepared in gut casings and was slightly towards higher side in the case of meat pie, since this product is not smoked. The quality of the products examined suggested that it is necessary to cook ham, garlic and ham sausages for 2 hours, and Frankfurter and hot dog for 20 minutes for imparting proper taste, aroma and tenderness to the meat. In the case of meat pie it was necessary to cook for about 4 hours.

POULTRY

Breeding

Research work was continued for the development of suitable strains of egg and meat-type chicken under the All-India Coordinated Project on Poultry Breeding. Evaluation, selection and regeneration of pure-bred White Leghorn strains constituted
the main feature of investigation in the poultry for egg project. Two- and three-way crosses were also made to study the performance of promising strains in various cross combinations. The selected strains were superior to the control or the previous generation for egg production up to 40 weeks of age by 5 to 15 eggs. Relative to base populations the rate of improvement was about 3 to 6 eggs per generation. Although there was slight decline in egg weight in most of the strains, inter-generation comparison did not present any definite trend.

The strain crosses were significantly superior to their parental genotypes for most of the economic traits. There were no significant differences between the 2-cross types derived utilizing 'G.H.I.' and 'J' strains for hen housed and survivor's production, 40-week body weight, laying-house mortality and albumin index. But the 2-way crosses were significantly superior to the 3-way crosses for egg weight, albumin height, yolk index and shell thickness. The 3-way crosses, were, however, superior for age at first egg and 20-week body weight.

Some cross combinations that lay more than 220 standard sized eggs during the first year of lay were identified from the test crosses. Ten cross combinations, 3 each from Indian Veterinary Research Institute, Izatnagar, and Jabalpur, and 2 each from Mathura and Hyderabad were under test at Anand centre of the project for evaluating their comparative performance. The same 3-cross combinations form the centre at the Indian Veterinary Research Institute were sent for random sample test conducted by the Government of India at Bangalore and Bombay for evaluating repeatability of results and economics of production.

Significant improvement was achieved in all the 13 broiler strains. The response to selection varied from 5 to 80 in different populations for 8-week body weight. Improvement was also observed in feed efficiency, viability and dressed weight percentage in most of the strains. From test crosses some cross combinations have been identified. They weighed more than 1,400 g at 8 weeks of age and had a feed efficiency of around 2.5. These cross combinations will be sent for random sample test during 1979. Two promising strains were set to the random sample broiler tests conducted by the Government of India at Bangalore and Bombay to study the repeatability of results and economics of commercial production. A broiler cross developed under the project was recommended for release for commercial broiler.
production. The nucleus stocks of this cross combination were being multiplied for the production of parent stocks.

The latest and significant achievement at the Indian Veterinary Research Institute, Izatnagar, was the development of broiler breed 'B' 77'. Repeated random sample tests confirmed that this strain attained a weight of more than 1,200 g at 8 weeks of age with satisfactory feed efficiency and excellent viability. Considering the overall performance, the broiler 'B 77' will be released for multiplication at the Government Poultry Farm, Chandigarh, in collaboration with the Animal Husbandry Commissioner.

Sexing in local (desi) fowl can generally be done at 6 to 8 weeks of age. Study on inheritance of fibromalanetic type of pigmentation in Karaknath breed of desi chicken, revealed that day-old chick can be saved with almost 100 per cent accuracy due to the presence of black pigment in shank, beak and skin of cross-bred day-old chick.

Considerable progress was made in breeding quail for high body weight and egg production, at the Indian Veterinary Research Institute, Izatnagar. Under proper management conditions, they produced for long periods 250 eggs per year. The ability of quails to produce 3 to 4 generations per year can be exploited to reap quick harvests for producing animal protein in a short time.

Nutrition

Studies carried out at the Indian Veterinary Research Institute indicated that erucic acid, a long-chain fatty acid present in the residual oilcake, is a possible factor limiting the utilization of mustard-cake as a protein source in poultry rations. The results indicated that solvent-extracted mustard-cake could be used as a protein source, replacing groundnut-cake, a costly ingredient. This would reduce the cost of poultry compounded feed by about Rs. 20 to 30 per tonne. Methods were also developed to make deoiled salseed-meal more useful for, replacing cereals in chicken feed. Chicken fed treated salseed-meal with boiling water, methanol and calcium hydroxide gave better performance than those fed untreated salseed-meal.

Studies carried out under the All-India Co-ordinated Project on Poultry Breeding on the effect of quantitative restriction of feed on production and reproduction traits indicated that...
two days a week' significantly reduced the body weight of growing pullets when compared with that of control group. Differences were also observed among different strains. The experimental group of pullets consumed 3 to 6 per cent less feed than control group during the 10-week experimental period with 'skip a day' and 6 to 12 per cent less feed with 'skip two days' programme.

Study undertaken at the Allahabad Agricultural Institute indicated that maize could be partially or completely substituted by hominy, a by-product of maize milling plant, without any adverse effect on growth rate, feed efficiency and carcass quality of broiler chicks. Study was also carried out on the effect of iso-protein energy ratio with variable energy and protein on growth rate, feed efficiency and carcass quality of starter chicks. The chicks attained higher gain in weight with high dressing percentage when maintained on 20 per cent protein diet with energy protein ratio of 132:1 as a starter feed. Similar results were obtained at the University of Agricultural Sciences, Hubballi, Bangalore.

Studies were taken up at the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, on the use of sunflower-cake as a component of poultry feed for broilers and layers. A negative correlation was observed between protein and oil content and between protein and NFE content of the kernel. The correlations between oil and protein contents are of particular significance in the selection of germplasm for higher oil content. The replacement of groundnut-cake with sunflower-cake in the diet of growing chicken resulted in improvement in the efficiency of protein and energy utilization. The inclusion of sunflower-cake in diets containing groundnut-cake increased the rate of weight gain by raising the feed consumption as well as by increasing the efficiency of utilization of the consumed feed. Sunflower-cake diet required only 4 per cent fish-meal supplementation, as against 8 per cent by groundnut-cake diet for almost equal body weight gain in broilers at 70 days of age. The results indicated that fish-meal allowance for broilers could be reduced by 50 to 75 per cent by incorporating sunflower-cake in the place of groundnut-cake in their diets. The information on the composition and the metabolizable energy content of sunflower-cake with or without hulls could be used profitably in the formulation of broiler and layer diets based on sunflower-cake by the feed manufacturers and poultry farmers in the organized sector. The use of sunflower-cake in the place
of groundnut-cake was also beneficial for growth and feed efficiency in chicks for egg production, egg-quality traits and feed efficiency in layers. While the use of hulled sunflower-cake should be preferred because of its low fibre content, sunflower-cake without hulling can be used preferably in layer diets.

Feasibility of employing restricted quantitative and qualitative feeding during the growing period as a means of reducing the overall cost of egg production was studied at the Andhra Pradesh Agricultural University, Hyderabad. By and large restricted feeding lowered the cost of raising growing pullets. It had no adverse effect on subsequent egg production, egg size or livability. Restricting feed of growing pullets to 20 to 30 per cent of full feed did not affect their future production potentials. Besides, longer the duration of feed restriction (from 5 to 20 or 25 weeks of age during growing period) the more beneficial it was.

**Physiology**

Studies carried out at the Punjab Agricultural University, Ludhiana, indicated that thyroid activity could possibly be used as an index for predicting as to how far the production traits in the form of meat or egg in various breeds of poultry can be used as an approach for selecting birds in breeding programmes.

**Health**

Marek’s disease, with special reference to its epidemiology, actio-pathology, diagnosis and control was investigated at 6 centres including the centre at the Indian Veterinary Research Institute, Izatnagar. At Izatnagar, it was found that even the indigenous breeds, i.e. Aseel and Karaknath, were not resistant to Marek’s disease, as had been thought earlier. A vaccine developed at Izatnagar against this disease gave 90 per cent protection to the birds both under laboratory and field trials. The know-how of the vaccine and the seed-virus for preparing the vaccine were passed on to the biological products institutes of Tamil Nadu, Rajasthan and Punjab. Investigation into the mechanism of protection (using a standard vaccine, killed MD antigen, killed Mycoplasma gallisepticum, thymosin, a hormone, and ‘Isatin’ an anti-viral drug, showed that resistance to MD depended on cell-mediated immunity (CMI), possibly through ‘T’ lymphocyte level in the chicks. The Institute had already developed a rapid and confirmatory test for the diagnosis of Marek’s disease. At the other research centres, the epidemiology of the disease was studied in
great detail. At Mathura Centre, AGPT and RID tests were found to be sensitive for detection of the disease. Of these the RID test was more sensitive. At this centre, rapid tests for diagnosis of the disease were also developed.

Investigations carried out at the Punjab Agricultural University, Ludhiana, revealed that for controlling infection with *E. maxima* Meticlorpindol was the most effective drug; Nicarbazin, Amprol and Amprolsol the least effective ones; and Pancoxin, Embazin, Duocoxin and Sequadil midway between the two groups. The drugs in the decreasing order of prophylactic activity were Meticlorpindol, Duocoxin, Embazin, Sequadil, Nicarbazin, Amprolsol and Amprol. The drugs in decreasing order of therapeutic activity were Pancoxin, Duocoxin and Sequadil. They possessed greater therapeutic activity when given in water. On the other hand, Pancoxin and Embazin used therapeutically gave better protection when administered in feed. For references to various drugs 56 field isolates of coccidia were tested. *E. acervulina* type occurred in 17 isolates, *E. maxima* in 13 isolates, *E. nicatrix* in 6 isolates, *E. tenella* in 44 isolates and *E. branctti* in 2 isolates. The strains resistant to Bifuran were also resistant to Sulphaquinoxaline. Other strains resistant to Amprolium showed cross resistance to Bifuran and Sulphaquinoxaline, and still other strains resistant to Amprolium showed cross resistance to Bifuran, Sulphaquinoxaline and Nicarbazin.

**EQUINE**

At the Haryana Agricultural University, research on equine abortion and foal mortality showed that a rough variant of *S. abortus equi ‘MI-170’* is a safe and immunogenic strain for vaccinating the horses. A test was standardized for the diagnosis of *Corynebacterium equi* infections, and an adjuvant vaccine against this infection was developed.

**CAMEL**

The research project on helminthic parasites of camels at the Bikaner Veterinary College, Rajasthan, was terminated. The incidence of *H. longistipes* was highest, followed by *T. globulose* and *N. dromedrii*.

**CANINE**

An important landmark in research for evolving vaccine was the preparation of canine distemper vaccine. It was prepared by
brewing the virus in chick embryo. The vaccine after a series of trials was released.

6. FISHERIES

INLAND FISHERIES

The Central Inland Fisheries Research Institute, Barrackpore, together with the all-India co-ordinated research projects under it, accomplished the following significant results.

Freshwater aquaculture

Production through composite fish culture: Most of the centres under the All-India Co-ordinated Research Project on Composite Fish Culture gave much higher rates of fish production than were originally targetted, thus confirming the success of the methodology developed. The highest rate of production was in the ponds of the Pune Centre, where the estimated production amounted to 10,194 kg/ha/year. The role played by supplementary feeding in these cases was significant and greatly accounted for the high rate of production.

Considerable success was achieved in the production of fish seed, which reached over 54 million hatchlings of carps besides 0.02 million of *Puntius gonionotus*. Establishing a relation between hydration and spawning gave a clue for predicting successful induced breeding of spawners. Multiple induced breeding of spawners also was possible by giving suitable conditions for the purpose.

The Fisheries College, Mangalore, under the University of Agricultural Sciences, Bangalore, reported success in inducing carps to breed with the use of marine fish pituitary extract which has also been ampouled.

To demonstrate composite fish culture with minimum inputs, an experiment was carried out by the Central Inland Fisheries Research Institute in a tank having an average water spread of 1.25 ha. The species cultured included catla, rohu, silver carp, grass carp and common carp. The inputs consisted of a low dose of cowdung (3 tonnes) as organic manure and a nominal initial booster dose (0.4 tonne) of artificial feed consisting of rice bran and oilcake which, with the natural plankton production, yielded encouraging results. A gross fish production of 1,606 kg/ha/10 months with a low input cost of only Re 0.51 per kg of fish and a net profit of Rs 3.49 per kg was the significant achievement of the experiment.

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**Culture of Macrobrachium rosenbergii: Substantial quantities of the giant freshwater prawn, M. rosenbergii, were obtained from the laboratory-raised second generation seed in 2 successive experiments. In one of the experiments, a freshwater pond (0.02 ha) at Balabhadrapuram (Andhra Pradesh) stocked with 319 specimens of M. rosenbergii (size 85-90 mm/6.14 kg) yielded gross and net productions of 11.55 kg (approx. 577.7 kg/ha) and 9.59 kg (approx. 479.7 kg/ha), respectively, in 4 months with 89 per cent survival rate. The size and weight of 284 prawns recovered on the termination of the experiment were on an average 157.8 mm and 40.7 g respectively. The management measures included pre-stocking fertilization of pond with 480 kg of cattle-shed manure followed by liming and supplementary feeding with minced land snail (*Pila*), rice bran and tapioca separately at 500-1000 g/day. In the subsequent experiment, the gross and net productions obtained from the adjoining pond on stocking 303 seeds of the same species (av. size: 67.05 mm/2.64 g) were 12.04 kg (approx. 602.05 kg/ha) and 11.21 kg (approx. 560.55 kg/ha) respectively, in 4¼ months with equally high rate of survival (81.12 per cent).

The Fisheries Faculty of the Konkan Krishi Vidya Bhavan made progress in the rearing experiments of *M. rosenbergii* and *M. malcolmsoni*. Laboratory trials on large-scale breeding of these species were successful and the seed produced were cultivated in the field.

Under an ICAR assisted ad-hoc scheme, the Fisheries Department of the Tamil Nadu Agricultural University designed and fabricated an indoor water recirculation unit using indigenous components for culturing fish and prawn. This arrangement was essentially to economize the use of water as well as space, and to have better control over the environment. Preliminary experiments with fingerlings of mrigal and the prawn *Macrobrachium* showed that these could be grown well under these conditions.

*Artificial breeding of fish and prawns*

The following fish and prawns were successfully bred artificially.

*Hilsa ilisha*: At the Bhagalpur Research Centre of the Central Inland Fisheries Research Institute *H. ilisha* was bred by artificial fecundation at Farakka on River Ganga. About 0.1 million hilsa hatchlings were produced in 2 sets of experiments conducted in October 1978. They were transported under oxygen packing...
from Farakka and stocked in 3 nursery ponds @50,000, 30,000 and 20,000 in the Rajoun Fish Farm near Bhagalpur where they showed satisfactory growth.

*Schizothorax niger*: *S. niger* which forms an important fishery in the Himalayan region was bred successfully for the first time by stripping under laboratory conditions, and eggs reared in still and flowing waters. The incubation period ranged from 10 to 15 days in still water, and was more than 40 days in running water. Percentage of fertilization and survival from egg to early fry ranged from 90 to 95 and 85 to 90 respectively. Spawn of *S. niger* was stocked @ 40 fry/m² in a pond of 4.0 m. After 45 days the fry attained a size of 31-47 mm from 15-22 mm at the time of stocking. These successful results indicate the possibilities of large-scale breeding of *Schizothorax* sp. and also provide new avenues for developing the fishery of the species in the upland wastes.

*Bagda*: The Central Inland Fisheries Research Institute succeeded in inducing maturation and breeding of the tiger prawn, *Penaeus monodon* commonly known as 'bagda chingri', in impounded brackishwater ponds in the Bakkhali Fish Farm in Sunderbans. Bagda in nature matures and breeds in seas. Immature specimens from virtually freshwater ponds in Sunderbans were induced to mature and breed by eye-stalk ablation. When the experimental phase is over and the technique commercialized, pond-reared bagda will be bred in the same manner as other commercial fish species.

Growing more fish with paddy

An experiment on paddy-cum-fish culture was initiated at the Rahara Fish Farm of the Central Inland Fisheries Research Institute. Waterway for fish culture was of the shape of trapezoidal canal along the perimeter of the agricultural field. A deep-water, pest-resistant hybrid paddy ('Jaladhi-II') was sown, and catla, rohu and mrigal were stocked @ 6,000 fingerlings/ha in the ratio C 4 : R 3.5 : M 2.5. The 'Jaladhi-II' crop yielded about 1,200 kg of paddy/ha without any application of fertilizer and pesticides. This was followed by cultivation of another high-yielding variety of paddy, viz. 'Jaya', which yielded 3,800 kg/ha. After harvesting the plot was allowed to dry up and the fishes took shelter in the perimeter canal. In this culture system, the fish and the paddy were grown together for 5 months since stocking. Supplementary
feeding of fish with mustard-cake and rice bran (1 : 1) was resorted to @ 24 per cent of the body weight of the stocked fishes. The fishes were reared for the full year in this system of culture (5 months in the paddy plot and the remaining 7 months in perimeter canal). The total fish harvested was 708.65 kg and the calculated gross production for the perimeter canal area alone (0.27 ha) was 2,624 kg/ha/annum as against the total area (1.02 ha) when the estimated production was about 700 kg/ha/annum.

Integration of agriculture and livestock

Duck-cum-fish culture: In duck-cum-fish culture experiment in a 1.48 ha water body, 6 species of Indian and exotic carps, stocked @ 6,000 fingerlings/ha, along with 100 ducklings (Bengal runner and cross breed of Bengal runner and Khaki Campbell) reared simultaneously on floating duck houses constructed on the pond, yielded a gross fish production of 4,323 kg/ha/year besides 1,385 duck eggs which fetched Rs. 734.00. The cost of production per kilogram of fish was Rs. 1.33 only. But for the duck droppings which go directly into the pond at an estimated rate of 10 tonnes/100 birds/year and automatically recycled no fertilization of the pond or feeding of the fish was resorted to. An overall profit of Rs. 27,095.00 was made from duck-cum-fish culture which corresponded to a profit of Rs. 19,353.57/ha/year. This profit was made by selling fish at government price of Rs. 5.50/kg to the local people against the prevailing retail market price of Rs. 8.00 to Rs. 10.00/kg.

Pig-cum-fish culture: The experiments on the pig-cum-fish culture also showed excellent results. The pond was fertilized only by the pig dung collected from the pig-sties constructed near the pond. Under heavy stocking density (8,500 fish/ha) and without the provision of supplementary feeding, silver carp and grass carp grew from their initial weight of 9 and 5 g to over 2.10 and 1.3 kg, respectively, in 12 months. Catla, rohu, mrigal and common carp recorded weights of 1.1, 1.0, 0.9 and 0.5 kg, respectively, from the corresponding initial average weight of 48, 28, 23 and 3 g in 1 year. Another notable feature of the experiment was the feeding of the grass carp purely on cattle fodder such as berseem and hybrid Napier grass grown on the terraced embankment of the pond. The gross fish production was 7,300 kg/ha.

The average cost of production of fish including wages of fishermen, netting charges and all other expenses came to 93 paise/kg only. A profit of Rs. 4,881.93 was made through the
fish culture operation from the pond with a water-spread of 0.1 ha. Two sets of piglets, consisting of 8 and 5, were reared during the experiment. A profit of Rs. 1,578.85 was made from the pig-rearing operation. An overall profit of Rs. 6,460.78 was made which corresponded to Rs. 64,000/ha/year. It was estimated that about 40 pigs (20,000 kg dung) would be required for proper fertilization of a pond of 1 ha water-spread.

Brackishwater fish and prawn culture

In monoculture, Liza parsia gave a production of 480 kg/ha/180 days (without supplementary feeding) and 750 kg/ha/180 days to 800 kg/ha/140 days with supplementary feeding consisting 21.6 and 26.20 per cent protein-rich diet; L. tade registered a net production of 878.2 kg/ha/100 days with supplementary feed. In multiple stocking and repeated harvesting a production of 1,775 kg/ha was obtained in 270 days in feeder canal; Chanos chanos registered a net production of 10 kg/ha at Kakdwip.

At Kakdwip, mullets (L. parsia and L. tade, 8 : 1 ratio) registered a production of 710 kg/ha/90 days. In Kerala, mullet (Mugil dussumieri) and pearl-spot (Etrouplus suratensis) (ratio 1 : 1) gave a net production of 410.9 kg/ha/9 months.

In polyculture, Chanos, mullets and prawn, stocked @ 8,000/ha in the ratio of 6 : 1 (fish and prawn) gave a production of 2,579.8 kg/ha/9 months with supplementary feeding at Kakdwip. At Madras, Chanos was cultured with Penaeus indicus and also with P. monodon, and a production of 1,396 kg/ha/6 months and 1,125 kg/ha/140 days was obtained with supplementary feeding. At Vytilla (Kerala), a yield of 629.50 kg/ha/10 months was registered with pearl-spot, Mugil dussumieri and Metapenaeus dobsonii.

Culture of Lates calcarifer carried out in the farm feeder canals at stocking densities ranging from 2,000-3,000/ha with periodical harvesting of large specimens and restocking with equal number of juveniles gave a production of 3,200 kg/ha/year.

Monoculture of prawn: At Madras centre a 1.24 ha pond was stocked with Penaeus indicus @ 70,000/ha, the average size of stocking being 42.2 mm/0.4 g. A production of 301.8 kg was achieved after 130 days and the prawns attained the average size of 130.7 mm/33.7 g. In this experiment no supplementary feed was provided but regular fertilization of the pond was done with
inorganic fertilizers. The experiment indicated the possibility of obtaining a production of almost 1,000 kg \( P. \textit{indicis} / \text{ha} / \text{year} \) from such environments.

**Mixed culture of brackishwater prawns:** Mixed culture of brackishwater species of prawns \( \textit{Peneaeus indicus}, \textit{P. monodon}, \textit{Palaemon styliferus}, \textit{Metapenaeus monoceros} \) and \( M. \textit{brevicornis} \) in 0.02 ha pond gave production of 863.5-1185.0 and 350-725 kg/ha/year in 4 crops at 0.2 and 0.4 million/ha stocking density respectively. Prawns attained marketable size in 90 days. However, increased productivity through regular manuring of the pond with superphosphate, urea and poultry manure gave record yield of 1,185.0 kg/ha/year from these ponds.

**Artificial feed for \( P. \textit{monodon} \):** Six feeds having different ingredients were formulated for \( P. \textit{monodon} \), with locally available cheap ingredients, viz. offal-meal, fish-meal, shrimp-meal, squid-meal, maize powder, wheat flour, soyabean-meal, algal powder, rice bran and groundnut-cake, along with micro-ingredients like brewer’s yeast, vitamin mixtures, calcium phosphate and sodium hexametaphosphate. Sodium alginate, wheat powder, etc., were used as binding materials.

The feeds, both in powdered and pelleted forms, were tried with post-larvae and early juveniles of \( P. \textit{monodon} \). One of the feeds, having squid-meal as a major ingredient with 35.8 per cent of crude protein, gave a conversion of 2.5 : 1.

The availability of tiger-prawn seed in appreciable quantities in Cochin backwaters was confirmed by the Fisheries Department of the Kerala Agricultural University as a result of a survey conducted by them.

**Culture of air-breathing fishes**

In rural ponds, with moderate inputs, \( \textit{Clarias} \) (magur) yielded production ranging from 3,170 kg/ha/6 months to 7,272 kg/ha/6-1/2 months, whereas \( \textit{Heteropneustes} \) (singhi) yielded 4,400 to 4,815 kg/ha/6 months. With high stocking rate of 0.5 million/ha, intensive feeding and regular periodical change of water, magur yield of 55 tonnes/ha/7 months was obtained. With the stocking rate of 0.25 million/ha for singhi the production was 35 tonnes/ha/7 months. Experiments on mixed culture of air-breathing fishes suggested excellent compatibility of magur with carps. This was repeatedly demonstrated in farmers’ ponds.
with production figures ranging from 800-3,500 kg/ha/6 months in addition to usual carp production involving no extra feeding or management.

**Utilization of NPN by air-breathing catfishes**: Capacity of magur and singhi to feed on toxic organic detritus and tolerate high content of ammonia in culture water prompted assessment of their ability to assimilate non-protein nitrogen. This was also relevant in regard to exploration for a possible cheap feed combination for reducing culture operation cost, and achieving faster and better growth of catfishes under culture. Neither any mortality nor any apparent symptoms of toxicity could be noticed in magur and singhi, in a 60-day experiment when approximately 50 per cent protein in the diet was replaced by urea supplying equivalent nitrogen. Growth performance of singhi was 60 per cent more than in groups fed on standard test diet with 45 per cent protein. Growth recorded in magur was also comparable with that of fish groups fed on standard test diet. Introduction of about 1 g rumen digesta from goat intestine per fish in addition to experimental diet did not produce any further increase in body weight. Inherently occurring ureolytic enzymes activity-bearing bacteria needed no augmentation by external source of rumen bacteria.

With the experimental growth pattern obtained, the incorporation of NPN source with oil in the feed consisting of dried marine trash fish and rice bran could reduce the feed cost input by 45 per cent in culture operation. Acceptance of raw cattle dung and **gobar** gas slurry by both magur and singhi suggested an effective binding material of ruminant source for the feed.

**Effect of malathion on magur culture in paddy field**: Change in tissue structure, haematological parameters and levels of certain biochemical constituents in liver and serum of magur exposed to sublethal chronic doses of malathion were studied. Gas chromatographic studies on residual accumulation of malathion in different tissues indicated that residual accumulation occurred mostly in the gills, whereas the tissues from liver, kidney, intestine and body muscles did neither indicate any trace of malathion nor its degraded products when magur was exposed to 0.5 ppm malathion for 40 days. Under the circumstances, decapitated fish from malathion-treated environment should be acceptable for human consumption.
Culture of Mystus seenghala in running water: *M. seenghala* hatchlings were reared in floating nylon cages (1 m x 1 m x 1 m) in River Ganga at Shankerghat. The feed provided was chironomid egg-mass followed by semi-boiled trash fish. The fry ranging from 20 to 30 mm size attained 113 to 180 mm in 111 to 143 days. The fingerlings of 146 mm size attained an average size of 228 mm in the monoculture experiment in 280 days. The feed given was semi-boiled trash fish at the rate of 5 per cent of body weight twice a day; 100 per cent survival was achieved during rearing.

At the Post-Graduate Department of Zoology of the Bhagalpur University investigations were continued on the physiology of air-breathing fishes, particularly with reference to oxygen consumption and the activities of the thyroid, gonad and adrenocortical tissues.

Reservoir ecology and fisheries

From the all-India co-ordinated research project centres relevant data on the hydrological cycle as well as the fisheries characteristics of the major reservoirs were obtained and analysed. In Bhavanisagar reservoir (Tamil Nadu) a change in the hydrological regime consisting of a much higher water level than the normal and the consequent reduced fish catchability was found to be a major factor resulting in a lower yield of only 215 tonnes (58.37 kg/ha) as against 294 tonnes during the previous year. Breeding of *Labeo bata* and *L. calbasu* in the reservoir was comparatively better than that of *L. fimbriatus*, *L. koftus* and *Catla catla*. In the Nagarjunsagar reservoir (Andhra Pradesh) fishing in the intermediate sector which constitutes only a small area, yielded a high catch of 33 tonnes in 90 days. It improved the total yield of the reservoir to 145 tonnes. In the Govindsagar reservoir (Himachal Pradesh) the year’s fish yield registered an all-time high (735 tonnes; 67 kg/ha), with the Gangetic carps constituting the major item. The possible ecological impact arising from the diversion of Beas water into Sutlej since October 1977 is now under study. Commercial fishing was arranged for the first time in the Gersalsud reservoir (Bihar); in 28 days 871 kg of fish consisting largely of *Catla* was obtained. As the percentage of other major carps was low, large-scale stocking of major carps would be required to improve the yield. In the Rihand reservoir (Uttar Pradesh) the possible natural mortality of *Labeo rohita*, *L. calbasu* and *Cirrhinus mrigala*, besides the reduction in the mesh size of the gill-nets affecting the
catch of Catla, appeared to be the factor responsible for low yield. Large-scale upstream migration and breeding of major carps were observed in June and July in Ukai (Gujarat), where an yield of 749 tonnes of Catla catla, Labeo rohita, Cirrhinus mrigala, Tor tectorum and other miscellaneous fishes was obtained. An yield of 10.5 tonnes was obtained from the Kangsabati reservoir (West Bengal); it was mainly composed of major carps. However, the fish did not breed during the year.

Frog culture

Tadpoles of Rana hexadactyla stocked at the rate of 10,000 and 20,000/ha and fed with Hydrilla recorded 85 and 60 per cent metamorphosis. In a 0.002 ha rearing enclosure, early frogs with an average size of 15 mm/0.5 g stocked at the rate of 0.1 million/ha attained 65.4 mm/49 g in 8 months with a survival of 25 per cent. Juvenile frogs (51.2 mm/22.1 g), stocked at the rate of 6,000 grew to 69 mm/73.3 g in 7 months.

Further progress was made at the New Science College in Hyderabad on the hormonal influence on reproductive physiology of Anura. There was tremendous increase in the maturation of follicles in the ovaries and enlargement of seminiferous tubules in the testes after the administration of several steroidal hormones, each showing different grades of action. Frogs treated with 5 pituitary/ml (prepared out of frog pituitaries collected during pre-breeding season) gave good results in ovulation. The tadpoles thus obtained from induced breeding were reared under laboratory conditions with different feeds.

Extension and training

A 2-month field-oriented training on brackishwater prawn and fish farming was organized for the farmers and officials of different organizations at the Brackishwater Fish Farm of the Kakdwip Research Centre, West Bengal, during 1 August to 30 September 1978; 40 participants were trained.

Lecture demonstrations on the composite fish culture and fish-seed production were arranged at different centres to the enterprising fish culturists. ARS probationers, Block Development Officers, trainees of Staff Training College, Madras, trainees of co-operative societies of North-Eastern Region, field officers of the State Bank of India of Assam, post-graduate students of different universities and foreign dignitaries from different countries.
A short-term training course on composite fish culture and fish-seed production was organized at the Pune Centre for Technical staff deputed by Vidarbha Vibhagiya Machhimar Sahakari Sangh Ltd., and Fish Farmers’ Development Agency, Bhandara.

A 10-week field-oriented training course on brackishwater prawn and fish farming was organized at the Brackishwater Fish Farm of the Institute at Kakdwip from 26 December 1977 to 5 March 1978.

Under the All-India Co-ordinated Research Project on Composite Fish Culture and Fish Seed Production at the Karnal Centre, step by step demonstration of composite fish culture was carried out in a pond of 0.5 ha in Shyamgarh village.

From the Gahuati centre of the project, the Indian and exotic carp fish seed were supplied to the different districts of Assam, fisheries departments of Bhutan, Mizoram and Meghalaya, Assam Agricultural University and North-Eastern Hill University.

The Krishi Vigyan Kendra Trainees of Kausalyagang, Orissa, were given practical training on the induced breeding of exotic carps, and lecture demonstrations on various aspects of fish culture by the staff posted at the main centre. Lectures were given to a batch of fish farmers sponsored by the North-Eastern Council, Shillong. At Bhavanisagar centre (Tamil Nadu) 1 week’s training course was conducted on composite fish culture for the fish farmers of Fish Farmers’ Development Authority, Thanjavur.

The Institute participated in the Indian Exhibition at Moscow, Burdwan Agricultural Fair and Bankura Exhibition.

Summer Institute on ‘Inland Aquaculture’ was held at Barrackpore during 19 June to 18 July 1978. A number of scientists from different universities/institutes/state fisheries departments participated in it.

Besides the above activities, the scientists of the Central Inland Fisheries Research Institute also contributed papers and actively participated in almost all scientific meetings, symposia and seminars organized by various agencies which had relevance to fisheries research and development.
Marine fisheries resource survey and assessment

The Central Marine Fisheries Research Institute continued the assessment of marine fishery resources and the maintenance of relevant information for the benefit of the fishing industry, government organizations and other agencies.

The total marine fish production in India (excluding Andamans and Lakshadweep) during the first half of 1978 was provisionally estimated at 530,056 tonnes when compared with 564,184 tonnes during the corresponding period of 1977. It showed a decline of about 34,000 tonnes (5.38 per cent). While the total landings in West Bengal, Orissa, Andhra Pradesh and Maharashtra declined, it was comparatively higher in Tamil Nadu, Kerala, Karnataka, Goa and Gujarat. In Pondicherry the production remained more or less at the same level.

Trend in capture fisheries

In the capture fisheries, the landings of the demersal group were about 50 per cent more than those of the pelagic group. The estimated catches during the first half of 1978 when compared with corresponding period of 1977 revealed that decrease in the catches was mainly of Bombay-duck, oil-sardine, catfishes, pomfrets and non-penaeid prawns. Landings of elasmobranchs, anchovies, mackerel, ribbon-fish and penaeid prawns were more. In the state-wise composition of the fish landings the notable decreases were: oil-sardine in Kerala, Bombay-duck and non-penaeid prawns in Maharashtra, pomfrets in Maharashtra and Gujarat, and catfishes in most of the states. The increase in the catches were: penaeid prawns in Kerala and Tamil Nadu, anchovies in Kerala, Tamil Nadu and Orissa, mackerel in Kerala, Karnataka and Andhra Pradesh, and ribbon-fish in Kerala, Tamil Nadu and Gujarat.

The provisional estimate of total marine fish landings up to September 1978 was 884,300 tonnes showing increasing trends in the catches of mackerel, ribbon-fish, perchess and penaeid prawns during the third quarter. The landing during January to September 1977 was 889,894 tonnes.

A case study made at the Institute on the economics of operation of traditional indigenous fishing units at Cochin revealed that the fishing operations by indigenous units gave better economic returns than those by mechanized fishing vessels. The per
caput income of a fisherman employed in the unit using ‘Thangu vaIa’, a traditional boat seine, was Rs 26.57 per working day and the percentage of net profit over initial investment on a new unit was 171.7 per annum. In the case of mechanized units operating at Cochin (11—13 m long boats) this profit rate was about 30%.

Mariculture

The Institute has been constantly striving to improve the techniques in mariculture for arriving at better production rates per unit area. Based on the experiments carried out by the Institute, the following production rates were obtained for various culturable organisms: brown mussel, 150 tonnes/ha/annum; green mussels, 235 tonnes/ha/annum; edible oysters, 100 tonnes/ha/annum; eels, 3.8 tonnes/ha/2 years; Sillago sihama, 20 cm in 7 months; seaweeds, 4-6 kg/m² of coir netting in 80 days; and cultured pearls, success of 60-70% of implanted nuclei.

Breakthrough in prawn culture

Breeding was induced in the marine prawn by the eye-ablation technique at Narakkal centre of the Central Marine Fisheries Institute. Within 12 days after cauterization of one of the eyes, the female prawn released about 60,000 eggs, which were reared further to post-larval stages. Similar success was achieved in respect of Parapeneaeopsis stylifera which breeds and completes its life-cycle in the marine environment.

The Institute developed improved methods for packing and air-lifting of live prawn seeds to different parts of the country for stocking in various fields.

Lobster culture

In the field laboratory at Kovalam, the young ones of lobsters collected from the inshore region by special collectors were reared in the laboratory in large plastic pools. These young lobsters after growing in the laboratory for 1 year, matured, mated and got berried. Subsequently the eggs hatched out into free-swimming Phyllosoma larvae. Pueruli reared in the laboratory attained marketable size within about 18 months.

Phytoplankton culture

Phytoplankton cultures (Thalassiosira subtilis and Chaetoceros affinis) developed on a mass scale for the first time in fibre-glass tanks of 150-litre capacity were made available for feeding prawn larvae reared in the hatchery at Narakkal.
Survey of seed resources

The Institute conducted, along the coasts of Tamil Nadu, Kerala and parts of Andhra Pradesh, extensive surveys to locate suitable sites for the collection from natural sources seeds of fishes, prawns and molluscs. The information on the seasonal abundance, quality and quantity and other ecological parameters was consolidated. This information is vital for any accelerated programmes in the development of mariculture.

Special surveys

A comprehensive mariculture survey of the Andaman and Nicobar Islands was completed during the year. It revealed that many areas in the islands were potentially good for mariculture of prawns, fishes and molluscs. In another survey, the mangrove ecosystems and coral reef resources in the Gulf of Kutch were investigated. A survey was undertaken in the Cochin backwater and adjacent low-lying areas to evaluate the productivity of the perennial and seasonal fields and potential areas for mariculture.

Studies on molluscs

Based on a detailed study of the gonadial cycle of some of the more important oysters of the Saurashtra coast, their spawning season and sex ratios were worked out by the Department of Biosciences of the South Gujarat University. The effect of pollutants on these oysters along with their growth and other aspects were also taken up by this Department under an ICAR-supported ad-hoc scheme.

A comparative study of the digestive system of some of the bivalve molluscs was initiated at the Department of Zoology, Calcutta. The results are expected to be of help as models for evaluating primary productivity of the aquatic system inhabited by them.

Extension, education and training

Endeavours were made to transfer the technologies developed by the Central Marine Fisheries Research Institute on various aspects of mariculture to the fish farmers. Intensive culture of fast-growing species of prawns such as Penaeus indicus and P. monodon was demonstrated in 3 different farms around Cochin. Both the perennial fields and the fallow canals among coconut groves were chosen for demonstrations. The Institute also participated by providing technical expertise in the Co-operative Prawn
Farming Project at Narakkal. Several fish farmers have now taken up intensive culture of prawns in the Pokali fields and perennial water areas of central Kerala. The above demonstrations helped the Institute in securing valuable feed-back information vital for improving and perfecting the techniques in mariculture.

The Krishi Vigyan Kendra at Narakkal, attached to the Institute, successfully imparted training in prawn and fish culture with practical demonstrations to farmers and farm-women. So far the Krishi Vigyan Kendra has conducted 10 long-term courses and 6 short-term courses; 170 farmers and 39 farm-women were trained till the end of November 1978. A short-term special course on collection, identification, and transportation of fish/prawn seeds was organized for the benefit of the trainees, mostly women.

The Operational Research Project at Kovalam (near Madras) on an ‘Integrated approach to blending sea farming with traditional capture fisheries’ made a good beginning. The Institute achieved a breakthrough in establishing good liaison with the fishermen, of the village who voluntarily involved themselves in the project work as a part-time or full-time avocation. About 150 poles were fixed in the sea and seed mussels attached. These showed good and healthy growth despite adverse sea conditions due to North-East monsoon.

During 6-9 December 1978, the Institute successfully organized a Seminar at Madras on ‘The role of small-scale fisheries and coastal aquaculture in integrated rural development’. It was for the first time that a seminar was organized on such an integrated theme bringing together a broad cross-section of people such as fishermen, social scientists, economists, scientists, administrators, planners and representatives of international organizations. The seminar deliberated in detail various problems relating to small-scale fisheries and coastal aquaculture, and their role in integrated rural development. Many significant recommendations were made in the seminar, and these are being placed before concerned authorities for consideration and implementation.

**FISHERIES TECHNOLOGY**

Steady progress was maintained in all the research programmes and activities undertaken by the Central Institute of Fisheries Technology, Cochin.
Fishing gear technology

A new design of parallel twin-body trawl, in which 2 small nets are put side by side, their inner wings removed and then connected in parallel, was developed. This new net showed an overall increase in efficiency by 28% over the conventional trawl with a break-up of 39.90 and 23.10%, respectively, for prawn and fish. This trawl has an extra wide opening, resulting in about 9% lesser utilization of horse power than the conventional shrimp trawl. It can be used as an alternate gear for small and medium-class vessels where double-rig and twin-rig trawling are not possible. A design was also developed for a large mesh-trawl for demersal fishery. Comparative field trials of a 32-m-long mesh-trawl with a conventional trawl of same head rope length showed an increase in catch by 171 and 87% in off-shore and inshore waters respectively. The gear is simple in construction and the cost of its fabrication is also comparatively less. Gear design of a purse seine for operation from smaller classes of vessels was developed and released to the industry. The net has an overall length of 260.5 m and maximum depth of 28 m, and can be successfully operated from a 9.75-m (32 ft) vessel. The net is bound to increase marine fish catch especially of sardine and mackerel. Successful field trials were carried out with two 10.2-m trawls with sleds employing a pair of otter boards from a single warp.

Incorporation of denier sizes of yarn other than 210 for the preparation of nylon twines was done and the Indian Standards for the products was suitably modified. Specifications were worked out for aluminium and glass floats for different types of fishing nets.

Fishing craft technology

Technological characteristics of boat-building materials like FRP, ferrocement and aluminium for fishing boat construction were made available to the industry and the various state fisheries departments as alternative materials to the conventional wood and steel.

The proper utilization of secondary species of timbers like mango and haldu in boat building practices after careful seasoning and preservative treatment was further explored and experimented with prototype mock-ups and field riggings.
Standard methods were worked out for the proper maintenance of fishing boats to enhance their normal service life, with special reference to anti-fungal, anti-borer, anti-fouling and anti-corrosion measures.

A combination of an inboard engine with outboard drive was developed for the mechanization of country crafts so as to increase the efficiency and economics of coastal fishing.

Fish processing technology

Studies on the storage characteristics of frozen oil-sardines showed that during frozen storage at —18°C, the skin lipids of the fish were more prone to anti-oxidation than the muscle lipids. This was attributed to some pro-oxidants present in skin lipids.

Continued investigations on the nutritional and biochemical characteristics of red and white meat of tuna confirmed that red meat was superior to white meat in the matter of distribution of important nutrients, amino acids and minerals with an overall calorific value of 120 K cal/100 g compared with 103 K cal/100 g for white meat. Further, biochemically, red meat is a centre of aerobic metabolism whereas white meat has a predominant anaerobic metabolism.

Procedures were standardized for commercial production of cooked and frozen crab meat, and cooked, peeled and frozen prawns conforming to international standards.

The shelf-life of the frozen Indian oil-sardine could be enhanced up to 9 months by selecting very fresh raw material, and freezing and storing them at —20°C or below. This finding is expected to dispel the belief that oil-sardine has frozen shelf-life of only 2-3 months. The methods of freezing, glazing, packing and conditions to be followed during cold storage of frozen oil-sardine were also worked out.

A method was developed for the production of frozen fish fillets for export and internal trade from poor-quality fishes like catfish, jew-fish, thread-fin bream and Indian halibut. This is likely to generate more employment potential since the operations involved are mainly manual, and enhance the returns to the fishermen.

A rapid colorimetric test using a reagent-impregnated filter-paper was developed to measure available chlorine levels from 20 to 250 ppm. This would help the processing factories in adjusting the chlorine levels in the water used for various operations.
Complete utilization of *Squilla*—a shell-fish, now being wasted—was attempted, and methods worked out for extracting proteins and soluble non-protein nitrogen fractions and preparation of chitosan from its shell.

A process was standardized for canning Bombay-duck paste, and a ready-to-serve product like bread-spread successfully prepared from this paste.

Smoked products were prepared from fillets of Razor-edge fish. The product has a very good appearance and appealing taste. Salted and smoked products were also prepared from silver-bar fish. Minced meat of these fishes were utilized for the preparation of frozen blocks as well as speciality products.

A process for the production of dried mussel meat was standardized, as also that for the preparation of light-smoked and dried product.

A prototype model of modern sun-drying yard was fabricated. It consisted of raised platforms as drying racks fabricated out of bamboo-reinforced concrete slabs on wooden structure. A commercial design, based on this principle was undertaken.

Under the All-India Co-ordinated Research Project on Transportation of Fresh Fish and Utilization of Trash Fish, attempts were made to control the spoilage of fish being transported from fish-production centres to fish-consuming centres. Optimum condition of icing, packing, freezing and other parameters of fish transport under varying conditions as by rail, trucks, carrier boats, etc., were worked out, and cheap, insulated fish-boxes developed. These are expected to have intensive commercial application. Special emphasis was laid at the Veraval Research Centre of the Institute to popularize the standardized second-hand tea-chest insulated with polythene-lined thermocol of 15/25 mm thickness. The efficiency of the container was proved beyond doubt by subjecting it to tests under rigorous conditions with respect to temperature and distance covered. Detailed studies were also undertaken on various factors like ice to fish ratio, thickness of insulation, size of box, species of fish, ambient temperature, etc., to get an idea about the change undergone during transportation.

Non-penaeid prawns are landed in abundance along the coast of Maharashtra. At the Institute’s Centre at Bombay studies were initiated for effective utilization of this fishery wealth. A method was developed for extracting the muscle proteins alone.

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free of shell portion. This extracted meat can be preserved either in the dry or frozen condition and then subsequently utilized for incorporation in different food products. The Marine Biological Research Laboratory, Ratnagiri (under Konkan Krishi Vidyapeeth), developed a cheap method for the preparation of meat pulp from such non-penaeids, and various uses of this pulp in human dietary consumption established.

A number of low-cost protein-rich products from uneconomical varieties of fish developed at the Fisheries College, Mangalore, (University of Agricultural Sciences), and conforming to the standards laid down by the FAO were readily acceptable to the consumers.

The Centre of Advanced Studies in Marine Biology in Portu Novo undertook an extensive study of the ecology of *Vibrio parahaemolyticus* in the marine environment of that region. A record and analyses of their incidence, seasonal fluctuations, etc., in the environment as well as in the marine organisms were carried out.

**Extension and training**

Technical assistance was continued to be given to all those who called at the Central Institute of Fisheries Technology. Over 400 technical queries on different aspects of fishing and fish processing were replied. Seventy-seven designs of nets, otter boards, winches, tunnel-dryer, rotary-dryer, etc., were supplied to interested parties on request, as also 14 copies of the special bulletin on ‘Inland Fishing Gear and Methods of India’. More than 80 samples of twines, ropes, hooks, yarns, webbings, etc., and a number of samples of processed products, raw materials, and water and ice samples were analysed and reports furnished to the concerned parties. Refresher courses on the preservation of raw material, fish-plant sanitation, quality control and inplant inspection, filleting and freezing of fish, and handling and transportation of fish were conducted for the benefit of technical personnel and supervisors of the fish-processing industry. About 5 such courses were conducted in addition to short-term training imparted to a few personnel sponsored by the fishing industry. About 11 film shows were held at the request of private and other government organizations in which films on fish spoilage and control, as well as technologies in pond culture and induced breeding of fish, etc., were shown.
7. AGRICULTURAL ECONOMICS AND STATISTICS

Agricultural Economics

Block plans of seven areas in Karnataka State prepared by the University of Agricultural Sciences, Bangalore, indicated the possibilities of providing employment to all in the course of ten years mainly in the agriculture sector. It was further revealed that in order to make small farmers viable, minor irrigation and land development investments are economically profitable and financially sound.

Inter-cropping trials with Cassava conducted at Peddapuram (Andhra Pradesh) under the All-India Co-ordinated Research Project for Tuber Crops showed that bhindi was the most remunerative crop although it cannot be universal. The next best was soyabean which again has limited market. There were new indications that the red gram short duration variety “Upshar” was likely to be a more acceptable alternative. Similar trials at the Jorhat centre indicated that Cassava with green gram as inter-crop was much better with a net profit of Rs. 3807 per hectare. This was followed by Cassava and soyabean with a net profit of Rs. 3745 per hectare.

Studies on production economics of soyabean, maize, jowar and groundnut from centres in U.P. and M.P. under the All-India Co-ordinated Research Project on Soyabean revealed that in both the States soyabean was relatively more profitable. Moreover, most of the kharif fallows in the two states could be brought under this crop without affecting the succeeding wheat crop, provided there was reasonable assurance for the marketing of the produce.

An economic analysis of Sericulture in Coimbatore district carried out by the Tamil Nadu Agricultural University indicated a high potential for the extension of this enterprise as it created employment for 600 men and 830 women per hectare.

In Madurai district, the cost of production per quintal of paddy worked out to be Rs. 83.67 and Rs. 91.20 for Karuna and I.R. 20 varieties, respectively. The input-output ratio was 1:1.25 under cost C basis. The average cost of production of MCU-5 cotton was worked out to be Rs. 225.

The input-output ratio was calculated as 1:2.18 under cost C basis. For sugarcane the cost of production was worked out
as Rs. 91 per tonne of cane and Rs. 119 per quintal of jaggery with input-output ratio of 1.19 for cane and 1.35 for jaggery.

The cost of production of banana was estimated as Rs. 1.85 per bunch with input-output ratio of 1.15 under cost C basis. In groundnut the cost of production per quintal of pods was Rs. 127.36 with input-output ratio of 1.17. Regarding irrigated "cholam", the production cost was estimated as Rs. 77.68 per quintal and the input-output ratio was 1 : 1.63.

Studies on the cost of production of milk in Haryana carried out by the Haryana Agricultural University revealed the per kg. cost to be Rs. 1.80 in winter, Rs. 2.01 in summer and Rs. 1.65 in the rainy season. Studies on the marketing of potato in the State indicated that the producer's share in the consumer's rupee varied from 50.8 to 54.2 per cent.

Agricultural Statistics

Production potential experiments conducted at various centres under the All-India Co-ordinated Agronomic Research Project during 1977-78 indicated 3 or 4 crop sequences, viz. maize-rice-bajra, rice-wheat-rice, maize-wheat-gram and rice-wheat-gram as highly productive.

Studies on intercropping at Bhavanisagar (Tamil Nadu) indicated that with cotton as main crop, green gram, groundnut or onion can be raised as inter-crop without affecting the yield of the main crop. Similarly at Karamana (Kerala), groundnut or cowpea could be raised as intercrops in Tapioca fields without reduction in the main crop yield.

Fertiliser experiments on cultivators’ fields conducted during 1977-78 indicated the following salient results:

(a) *Rice*: Under assured water supply, with application of chemical fertilisers at the rate of N₈₀ P₄₀ K₄₀ per hectare to high-yielding varieties of rice, responses of the order of 17.1, 18.4, 14.0 and 17.0 quintals per hectare were obtained in the North Western, North Eastern, West Central and Southern regions of the country. The average yields at the native fertility level in the districts covered in these regions were 31.1, 22.1, 24.0 and 30.7 quintals, respectively per hectare.

(b) *Wheat*: With adequate irrigation and application of fertilisers at the rate of N₈₀ P₄₀ K₄₀ per hectare to
the high-yielding varieties of wheat, responses of the order of 16.8, 16.1 and 9.8 quintals per hectare were obtained in the North West, North East and West Central Regions.

(c) **Pulses**: Under dryland conditions, application of balanced fertilisers at the rate of N\textsubscript{20} P\textsubscript{40} K\textsubscript{20} per hectare more than doubled the yield rates of gram, green gram and horse gram in the districts covered, the responses ranging from 5.6 to 9.2 quintals per hectare.

(d) **Oilseeds**: Fertiliser application at the rate of N\textsubscript{60} P\textsubscript{40} K\textsubscript{20} per hectare to mustard gave on an average a good response of 7.3 q/ha in the North Western region. Response of til to the same level of fertiliser application in the same region was moderate being about 3.1 Q/ha.

Linear regression analysis was carried out with jowar and cotton yield and data on weather factors of Jalgaon district, Maharashtra. On the basis of these functions and the stability of the effective factors influencing crop production, the jowar crop appeared to be more suitable for this region.

Under the scheme for National Index of agricultural field experiments, compendium volumes for the period (1960—65) relating to the North-Western Region and for Bihar were brought out. The National Index volume III covering the period 1973 and volume IV for the period 1974 and 1975 were published during the year. A report on 30 years of agricultural field experiments in India (1948—77) was also brought out. It was observed that the number of experiments planned and conducted during this period have increased vastly.

Results of studies on rice, wheat, cotton and jute have shown the feasibility of building up satisfactory prediction models of yield based on measurements of biometrical characters. Analysis of data on sugarcane in respect of Meerut district revealed that three biometrical characters viz., number of millable canes, height of cane and its girth contributed over 70 per cent of the variation in the yield rate. The suitable time for forecasting yield of sugarcane seems to be 7 to 8 months after planting.

Studies were undertaken to develop suitable crop-weather models for yield assessment. Analysis of data from Raipur district showed that forecasting of rice yield is possible when the crop is
about 2-1/2 months old, explaining about 70 per cent of the variation in yield due to weather parameters and time trend.

The IASRI has developed a suitable sampling methodology for estimation of both availability and cost of production of milk so as to help formulate sound milk procurement and pricing policies. Similar methodology for estimation of cost of poultry and egg production under commercial management conditions has also been developed.

Studies on progeny testing of breeding bulls have shown that for cross-breeding programmes in cattle, the level of exotic inheritance should be between 50 per cent and 75 per cent. Infusing foreign blood beyond 75 per cent level may result in significantly higher calving interval coupled with lowered lactation yields.

Results of sample surveys for methodological investigations into HYV programme conducted during 1975-76 in 38 districts spread over 15 States showed that the coverage under HYV was the highest for wheat crop, being 90 per cent or more in about 50 per cent of the districts studied for this crop. For rice crop also, the coverage under HYV was 90 per cent or more in 50 per cent of the districts studied during *rabi* season. However, during the *kharif* season the coverage under HYV rice was less than 50 per cent in a majority of the districts studied. The highest average yield for HYV of wheat, rice, maize, jowar, bajra, cotton and groundnut was 37.4, 33.2, 25.9, 21.6, 25.2, 6.1 and 14.2 q/ha respectively.

A study was undertaken to develop a technique for estimation of cotton yield on partial harvest data. The results showed that it was possible to estimate the yield of cotton with good precision by adopting double sampling and component sampling approaches. The results also showed that it was possible to obtain a quick check estimate of cotton yield from the data of first one or two pickings only.

A study relating to estimation of labour use in crop production in Uttar Pradesh indicated that, for the State as a whole, the maximum amount of the labour was used for the sugarcane crop followed by potato, while the per hectare labour use was minimum for jute. It was also observed that nearly half of the available labour force in agriculture was directly employed in crop production.

A training course in the methodology of constraint analysis was organised at the IASRI for the benefit of subject matter
specialists working in the various operational Research Projects sponsored by the Council. During the period under report, 10 students have completed the Junior Certificate Course, 15 have completed the Senior Certificate Course, 18 have completed the Professional Statisticians' Certificate Course and 6 have completed the Diploma course being run at the Institute.

The new III generation Computer System B-4700 installed at the IASRI in March, 1977, continued to provide programming assistance and data processing facilities to ICAR Institutes, Agricultural Universities as well as other institutions. The Centre has also installed an information storage and retrieval system for documents generated in Agriculture all over the world with the collaboration of the FAO.
V. AGRICULTURAL EDUCATION

The development of agricultural universities continued to be the major programme of the Education Division. Apart from the usual activities a special feature of this year was the review of the progress of agricultural universities carried out by the Council with the help of a high level Committee headed by Dr. M. S. Randhawa. The main purpose of the review was rural orientation of agricultural and home science education with emphasis on practical training and self-employment. The review committee has in its report (June 1978) made far reaching recommendations which are currently under active consideration of the ICAR, the agricultural universities and the State Governments.

While giving assistance for infrastructure development according to prescribed pattern of assistance, the Council maintained thrust towards consolidation and quality improvement. No new college of agriculture was established except in Nagaland. This College was inaugurated in October, 1978 and is expected to function as an autonomous college of the North Eastern Hill Universities. The Agricultural Complex of the erstwhile Himachal Pradesh University was separated and given the status of a fullfledged Himachal Pradesh Agricultural University. The number of affiliated colleges recognised by the ICAR for central assistance was further reduced on the recommendations of the Norms and Accreditation Committee to only eleven. Only those maintaining satisfactory standards of education were recognised.

Based on the recommendations of an ICAR-UGC team, the Council agreed to the upgrading of the faculty of agriculture of Banaras Hindu University, Varanasi into a fullfledged Institute of Agricultural Sciences, within the scope of Banaras Hindu University Act. The Institute would, by and large, be developed on the principle of integration of teaching, research and extension and would be expected to adopt the educational reforms introduced in agricultural universities.

The post-graduate college of animal sciences at the Indian Veterinary Research Institute, was being considered by the UGC
for being given the deemed University status. The Government of India decided to transfer the Central Institute of Fisheries Education, Bombay, to the ICAR.

To meet the demand for specialisation in diverse fields like Dairy Science, Fisheries Sciences and Forestry, a number of Agricultural Universities proposed the establishment of full-fledged colleges in these subjects during the year. The following proposals were being considered:


2. Establishment of faculties of Forestry and Dairy Science at UAS.

3. Establishment of Agricultural Engineering and Dairy Science College under APAU, Hyderabad.

4. Establishment of a Fisheries College under Kerala Agricultural University.

To meet the diversified needs of training and the demand for specialisation in different areas, the Council was considering a proposal to establish some new faculties/departments like Fisheries, Forestry, Dairy Science, Agricultural Engineering, Agricultural Meteorology, Nematology, etc. in the existing universities. The Council also encouraged the development and establishment of a number of new departments such as agro-meteorology, agricultural management, food technology and farm forestry. A collaborative arrangement with the Indian Institute of Management, Ahmadabad, for offering post-graduate courses in Agricultural Management was under consideration.

The Council convened two meetings of the Vice-Chancellors of agricultural universities during the year, one of these a joint meeting with the Directors of Central Research Institutes. These meetings together with the convention of agricultural universities provided forums to discuss problems and programmes of mutual interest as well as to develop consensus and an agreed strategy on some of the issues of national importance.

An effort was made during the year to utilize the expertise of the Scientific Panel on Agricultural Education to advise on how to bring about an improvement in course curricula, evaluation system, teaching methods, practical training and production of
teaching material. It is also proposed to hold teaching methods seminars in collaboration with the Association of Agricultural Universities. Assistance towards implementation of U. G. C. pay scales in agricultural universities was continued as in the previous year. Schemes relating to staff development were further streamlined and revised.

Recognising the importance of faculty improvement, the Council introduced new schemes for advanced training of teachers and research workers within India and abroad. The facility of faculty improvement programme would also be extended to the teachers of approved affiliated colleges with effect from 1979-80. An apprenticeship scheme was introduced to impart on-the-job practical training to the graduates in Veterinary Sciences and Animal Husbandry. They would be given an allowance at the rate of Rs. 250 p.m. for a period of six months. This apprenticeship period would be made a compulsory requirement for the award of the degree. The Council also decided to assist the agricultural universities in their participation in the National Adult Education Programme launched by the Ministry of Education. The assistance would be given on the pattern of assistance adopted by the Ministry of Education.

Review Committee on Agricultural Universities

The Review Committee on Agricultural Universities set up in January, 1977 by the ICAR under the Chairmanship of Dr. M. S. Randhawa, submitted its report on 7 June, 1978. The Committee’s overall assessment was that the agricultural universities together had made a tremendous impact on agricultural production during the short span of their existence. The Committee, however, stated that there was a high degree of variability amongst agricultural universities with regard to achievements and output, quality of leadership and competence of faculty, degree of institutional development and maturity, magnitude of financial support from the State Governments, extent of transfer of research responsibilities to the university, quality and relevance of teaching and research programmes, operational efficiency and commitment to public service. The quality of leadership and degree of commitment and support from the State Governments were identified as the two main factors responsible for this variability in growth, performance and potential. The Committee inter-alia, recommended that:

(a) The Selection Committee for choosing Vice-Chancellors should include the Director-General, ICAR, and Chairman, UGC as members in each case.
(b) The Vice-Chancellor should be the Chairman of a compact Board of Management with a membership not exceeding fifteen, and

(c) The State Government should adopt a positive policy of support to agricultural universities. First, they should review the University Acts and bring them in line with the Model Act recommended by the ICAR and implement it faithfully. They should transfer State-wide agricultural research responsibility to agricultural universities along with staff, farms, budget, buildings, equipment, etc. Parallel research organisations should not be set up in the State Departments in the name of adaptive research. Secondly, agricultural universities are essentially State-institutions and as such State Government should accept direct responsibility for both the development and operational costs. The Central support from the ICAR could only be supplementary in nature.

(d) ICAR should use central assistance as an incentive and instrument to achieve the organisational pattern and institutional model of agricultural university with all essential features.

In view of the stress laid in its terms of reference, the Committee made several important recommendations for improving the practical training programmes, promoting self-employment of agricultural graduates and for giving rural reorientation of Home Science Education. The Committee also made a number of recommendations with regard to improvement in the education, research and extension programmes, staff development, strengthening of financial resources of the universities, development of infrastructure facilities and strengthening of machinery for planning evaluation and coordination of universities. The Committee also briefly reviewed the progress of each university and made observations about some major aspects of their functioning.

The report of the Committee was forwarded to all the State Governments and agricultural universities. The Minister for Agriculture and Irrigation also addressed the Chief Ministers of State Governments to examine the important recommendations of the Committee. The report was also discussed at the Conference of Vice-Chancellors of Agricultural Universities held on the 16 to 17 October, 1978. There was general consensus that the recommendations of the Review Committee were by and large acceptable, subject to modifications in certain areas to suit the local condi-
tions. Universities have agreed to implement such of those recom-
mendations which do not involve any outside approval. It was ag-
reed that in respect of recommendations in the field of govern-
ance of universities the transfer of research staff and increasing
the state financial support, the concerned universities would dis-
cuss with respective State governments and, if necessary, the mat-
ter would be pursued by the ICAR also. The ICAR was taking
action to reorient the financial pattern of agricultural universities
in the light of the recommendations of the Committee. It was also
decided to constitute a committee of Deans for revision of course-
rs and curricula in the various disciplines in the light of several
important recommendations of the Committee.

ICAR-IBRD National Agricultural Research Project

The National Agricultural Research Project (NARP) for stren-
thening the regional research capability of agricultural universities
(to be implemented with assistance from IBRD) was finalised
during the year in consultation with the Planning Commission and
the Department of Economic Affairs. An IBRD Mission appraised
this project in March, 1978 and negotiations for finalising the
agreements were held in July-August, 1978. After obtaining the
approval of the Cabinet, agreements have been signed with IBRD
on the 7th December, 1978.

The main objective of the project is strengthening the regional
research capabilities of agricultural universities as an important
means of finding solutions to location-specific problems. The eff-
orts under this project would be concentrated on foodgrains,
cereals, pulses and oilseeds in each agro ecological zone. Parti-
cular attention would be paid to foodgrains grown under rain-
fed conditions and mixed farming systems involving crop, live-
stock and crop-fish production systems. In furtherance of this
objective, regional stations would be developed/strengthened in
selected agro-climatic zones and will be provided with resources
like staff, equipment and infrastructure.

All the agricultural universities are eligible for participation in
the project on certain terms and conditions.

The Project will be implemented during the current medium
term plan (1978-79) to (1982-83). Projects in respect of the
three agricultural universities have so far been approved.

The total outlay involved in this project during the current
medium term plan (1978-79 to 1982-83) is Rs. 42.30 crores.
A sum of Rs. 22.30 crores (US $ 27 million) is expected to be received as credit from IDA for this project.

During 1978-79, the participation of four agricultural universities was approved. Sanction for implementing two sub-projects, one relating to the strengthening of the Regional Station at Tirupathi under the Andhra Pradesh Agricultural University (involving a total outlay of Rs. 1.05 crores in five years) and the other for strengthening the sub-station at Bawal under Haryana Agricultural University, Hissar (involving a total outlay of Rs. 73.72 lakhs in five years) was issued in December, 1978. The sub-projects received from the University of Agricultural Sciences, Bangalore and Jawaharlal Nehru Krishi Vishwa Vidalaya, Jabalpur, were under examination. During 1979-80, the participation of some more agricultural universities would be finalised.

As part of this project, a comprehensive review of the research programmes in progress in the service area of the University would be undertaken to rationalise the working of various research stations, avoid duplication, pool resources and identify research gaps in each State. Such a review had been initiated in respect of the University of Agricultural Sciences, Bangalore, Andhra Pradesh Agricultural University, Hyderabad, Haryana Agricultural University, Hissar and Jawaharlal Nehru Krishi Vishwa Vidalaya, Jabalpur.

**ICAR/UNDP Project on Postgraduate Agricultural Education and Research**

Appreciating the need for establishment of centres of Advanced Studies for post-graduate education and research in selected fields of agricultural science, the ICAR, with assistance from UNDP, launched in 1973 this project covering the following disciplines:

(i) Soil & Water Management at the Haryana Agricultural University, Hissar;
(ii) Plant Protection at the University of Agricultural Sciences, Bangalore;
(iii) Agricultural Engineering at the Punjab Agricultural University, Ludhiana;
(iv) Dairy Science at the National Dairy Research Institute, Karnal;
(v) Poultry Science at the Indian Veterinary Research Institute, Izatnagar, and
(vi) Agricultural Economics at the Indian Agricultural Research Institute, Delhi.

The Departments participating in this programme have been able to strengthen their post-graduate teaching and research programmes on an inter-disciplinary basis, augment their infrastructure facilities and build up a cadre of highly competent scientists through advanced level training in India and abroad. During the current year 10 leading scientists from abroad have spent two to three months each at the above Centres and have offered advanced courses, conducted seminars at national level and have played an active role in developing research projects, equipment lists and in developing other facilities. Also 20 Indian scientists visited for short periods leading overseas institutions during the year to study modern teaching use and research methodology. Supplies of sophisticated equipment like ultra centrifuges, spectrophotometers, microscopes, digital PH meter, precision analytical balances, mini-computer, books, journals etc. not available in India have been arranged at a cost of approximately $300,000 during this year.

The UNESCO/FAO Technical Advisory Mission visited all the Centres in January 1978 and highly commended the project work. The Government of India and the ICAR have since decided that Centres on Plant Protection, Dairy Science, and Poultry Science should be phased out by June 1979 as the objectives of these sub-projects have been achieved by and large. They have already earned recognition throughout the country as advanced centres in their respective disciplines and are starting to get international recognition. The Mission recommended an additional UNDP input of U. S. $1 million for three years from June 1979, for Soil and Water Management at the Haryana Agricultural University, Hissar. Agricultural Engineering at the Punjab Agricultural University, Ludhiana and Agricultural Economics at the Indian Agricultural Research Institute, New Delhi, as these centres have not yet achieved an advanced level envisaged for them.

In view of the overall success of the project, the Government and ICAR have decided to request for further UNDP assistance to start similar seven new Centres of Advanced Studies from 1979 as follows:

(i) Agricultural Microbiology at the Tamil Nadu Agricultural University, Coimbatore.
(ii) Tropical Horticulture at the Indian Institute of Horticultural Research, Bangalore, in collaboration with the University of Agricultural Sciences, Bangalore.

(iii) Temperate Horticulture at the Himachal Pradesh University, Solan Campus.

(iv) Mariculture at the Central Marine Fisheries Research Institute, Cochin;

(v) Plant Physiology at the Indian Agricultural Research Institute, Delhi.

(vi) Dairy Processing at the National Dairy Research Institute, Karnal; and

(vii) Agricultural Communication at the G. B. Pant University of Agriculture and Technology Pantnagar.

ICAR-IBRD Project for the Development of Rajendra and Assam Agricultural Universities.

The IDA Education Project operative at the Assam and Bihar Agricultural Universities and the Computer Centre, Indian Agricultural Statistics Research Institute, New Delhi completed its Fifth Year as on 31-12-1978 with a long-term loan of 12m dollars being provided by the World Bank.

At the Assam Agricultural University 6 units of staff quarters have been completed. Civil works costing 0.37 m dollars were completed during the year under report, thus raising the total expenditure to 2.30 m dollars. Out of the total allocation of 1.63 m dollars earmarked for equipments, books and furniture, equipments worth 0.34 m dollars were procured, thus raising the total expenditure to 0.91 m dollars. Under the following programme 20 Fellows completed their training during the year under report. The total disbursements claimed during the year amounts to Rs. 85.23 lakhs.

The new Third Generation Computer System Borrow B-4700 was installed on schedule at the Indian Agricultural Statistics Research Institute, New Delhi, and its Linkages were thoroughly studied. Full advantage of the computer facility is now being taken by other Agricultural Universities in the country. The savings accrued after installation on the System are also being utilised for extension purposes.

ICAR-UNICEF Project on Higher Education & Training in Food and Nutrition for Agricultural Universities

This project has been in operation since 1974 with UNICEF
assistance. To begin with, the assistance was utilised for orientation course in Human Nutrition. Later assistance was given to participating institutions in the form of staff support, equipment, books and journals. The target of starting under-graduate courses in Food and Nutrition at 12 Agricultural Universities under an UNICEF-ICAR project was achieved during the year. Nine of these universities offered courses and training to about 7000 students in Human Nutrition. These Universities received an assistance of about Rs. 4.00 lakhs in terms of equipments, books and staff salaries from the UNICEF. It is expected that programme will be extended to all the Universities and post-graduate courses in Nutrition would be started at least in the four Agricultural Universities during the Sixth Plan. This scheme has been included in the Master Plan of Operations of UNICEF, with added financial allocation with ICAR providing the matching grant.

An intensive campagin for promotion and establishment of Nutrition Gardens has been launched in all Agricultural Universities, Krishi Vigyan Kendras and other Agricultural Institutes. The emphasis in the campaign is to promote cultivation of low-cost nutritious fruits trees, vegetable crops and green leafy vegetables in the kitchen gardens. These efforts will be further intensified in 1979, the Golden Jubilee Year of the ICAR and also declared as International Year of the Child.

Scheme of Professor of Eminence/National Fellows

A scheme was finalised for the award of Professional Chairs (Professor of Eminence with Rs. 3000 per month and National Fellows in the grade of Rs. 1500-2500) to develop strong centres of research and education around outstanding scientists of proven competence and leadership.

The selection for the first awards under the scheme of Professor of Eminence and National Fellowships were finalised in December, 1977. After negotiating with the Scientists, details regarding the research projects, staff, equipment etc. needed, the awards were made in 1978-79. Seven outstanding Scientists were awarded "Professor of Eminence". While all of them have accepted the offer, only four of them have joined so far. Twelve outstanding Scientists were offered the award of National Fellows out of whom six have joined so far. Action for making the second series of awards has been initiated and the awards are likely to be finalised during the current financial year.
Krishi Vigyan Kendras

The Krishi Vigyan Kendras, a set of first line institutions for training the practising farmers and fishermen were started by the ICAR about the middle of 1976. The scheme aimed at imparting skill-training by the method of providing work-experience on the principle of learning by doing. In all, 19 KVKs have been established by December, 1978. Visualising the dearth of practical teachers for the skill-training side by side, 7 specialised Trainers, Training Centres mostly an integral part of the ICAR research institutes have also been set up.

The Kendras/ Centres still being in their initial stages of development during the year, major efforts were continued to be directed towards developing basic infrastructure like building construction, procurement of training equipments, recruitment of staff, establishment of demonstration units (poultry, goatery, fish-ponds, workshops etc.) and farm development. Training courses both on the campus as well as in the villages for farmers, fishermen, farm women, school drop-outs and field level extension workers were taken up.

Formulating skill-oriented and need-based training courses, require a thorough understanding of the farmers and farming systems, specially the gap which existed between the available technologies and their transfer to the clientele. Hence, each KVK/ TTC was entrusted with the task of conducting the village as well as farming family survey as a basis for organising relevant short and long duration training courses. During the year 432 training courses of varying durations were organised by the KVKs/ TTCs benefiting 7220 farmers, farm women and in-service training and development staff.

The second All-India Workshop on Krishi Vigyan Kendra was organised at KVK Campus at Kosbad Hill, Maharashtra, in which 37 Training Organisers and Incharges of the host institution, 8 Officers of the ICAR, 10 representatives from other related Government and non-Government organisations took part. The Workshop critically reviewed the progress made so far and the problems being encountered in accelerating the development of the KVKs, and enlarging their training programmes. It was particularly noted that (a) the recruitment of the KVK staff was slow in several cases (b) the progress of the village and family survey could not keep pace with our expectations, and (c) the linkages with agricultural research institutes, agricultural universities and other sister organisations and departments needed strengthening. The Workshop recommended to take prompt and appropriate actions to remove these bottlenecks at the earliest.
In addition, the Workshop (i) worked out a plan of action for the village survey, (ii) developed a plan for organising training courses for the KVK trainers in different specialised areas like dryland agriculture, animal husbandry, dairy, horticulture, fisheries and home science; (iii) recommended for devoting 50 per cent time of the Management Committee on educational programmes of the KVK; (iv) provided necessary guidance on preparing the Sixth Plan proposals; and (v) outlined the mechanism for having functional linkages, with the Directorate of Adult Education of the Ministry of Education and Social Welfare, the C.S.I.R., and Khadi and Village Industries Commission.

A Hindi version of the English bulletin on Krishi Vigyan Kendra was brought out and distributed to KVKs and TTCs and other related organisations/agencies during the year. Besides, each of the KVKs produced some publications on its work as well as prepared technology oriented extension literature for the farmers.

A set of norms were developed as a guideline for considering the proposals on KVK and providing them with appropriate financial assistance. On the basis of the past experience, the items for assistance under recurring and non-recurring heads have been identified and defined for smooth monitoring of the scheme. A Memorandum of Understanding between the host institutions and the ICAR was also developed and circulated to the concerned host institutions for execution.

Over seventy new proposals for establishing KVKs during Sixth Five-Year Plan have been received by the Council. As an advance measure, 20 locations for new KVKs have already been visited.

**Fellowship and Scholarship Programmes**

As in previous years the Council continued to offer Merit-cum-Means Scholarships for under-graduate studies and National Science Talent Search Scholarships for continuing agricultural education. In addition to scholarships at under-graduate level, 312 Junior Fellowships were awarded for study at Masters level on the basis of competitive written examination held in 30 centres all over the country. The Council also offered 125 Senior Fellowships including 25 fellowships under Teaching Faculty Improvement Programme and 10 Fellowships specially reserved for ICAR employees for pursuing studies at Doctoral level.
A number of changes were introduced or proposed to be introduced in the scholarship/fellowship programmes during VI plan period:

(a) Coverage of Merit-cum-Means Scholarships proposed to be increased from 7 1/2 per cent to 15 per cent.

(b) Number of Junior and Senior Fellowships proposed to be increased from 312 to 350 and 100 to 150 respectively.

(c) Post-doctoral fellowships on UGC pattern proposed for implementation during Sixth Plan.

(d) A scheme for advanced training of Agricultural University staff in foreign countries included to get scientists trained in areas in which facilities for high level training were not available within the country.

Reference has already been made earlier to the introduction of teacher fellowships at agricultural universities and the financial assistance to be given by ICAR for implementation of the Internship scheme by Agricultural Universities.

Revised Admission Procedures for Foreign Students

ICAR has reserved 10 per cent of the admission capacity in Under-graduate programmes in all agricultural universities in the country for students from the States which do not have educational facilities in a particular discipline and also for the foreign nationals both self supporting and those selected under bilateral and cultural agreements. In 1978-79 there was an unprecedented rush of foreign nationals who desired educational facilities in India in various fields of Agriculture. This necessitated a review of admission procedures of foreign nationals in order to resolve some of the problems encountered during 1978-79. The Council convened an Inter-departmental Committee Meeting in May, 1978 comprising representatives from the Ministry of External Affairs, Ministry of Education, Economic Affairs and Agricultural Universities and has developed an agreed procedure for admission of foreign nationals which will be adopted with effect from 1979.

Jawaharlal Nehru Award

Five awards of the value of Rs. 5000 each were given to the young scientists for their outstanding work at doctoral level in
the fields of (i) Plant Breeding and Genetics; (ii) Agricultural Engineering; (iii) Plant Pathology; (iv) Animal Nutrition, and (v) Fisheries.

**Summer Institutes**

The Indian Council of Agricultural Research has so far organised 163 Summer Institutes/Schools. About 3300 research teaching extension workers have been benefited by updating their knowledge in different disciplines in agricultural field.

Twenty-four Summer Institute/Schools (Twenty Summer Institutes, three Summer Schools and one Winter School) were organised during the year under report including thirteen in agriculture, one in agricultural statistics, two in agricultural engineering, one in home science, five in animal sciences and two in fisheries.

These Summer Institutes aim to impart specialised in-service training in specific disciplines and to revise courses and develop practical manuals and other teaching aids and materials.

**Scheme for Utilisation of Internal Competence for the Development of Agricultural Universities**

The scheme is in operation for the last five years and so far 9 agricultural universities have benefited from this Scheme by utilising the services of 24 experts. However, due to revision of UGC pay-scales, the scheme became less attractive because of the smaller differences in pay-scales, offered for the experts. Therefore, the scheme was reviewed by an Expert Committee which recommended attractive terms for experts prepared to take up the assignments under this scheme. It is expected that the provisions in the revised scheme will be utilised fully by the developing agricultural universities during the Sixth Plan period.

**Linkage of ICAR with APEID of UNESCO**

The Asian Programme of Educational Innovation for Development (APEID) aims at stimulating and encouraging innovations in education. It also aims to link education with national development programmes in Asian Region. ICAR was recognised as an associated centre of APEID during 1978 as the first research organisation outside the orbit of educational institutions. Accordingly, ICAR participated for the first time in the Regional Consultation Meetings in March, 1978 as well as in the Planning Group meetings on Non-formal and Alternative Structures in Education in September, 1978.

This Division is also serving as a member of the Study Group constituted by the UNESCO for writing a handbook on "Preparing Teachers for Education in Rural Development."
Formulation of Sixth Plan Proposals

One of the important tasks of the year was to review the achievements of Fifth Five-Year Plan Programmes of education with the help of the Working Group on Agricultural Education, identification of new avenues of growth and formulation of revised and new programmes for implementation during the Sixth Plan. Objectives of the Sixth Plan were reoriented mainly along following lines. In addition to increased agricultural production an added objective in the subsequent plans would be to develop facilities for technological education and training relating to processing, utilization, marketing and management aspects. During the next five years the process of dissemination of new technology through programmes of middle and non-formal education would be particularly accelerated. Special attention will be given to rural orientation of Home Science education and to train professional farmers/school drop-outs in technical skills required for scientific agriculture. Special efforts would be made to provide greater educational opportunities by offering more incentives to students from rural and backward areas. Assistance would be given to appropriate institutions to support programmes of middle level technicians’ training to establish Krishi Vigyan Kendras (KVKs) and to agricultural universities to develop correspondence courses and post-secondary supportive programmes of agricultural education. An attempt would be made to relate agricultural education planning to manpower needs and to develop self-evaluation system for continuous improvement. New programmes would be initiated to fill in the gaps identified in the existing educational system such as nutrition, agro-meteorology, aero-physics, population education, social forestry, veterinary public health and epidemiology, food science technology, processing and utilisation technology and environmental science, etc. The approach would be mainly to strengthen agricultural universities so that they may serve as fountain-heads of new knowledge and instruments for increasing agricultural production for transforming rural life.

The following schemes have been proposed for the Sixth Plan period:

Continuing Schemes: Establishment & Development of Agricultural Universities, Development of affiliated colleges of Universities, General Division of Agricultural Colleges of Central Universities (Banaras and Vishwa Bharati), Establishment of Krishi Vigyan Kendras, Contribution for UGC pay scales, Creation of Professional Chairs, Post-graduate Agricultural Education and Research (with UNDP assistance & Centres of Advanced Studies), Development of Nutrition Education and Research with UNICEF
assistance, Organisation of Summer Institutes, Improvement of Teaching Faculty Competence, Travel and Study grants and Fellowships, Advanced training for faculty members of Agricultural Universities in foreign countries leading to Ph. D. degree in Agricultural subjects, Utilisation of Internal Competence for Agricultural Universities, Award of Merit-cum-Means Scholarship to Under-graduate students, Award of National Science Talent Scholarships, Award of Post-graduate fellowships, Award of Post-Doctoral Fellowships and Publication of University level Text Books on Agricultural and allied subjects by Indian Authors.

New Schemes: Apprenticeship|Internship Scheme, and Development of Agricultural College, Nagaland.

World Bank Scheme

National Agricultural Research Project.

New Developments at Agricultural Universities

Andhra Pradesh Agricultural University

An elective course in Farm Forestry was introduced for the first time during the year as a part of the Under-graduate curriculum. University has started three new departments, viz., (i) Department of Genetics and Animal Breeding; (ii) Department of Food Technology; and (iii) Department of Meat Science and Technology. Post-graduate programme leading to M.V.Sc. in Dairy Technology and Ph.D. in (i) Parasitology, (ii) Gynaecology and Animal Reproduction, and (iii) Animal Nutrition were initiated during the year. A new diploma course in Swine Husbandry was started during the year. Programme leading to the degree of M.Sc. (Home Science) in two subjects, viz., (i) Child development and (ii) Home Management were also initiated during the year.

Haryana Agricultural University, Hissar

A new three-year programme of B.Sc. (Hons.) Agriculture was started for V.L. Workers and the diploma holders in Agriculture and Animal Sciences. M.Sc. programme in Animal Products Technology was also started during the year.

Kerala Agricultural University

(a) B.V.Sc. programme of this university has been made as a five-year programme introducing internship for a period of six months.

(b) The University started new sections of Nematology, Food Science and Nutrition and Microbiology and
Virology under the existing Departments of Entomology, Agricultural Extension and Plant Pathology, respectively.

(c) The Horticulture students were assigned pot-culture, maintenance of perennial crops and also ‘Earn while you learn’ scheme as programmes of practical training.

(d) 36 teachers were deputed with full salary and allowances for higher education in different disciplines.

*Narendra Dev University of Agri. and Technology, Faizabad*

The foundation stone of the University was laid by Chief Minister of U.P. on 3rd November, 1978 at its new site at Kumarganj and it is expected that the infrastructure facilities will be developed by 1980. In the meantime the university started B.Sc. (Agri.) programme admitting 24 students at Masodhu.

*Udaipur University, Udaipur*

A five-year B.Sc. (Dairying), Dairy Technology programme was started. New departments in Limnology, Fisheries and Nematology have been started. This university offers training of middle level officers of DPAP of Rajasthan. The Home Science College undertook Extension programmes on indigenous supplementary food (Poshak) which was appreciated by the villagers since it helped to improve the nutritional status of the local children.

*Tamil Nadu Agricultural University*

(1) The following new programmes were started:

(a) M.E. (Agri.) in Soil and Water Conservation and Farm Power and Machinery.

(b) M.Sc. (Agri.) Microbiology and Agrostology.

(c) Ph.D. Environmental Biology, Seed Technology, Agricultural Extension, Poultry Science and Parasitology.

(2) Admission in Agriculture and Agricultural Engineering, programmes have been increased due to larger demand while the Veterinary admissions were cut down. 20 students were admitted to the new B.F.Sc. programme.

(3) Trimester system was introduced in the Vet. College for all programmes including M.V.Sc. and Ph.D.

(4) A UNESCO supported Post-graduate course on teaching field crop Agronomy was organised for which 14 students from 11 South-East countries participated.
VI. EXTENSION EDUCATION

Twenty-six operational research projects covering various aspects of agricultural technology, such as crop and livestock production, arid land development, management of problem soils, integrated pest control, water management, composite fish culture, etc. were in operation during the year under report. The highlights of a few operational research projects are given below:

Integrated Milk and Crop Production

The National Dairy Research Institute, Karnal, and a few other Institutes in the country established that the return from high yielding dairy cows and appropriate land utilisation through nutritious fodders was as high as that from crop farming with high-yielding grain and cash crop. To extend this concept and use the modern technology for milk production under rural conditions, the National Dairy Research Institute undertook the project under reference in three clusters of villages, each having 5-8 villages in the district of Karnal.

There was inter-institutional participation in the project. Indian Agricultural Research Institute, National Seeds Corporation and Haryana Agricultural University made seeds of high-yielding varieties of grains available for the project area. Similarly a Bank and an Insurance Company assisted the project by advancing loans to the farmers and providing insurance cover to high-yielding milk animals, respectively.

The Project has built-in orientation towards improving income and employment potential of the rural people, small and marginal farmers and the landless labourers. In addition, the cost and return analysis of the demonstrations conducted with cereal crops, such as paddy, wheat, maize were also maintained. The data of the demonstrations conducted on paddy (IR-8), maize (Ganga-5) and wheat (HD-1982) indicated that per rupee return was of the order of Rs. 3.11, 1.95 and 3.57, respectively. On an average, the rupee return per hectare of paddy and wheat in the demonstrations laid out in the operational area were Rs. 2265 and Rs. 2209, respectively. The economic analysis of fodder crops introduced in the villages showed that lucerne-hybrid napier netted...
highest income, i.e. Rs. 3,748 per hectare of all the fodders. This was followed by berseem and mustard with return of Rs. 3,746 per hectare.

The project covered a population of breedable cows and buffaloes numbering 2764 and 5316, respectively. Out of this 44 per cent of the buffaloes and 58 per cent of cows were owned by marginal and small farmers and landless households, respectively. Thus, while increasing the productivity of cows and buffaloes, emphasis under the project was to increase income of relatively poor households by undertaking special programmes for them. Together with production of cross-bred heifers on farmers' fields, through artificial insemination, over 100 cows were bought by farmers from National Dairy Research Institute and outside agencies. With the initiation of the project in the area, the milk production potential registered an increase of about 2.50 lakh liters per annum. The cross population in the area has registered an increase by 300 per cent.

One of the outstanding features of the project was the establishment of Dairy Units which focussed attention on employment potential of milk production enterprise either as a constituent of mixed farming systems or as an independent source of livelihood. It was demonstrated through these Units that a family can earn Rs. 700 per cow per year resulting in harnessing of idle and unemployed labour in a more productive manner. As a felt need arrangement, Cooperative Milk Marketing was organised in the operational area where collection of milk both in morning and evening from three villages was undertaken involving 90 milk producers. During the year 1976-77, these producers supplied about 890 quintals of milk and received Rs. 1,28,000 as return.

Easy credit was made available to the milk producers through State Bank of Patiala. In a short period of about one and half years, the Bank advanced nearly 5 lakhs of rupees for purchase of cross-bred cows, tractors, tubewells, equipment, etc.

Reclamation of Alkali Soils

According to the available figures the area under salt-affected soils in India is about 7 million hectares, out of which about 2.5 million hectares are alkali soils and lie in the areas of Indo-Gangetic alluvial plains of Uttar Pradesh, Haryana and Punjab. These soils either fail to grow any crop or produce extremely low yields and, therefore, lie uncultivated. However, the technology evolved by the Central Soil Salinity Research Institute, Karnal,
clearly indicated that such soils could be made reasonably productive. To test and demonstrate scientific technology of the Institute for reclamation of alkali soils in farmers’ fields, an Operational Research Project was initiated in the district of Karnal in 1975. The project covered an area of about 6000 hectares in three clusters of villages. During the year 1978, 144 demonstrations were conducted in the farmers’ fields where the essential technology of alkali reclamation was demonstrated. The technology essentially consists of package of practices including proper land levelling and bunding, treatment of soil with amendments, selections of suitable crop varieties, raising of rice as first crop in monsoon seasons, increased application of fertilizers including gypsum, growing of wheat/barley/berseem in rabi followed by dhaincha as green manure crop in summer, proper management and adoption of proper crop sequences. Average grain yields of rice and wheat in thirty-six such demonstrations during the year 1976-77 on farmers’ fields were of the order of fifty-one quintals and sixteen quintals per hectare respectively. During the 2nd year, no gypsum was added, and the average yields of paddy and wheat obtained were of the order of 64 q and 20 q per hectare respectively. This showed that both rice and wheat could be grown successfully on such soils after necessary management and reclamation practices were followed. In addition, horticulture and animal husbandry programmes were also taken up. Hundred ber plants and 5675 eucalyptus trees were planted in the operational area. Most of these trees will inculcate enthusiasm and interest in the farmers for promoting agrosilv system of farming adding to their agrarian economy. Programmes, such as introduction of gobar gas plants, poultry, dairy farming, improvement of cattle, help in the overall improvement in economic conditions of the farming families.

A similar project was initiated by the Punjab Agricultural University in the district of Kapurthala covering three units of villages each having 2-3 villages. Bench-mark survey conducted showed that the productivity of alkali soils in the operational area was very low, the average yield of paddy being 23.7 q/ha and that of wheat 11.7 q/ha. About 40 such demonstrations were conducted during the year 1977-78 on the farmers’ fields where the technology for reclamation of such soils was demonstrated. The average yields of paddy and wheat obtained in such demonstrations were 55 q/ha and 16.5 q/ha respectively thereby indicating that the productivity of such soils could be enhanced considerably provided the technology evolved by the Central Soil Salinity Research Institute, Karnal, could be suitably adopted.
Composite Fish Culture

An Operational Research Project on Composite Fish Culture was initiated at Krishinagar in the district of Nadia, West Bengal. Technique of breeding fish through injections of pituitary extract has now been suitably simplified and farmer and educated unemployed youth can take fingerling production in seasonal ponds so as to effectively improve the seed requirements of their own and neighbouring villages on mutually advantageous basis. Possibility of rearing fish fry and fingerling to increase production potential of large water bodies formed the major objectives of the project under reference. The project, however, provided training to the local fish farmers and uneducated unemployed youth in fish production. In addition, compatible combination of horticulture, agriculture and animal husbandry with composite fish culture was also brought within the field of this project.

During the years 1976-77 and 1977-78 about 75 demonstrations were arranged in small and large ponds owned by individual fish farmers to show various steps of the technology for increasing fish production. In each pond five species of fish, namely, rohu, catla, grass carp, common carp and silver carp were raised. Besides, six training programmes were also conducted involving over 100 trainees where various aspects of composite fish culture were taught.

As a result of this project, fish production in the demonstration ponds ranged from 2654 to 4298 kg/ha annually. This production obtained is nearly 8 times more than the average production of 462 kg/ha/year from the same ponds. The cost of fish production in such ponds ranged between Rs. 2.94 and 3.06 per kg. of fish.

As a result of this Project, the local uneducated unemployed youth of the area grouped themselves together to form three Co-operative societies for marketing the harvested fish from the Project area. They got some income by way of commission during the harvesting period. The West Bengal Government took up an extension of this project in a big way for propagating the composite fish culture in the State. Under this scheme, a total of 584 ponds were covered for fish production. The concept of integration of duckery, piggery and poultry with composite fish culture was being advocated in the operational area. The progress so far made was very encouraging and it was hoped
that the results would give a great boost to idea of rural development through integration of horticulture, and animal husbandry with fish culture.

**Integrated Control of Cotton Pests**

Considering the ill-effects of excessive use of pesticides and unilateral approach of chemical control in cotton pests, an Operational Research Project on Integrated Pest Control in Cotton was initiated by Punjab Agricultural University, in the district of Faridkot. Under this project, various effective pest control methods have been applied harmoniously. The sowing time, methods of cultural, mechanical and biological control were propagated in the pest control system. Chemical control was used only when necessary and where needed. Blanket treatment of the entire area with pesticides schedule was given up.

The project also provided training opportunities to farmers of the selected villages in the recognition of various pests and their control measures. The project initiated community action for undertaking control measures for collective action.

The Project was implemented in village Rahurian Wali near Muktasar in district Faridkot, which is the heart of American cotton growing tract of the State. The total operational area is 2410 acres. Following measures were introduced for minimising carry over of the cotton pests:

- **Destruction of plant types**: This was carried out by allowing grazing of cotton fields after the last picking during the month of January and February. The cattle, especially goat, picked up the unopened flowers from the standing plants which are responsible for maximising the carry over of the past.

- **Timely removal of cotton sticks**: All the fields under desi cotton were cleared off the cotton sticks during November to facilitate timely sowing of wheat and those under American variety were out by the end of March. This eliminated the chances of the plants serving as a food for the bollworms and other cotton pests.

- **Proper stacking of cotton sticks**: Moths coming out of the cotton sticks spread into the fields, start infesting the new plants. In order to reduce the incidence of pests, sticks are to be stacked within the village premises. Since the infestation of the pink bollworm is confined to within about 500 meters of the village,
very little attack of this pest was recorded in the fields if the cotton sticks are stacked in the village, instead of on field bunds.

Ploughing of old cotton fields: Ploughing helps in uprooting cotton stubbles which could provide food to the cotton pests.

Destruction of alternate plants: Four camps were organised during March—June for uprooting and destroying two weeds, namely, Pili Buti and Kanghi Buti growing along the roads and in water channels in the village.

Timely disposal of seed cotton: During the year 1976-77 the price of seed cotton was fairly high and most of the farmers sold their seed cotton before March.

Non-feeding of cotton seed to animals: Efforts were made to convince the farmers to give up feeding of cotton seed to their milch animals since there was no special advantage of its feeding over the seed cake. On the other hand, keeping all the seed in the village helps in spreading the pink boll-worms because one quintal of seed may contain as much as 6,000 pink boll-worm larvae.

Fumigation of seed: Seed for sowing of over 600 acres of cotton in Bikaneri Narma was procured for the operational area and supplied to the farmers after fumigation. This helped in eliminating the sowing seed as source of carryover out the pink boll-worm.

In addition, other measures, such as, sowing of resistant varieties, timely sowing of crop, judicious use of water, removal and destruction of plants were undertaken. They also helped in minimising the attack of the insect pests on the cotton crop. Weekly observations for monitoring the pest population were made at distances of 250 metres. Sprays against jassid were undertaken in the operational area which resulted in saving of about Rs. 65,000 to cotton growers.

Since the complete cotton farming system is covered under the project, other activities, such as, improvement in storage of food-grains, supply of improved bajra and wheat seed, were also undertaken.

As a result of integrated control measures described above, the number of spraying with pesticides for the control of insect pest in cotton was reduced to seven to ten as compared with fifteen to twenty that normally farmers follow.
Oilseed Crop Production

An Operation Research Project for Stepping up the Production of Oilseed Crops was implemented in district Chittorgarh (Rajasthan) by Udaipur University. Main emphasis under the Project was on the introduction of improved varieties of oilseed crops, such as groundnut, mustard, sunflower, etc. and the technology for their cultivation so that the production of these crops was enhanced. In addition, other crops such as cereals, fodders that are rotated along with oilseed crops were also covered in the Project. During the year under report, 10 demonstrations on groundnut with varieties TG-1, TG-3 and AK 12-24 were conducted. The average yields recorded of these varieties were of the order of 26.5, 22.6 and 14.5 quintals/ha respectively. Demonstrations on T-15 variety of mustard with 2-3 irrigations gave an average yield of 16 q/ha. While working out the net return obtained from the mustard crop it was revealed that it was not less profitable than the wheat crop grown under similar conditions. On the contrary there was considerable saving in terms of applications of fertilizer and irrigation. It was reported that the benefits accrued to the farmers in the operational area as a result of initiation of this project was worth Rs. 16.65 lakhs. In addition, 20 per cent employment opportunities were also created on the farmer's farms by the introduction of new agricultural technology under this project.

As regards the programme under animal husbandry, two more Artificial Insemination Centres were established during the period under report and about 145 cross-bred calves were born so far. Demonstrations on introduction of berseem as a fodder crop were laid out in the farmers' fields and the average green fodder obtained was 920 q/ha. Balanced feeding of milch cattle supplemented by the improved management practices seem to have resulted in an average increase in milk production in the operational area by 20%. Taking overall impact of the project in the operational area, it was estimated that the increase in the farm income was from 20 to 50% since the project was initiated. Nearly 2,000 farm families, particularly small and marginal farmers in the operational area, were benefited by various activities undertaken under the project.

Arid Land and Development

This project was implemented by the Central Arid Zone Research Institute in Jodhpur district in five selected villages, namely, Manaklaao, Dhaijar, Basani Launchea, Basani Karward and Palari Khichiyn. It was established by the Bench Mark.
Survey of the operational area that the productivity of major crop enterprisers was quite low and most of the agricultural and non-agricultural works were attended by the family members. Only 17.96% of the total household were engaged as agricultural labourers. The yield levels of most of the crops grown in the area, namely, bajra, guar, moong, moth in kharif and wheat, raya and potato in rabi were very low.

Under this project, special efforts were made to introduce new varieties of crops along with their management practices, sand dune stabilisation, introduction of fruit plants, water harvesting and its recycling for irrigation purposes, dryland farming, improvement of sheep, etc. Nearly 22000 seedling of Acacia tortilis (Israeli Babool), Prosopis juliflora (vilayai babool), Dichrostachya nutans, Colophosphormum mopane, etc were planted on sand dunes during the year and covered nearly 200 hectares of the area. Fruit trees, especially Gola and Seb varieties of Ber, were introduced on marginal and sub-marginal lands of the farmers. Short training programmes were organised for farmers in budding operations of the ber plants. Besides this pomegranate, lemon, papaya were also introduced.

Towards stabilising agricultural production from arid land, four demonstrations on the use of simple water harvesting techniques like contour bunding, terracing, ridging and furrowing along with suitable check dams and culverts were introduced in the area. Crop grown with such techniques on the farmers' fields revealed 10—20% increase. Impact of sprinkler and drip irrigation systems in saving water, increasing irrigation command, economising in water use and increasing yield were also demonstrated in cereals and vegetative crops. Studies conducted have indicated that the use of sprinkler irrigation system alone can help in 100 per cent saving of water and 25 per cent of additional harvest on unit area basis. As regards sheep husbandry, introduction of rams (Chokla, Ramouillet) in the sheep flocks with different sheep owners have improved the size and body weight, quality wool and also appearance of newly born lambs as compared to local breeds. The second expected generation of 1500 rams might create a thrill with the farmers. The case study conducted on utilisation of bio-gas plants has revealed that net income of Rs. 114/- per month in the form of bio-gas for cooking and light could be obtained from a single plant.

**Sheep and Wool Production**

The Operational Research Project on Sheep and Wool Production was implemented in District of Jaipur by the Central
Sheep and Wool Research Institute, Avikanagar. The main emphasis in the Project was on cross-breeding of the local sheep with the exotic rams, provision of health cover, development of feed and fodder crops and imparting training to the sheep owners in various aspects of sheep maintenance and breeding.

It was reported that the wool production in cross-bred ewes and lambs produced in the project area with the launching of the cross-breeding programme through artificial insemination was found to be 1429 grams in cross-breds as compared to 476 grams in local sheep, respectively. The improvement in wool production, live weight gains and survivability might be attributed to the comprehensive programme of health coverage and the training imparted to the sheep owners on feeding and maintenance of sheep. During the year 1978, over 300 Artificial Inseminations with semen of exotic rams were carried out and a total of 107 cross-bred lambs were born during the year. Quite a large number of cross-bred lambs are expected during December, 1978. In addition 6490 vaccinations against Enterotoxaemia and sheep pox, 10190 drenchings against gastro-intestinal parasites, 6731 dippings against ectoparasites and 2486 treatments of various ailments were provided in the project area. The overall mortality in sheep which was recorded up to 18.78 per cent in 1975 has gone down to 11.46 per cent in 1978. The high mortality was recorded due to gastro intestinal disorder in adults and pneumonia in lambs.

To provide technical know-how in feeds and fodders for sheep four sylvi-pastoral demonstrations were laid out in 1975-76 which were continued even during the year under report. Crops like bajra and cowpea were also demonstrated for their use as fodder for raising sheep. The seeds of pasture grasses and cultivated fodders like berseem, luncern oats, etc. were made available to the sheep breeders in fodder development programme. Several exhibitions, film shows and field days were organised to educate the sheep owners covered under the Project where they were appraised of various aspects of cross-breeding, improved feeds and fodders and the necessity of providing health cover for better return from sheep. Efforts were also made to establish a Sheep Breeders' Cooperative Society in collaboration with the Rajasthan Wool Board. One such society is already functioning in Chhota Lamba and Dani village of the Project.

Projects Supported by Foreign Agencies

Indo-UK Dry Farming Project (Black Soil, Indore)

The Project is in operation at Indore, since December 1973. The Project covers an area of 2,000 hectares comprising 3
villages namely, Nainod, Ringlai and Samburali Hapsi. This pilot operational project seeks to increase the land productivity by adoption of advanced technologies in land improvement, soil and water conservation, crop husbandry, animal husbandry and exploitation of underground water resources etc. Main achievements are as under:

(i) *Replacement of fallow by kharif crops*

Out of the 1800 hectares of cultivated area of the project, during the kharif season, it was being left fallow due to poor textural conditions of the soil. However, with the known technology, the fallow area has been decreased and the sown area under crops during the kharif season has increased from 32 per cent (73-74) to 64 per cent (77-78). The increase in area of some important crops is as follows:

<table>
<thead>
<tr>
<th>Crops</th>
<th>Area cropped (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1973-74</td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td></td>
</tr>
<tr>
<td>Urid</td>
<td></td>
</tr>
<tr>
<td>Fodder crops</td>
<td></td>
</tr>
<tr>
<td>Others (Moong, flowers &amp; Veg.)</td>
<td>29</td>
</tr>
</tbody>
</table>

(ii) *Double cropping*

Farmers practised double cropping on 190 ha. in rabi 1975, on 850 ha. in 1976-77, on 1100 ha. in 1977-78 by growing gram after kharif crops.

(iii) *Increase in use of fertilizers:*

The use of N. P. K. nutrients viz. urea, superphosphate, DAP (18:46), gromer (28:28) and Iffco (12:32:16) has increased after 1974-76 as shown below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Nutrients used (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>1974-75</td>
<td>4260</td>
</tr>
<tr>
<td>1975-76</td>
<td>15931</td>
</tr>
<tr>
<td>1976-77</td>
<td>14714</td>
</tr>
<tr>
<td>1977-78</td>
<td>16630</td>
</tr>
</tbody>
</table>

16 A & I/78—15
(iv) **Introduction of High Yielding Varieties of crops**

In rabi, area under improved and high yielding varieties of wheat and gram increased to 625 ha. in 1976-77 and 755 ha. in 1977-78. In kharif, the area under high yielding varieties of sorghum (CHS-5), maize (Chandan 3) and soybean (T-49 and JS-2) increased to 270 ha. in 1976-77 and to 350 ha. in 1977-78. The yield data as compared to those obtained before project started are as follows:—

<table>
<thead>
<tr>
<th>Crops</th>
<th>Before project Variety</th>
<th>(1973-74) Yield/q/ha</th>
<th>1977-78 Project Variety</th>
<th>After project Range (q/ha)</th>
<th>Av.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>Desi</td>
<td>4.3</td>
<td>CSH-5</td>
<td>12.0-43.0</td>
<td>20.2</td>
</tr>
<tr>
<td>Maize</td>
<td>Satna</td>
<td>5.5</td>
<td>Chandan-3</td>
<td>10.0-24.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Soybean</td>
<td>Kalitur</td>
<td>5.5</td>
<td>T-49</td>
<td>6.5-11.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Wheat</td>
<td>Local &amp; Mexican</td>
<td>5.0</td>
<td>Narma-da-4</td>
<td>8.9-13.5</td>
<td>8.2</td>
</tr>
<tr>
<td>(Irrigated)</td>
<td></td>
<td></td>
<td>JS-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram</td>
<td>Local</td>
<td>4.5</td>
<td>Ujjain-24</td>
<td></td>
<td>8.3</td>
</tr>
</tbody>
</table>

**Livestock Management**

(i) **Forage Crop Demonstrations**

About 100 demonstrations were conducted in each season, on sorghum (Vidhisha 60-1 and J-69) and teosinte with and without cowpea in kharif, and on berseem, lucerne with and without oat, napier grass and barley in rabi. During 1977-78, 107 demonstrations covering area of 20 ha. were laid out on kharif and forage crops.

(ii) **Increase in milk yields due to feeding greens**

Based on observation on 27 cows and 56 buffaloes an increase of 400 ml. in daily milk yield of cow (ranging from 1.3 to 1.5 litres) and of 650 ml. in that of buffaloe (ranging from 3.2 to 3.6 litres) has been observed as a result of feeding greens.

**Rural Aquaculture Project**

The IDRC assisted project on Rural Aquaculture continued to maintain satisfactory progress. With the completion of specified period of experiments and demonstrations in some of the
centres, the activities were shifted to other places in the same States, for example, in West Bengal the Hanspukur Centre was shifted to Sanko-Nabastha in the Burdwan District and the Centre at Malda to Jalpaiguri. Similarly, in Orissa the Puri Centre was shifted to Cuttack. At all these new centres the ponds were selected and prepared for culture experiments.

Production of fish in all the experimental Centres was highly encouraging, ranging from 4038 to 7550 kg/ha in 10 months in different centres located in West Bengal, whereas in Orissa the production average 3046 kg/ha/yr. At most of the centres large quantities of carp spawn were also produced besides table size fish. In the experiments carried out in the Burdwan District the introduction of Magur (*Clarias batrachus*) and Singhi (*Heteropneustes fossilis*) along with carps proved a great success.

Short-term training programmes in scientific fish farming, fish breeding and rearing were arranged at the various centres in which pond owners, fish farmers, school teachers and educated unemployed youth actively participated. Certain centres organized Farmers’ Day in each village. A Cooperative Society “Unemployed Young Men Pisciculture Cooperative Society Ltd.” was established and registered at Jalpaiguri. Similar Cooperative Societies are being organised at some of the other centres.

**National Demonstrations**

The National Demonstrations Project on Major Food Crops continued in 50 districts of the country with the objective of demonstrating the potentials of the new agricultural technology on farmers’ fields.

Twenty-four demonstrations of suitable cropping in each selected districts with two or three crops were conducted. In addition to the demonstrations under assured irrigation, some demonstrations were also conducted in moisture deficit areas. A few special demonstrations on problem soils (alkaline) were also laid out.

The minimum yield targets for two or three foodgrain crops in the multiple cropping sequences adopted in national demonstrations continued to be 9 and 11 tonnes/ha respectively. Over 2,000 Farmers’ Days were organised at the demonstration sites during the period under report.
The number of demonstrations conducted during the last few years along with percentage cases exceeding targeted yield are as under:

<table>
<thead>
<tr>
<th>Year</th>
<th>Multiple crop Demonstrations</th>
<th>Single crop Demonstrations</th>
<th>Total cases exceeding target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965-66</td>
<td>920</td>
<td>416</td>
<td>416</td>
</tr>
<tr>
<td>1966-67</td>
<td>920</td>
<td>920</td>
<td>999</td>
</tr>
</tbody>
</table>
| 1967-68   | 929                          | 547                        | 1457                        | 55%
| 1968-69   | 1256                         | 457                        | 1713                        | 58%
| 1969-70   | 1671                         | 342                        | 1783                        | 57%
| 1970-71   | 2310                         | 230                        | 1901                        | 58%
| 1971-72   | 2235                         | 281                        | 2591                        | 60%
| 1972-73   | 1065                         | 303                        | 1368                        | 51%
| 1973-74   | 1043                         | 321                        | 1364                        | 55%
| 1974-75   | 1065                         | 321                        | 1364                        | 55%
| 1975-76   | 857                          | 127                        | 984                         | 57%
| 1976-77   |                              |                            | 1250*                       |

* Number of demonstrations allotted.

On the basis of the results obtained and experience gained therein, some of the rotations found more promising in various districts of the country are given below:

**Paddy-paddy**: This rotation could be successfully followed in the states of Andhra Pradesh (Chittoor, Guntur, Hyderabad), Goa, Pondicherry, Assam, Kerala, Tamil Nadu, Maharashtra, Bihar. The mean yield obtained in these states ranged from 68.43 q/ha. to 130.00 q/ha. In 77 per cent of these demonstrations, the yield exceeded the targeted yield of 90.00 q/ha. (Fig. 10)

**Paddy-wheat rotation**: The Paddy-wheat rotation was followed more successfully in the state of Bihar, Gujarat, Haryana, Punjab, Rajasthan and Uttar Pradesh. The average yield was 84.73 q/ha. The targeted yield was exceeded in 53 per cent cases. (Fig. 11)
Fig. 10. National Demonstrations 1976-77 Yield in Paddy-Paddy rotation.
Fig. 11. National Demonstrations 1976-77. Yield in Paddy-Wheat rotation.
Maize-wheat rotation: In all 93 demonstrations were conducted with Maize-wheat rotation in 8 states. The all India mean yield was 71.76 q/ha. It was observed that this rotation was found popular in the districts of Santhal Parganas, Giridih (Bihar), Solan (Himachal Pradesh) and Bullandshehar (Uttar Pradesh). (Fig. 12)

![Bar Chart](image)

Fig. 12. National Demonstrations 1976-77. Yield in Maize-Wheat rotation.

Jowar-wheat rotation: The all India mean yield from 51 demonstrations conducted with Jowar-wheat rotation was 62.36 q/ha. The demonstrations were mainly conducted in the states of Andhra Pradesh, Karnataka, Maharashtra and Madhya Pradesh, one demonstration each in Akola and Yeotmal and two demonstrations in Parbhani of Maharashtra State. This gave yield above 90 quintals per hectare. In all other districts the performance was very poor. (Fig. 13)

Bajra-wheat rotation: Sixty eight demonstrations were conducted in Gujarat, Haryana, Rajasthan and U. P. with this rotation. The mean yield ranged from 46.44 q/ha to 77.90 q/ha. Two and three demonstrations in the districts of Bharatpur and Jaipur respectively of Rajasthan State gave yield above 90 quintals per hectare. In all other States the performance was very poor. (Fig. 14)
**Paddy-ragi rotation**: This rotation was followed in Andhra Pradesh, Karnataka and Orissa. The average yield was 78.88 q/ha. The poor performance of the demonstrations conducted in Orissa has resulted in low average yield.

![Graph](image)

**Fig. 13.** National Demonstrations 1976-77. Yield in Jowar-Wheat rotation.

**Paddy-paddy-paddy rotation**: Three crops of paddy could be successfully grown in the districts of Trichur (Kerala) and Pondicherry. The mean yield ranged from 147.60 q/ha to 161.21 q/ha. In all the demonstrations the targeted yield of 110 q/ha was exceeded. (Fig. 15)
Paddy-wheat-paddy rotation: Two crops of paddy with wheat crop could be grown in Assam, Bihar and Punjab States. The mean yield ranged from 104.35 q/ha. to 149.12 q/ha. The targetted yield of 110 q/ha. could be attained in 93 per cent of the demonstrations under this rotation.

Paddy-wheat-moong rotation: This rotation was widely accepted in Bihar, Jammu and Kashmir and Uttar Pradesh. In all 52 demonstrations were conducted with Paddy-wheat-moong rotation in seven states. On an average 89.40 quintals of grain and 6.41 quintals of pulses could be produced in a hectare by following this rotation.
Fig. 15. National Demonstrations 1976-77. Yield in Paddy-Paddy rotation.
**Paddy-wheat-fodder rotation**: This rotation was popular in Punjab, particularly in the district of Amritsar and Patiala. The grain yield from this rotation was 104 quintals per hectare and the fodder yield was 283 quintals per hectare.

**Varietal Performance**

Paddy: The popular varieties of paddy included in the demonstrations were—IR-8, IR-20, IR-24, Jaya, Ratna, T. Hansa, Jagannath and Pusa 2-21.

IR-8 was included in 67 demonstrations in eight states. The mean yield was in the range of 30.00 q/ha. (Kerala) to 80.00 q/ha. (Andhra Pradesh). With 'Jaya' variety demonstrations (148) were conducted in Andhra Pradesh, Bihar, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Uttar Pradesh, Goa, Pondicherry. The mean yield ranged from 41.85 q/ha. (Goa) to 85.50 q/ha. (Andhra Pradesh).

'IR-20' was included in three States. The highest average yield was in Andhra Pradesh i.e. 70.70 q/ha. 'Ratna' was included in demonstrations (35) conducted in Bihar, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Uttar Pradesh and Pondicherry. The mean yield was 45.00 q/ha.

'T. Hansa' in Andhra Pradesh gave mean yield of 63.78 q/ha. in 26 demonstrations.

'Jagannath' in Orissa gave average yield of 46.40 q/ha. in eight demonstrations.

'IR-24' was included in eighteen demonstrations conducted in Uttar Pradesh. The mean yield obtained was 47.42 q/ha.

'Pusa 2-21' was included in the demonstrations (29) conducted in Assam, Bihar, Orissa. The mean yield ranged from 40.30 q/ha. (Orissa) to 46.80 q/ha. (Bihar).

**Wheat**: The wheat varieties, namely 'Kalyan Sona', Sonalika', 'WG-357', 'HD 2009', 'HD 1553', 'HD 1982' (were used in National Demonstrations.

'Sonalika' was included in the demonstrations conducted at Assam, Gujarat, Maharashtra, Orissa, Haryana and Punjab. The mean yield ranged from 13.87 q/ha. (Assam) to 43.57 (Haryana). 'Kalyan Sona' gave highest mean yield of 47.05-
q/ha. in Haryana and the lowest in Orissa 30.25 q/ha. Twenty
two demonstrations were conducted with 'WG 357'. This was
mainly used in Punjab and the average yield was 33.88 q/ha.
'HD 2009' gave mean yield ranging from 22.19 q/ha. (Jammu
& Kashmir) to 49.34 q/ha. (Uttar Pradesh). The overall
average yield from seventy demonstrations was 34.20 q/ha. 'HD
1982' in Uttar Pradesh gave mean yield of 49.72 q/ha. in twenty-
two demonstrations.

Maize: The popular varieties of maize were 'Ganga-2',
Ganga-5' and 'Deccan' 'T-41' and 'Vijay'. The performance of
'Ganga-2' was good in Bihar and Uttar Pradesh. The mean
yield was 33.61 q/ha. 'Ganga-5', gave the highest mean
yield of 42.37 q/ha. in Uttar Pradesh. 'Deccan' gave the yield
of 39.05 q/ha. 'Vijay' was included in 24 demonstrations in
Bihar, Himachal Pradesh and Punjab. The average yield was
31.01 q/ha.

Bajra: In seven states various high yielding varieties of
Bajra namely 'PHB-14', 'BJ 104', 'HB-3', 'HB-5', were grown
in National Demonstrations. The variety 'BJ 104' were grown in
Rajasthan and mean yield from 22 demonstrations was 30.20
q/ha. 'PHB-14' was included at 27 places in the states of Har-
vana and Uttar Pradesh. The mean yield was 24.32 q/ha.

Jowar: In the three States high yielding varieties of Jowar
namely 'CSH-1', 'CHS-4', and 'CSH-5', were used. The highest
number of demonstrations were conducted with varieties 'CSH-1'.
The mean yield ranged from 28.82 q/ha (Andhra Pradesh) to
40.49 q/ha. (Maharashtra).

Once again the relationship between the size of land holding
and the agricultural technology based on yield target was worked
out. The data were compiled primarily for cereal crops incul-
ded in the multiple crop demonstrations. Statistical analysis
revealed that there was no relationship between the size of holding
and agricultural technology introduced in the National Demon-
strations. Hence the technology introduced in these demonstrations
proved equally good in terms of production both for small and
big farmers.
VII. RESEARCH FOR TRIBAL, BACKWARD AND NEGLECTED AREAS

In pursuance of the policy of the Government of India to attain the balanced growth of socio-economic conditions in all parts of the country, additional efforts were made by the ICAR to strengthen research and training facilities in the tribal, backward and neglected areas. Thus a Central Agricultural Research Institute for Andamans and Nicobar Islands was established during 1978 at Port-Blair. The regional centres of Indian Veterinary Research Institute, Central Marine Fisheries Research Institute and Indian Agricultural Research Institute which were functioning in these islands earlier were amalgamated with the new Institute. The objective of this Institute is to generate technology suitable for the proper development of agri-horticultural, animal and fisheries enterprises for which the islands are richly endowed with natural resources. Ever since it was started, the institute besides taking up field trials on varieties of agri-horticultural crops, has been successful in advocating some practical measures to control the giant African snail. Application of 5 per cent metaldehyde was found to control the snails. Studies are also being intensified to explore the possibility of biological control of these snails, which cause a lot of damage.

Filarial dermatitis is a serious disease in the islands causing considerable loss in cattle and buffaloes. Some control measures were found with the application of indigenously available organophosphorus filaricides like Nuron, Dimerren, Marvex-Super, Paramar M-S'o, Hekneima, etc.

For the improvement of horticulture in tribal areas, two research stations are being established in Godhra (Gujarat) and Ranchi (Bihar). A rice and Cassava research centre was established in Koraput (Orissa). A research centre was sanctioned for the improvement of niger (an oilseed crop of tribal areas) in the tribal areas of Srikakulam in Andhra Pradesh. An operational research project for the improvement of socio-economic conditions of tribals in Mehghat area of Amravathi District in Maharashtra was sanctioned. Two schemes: (1) Studies of natural and physical resources, socio economic constraints and
farm and forest practices of three tribal Districts of Madhya Pradesh and (2) Operational Research project for the development of tribal area in Mandla District of Madhya Pradesh were also sanctioned. A national research centre for the improvement of pigs in Nagaland and a National Research Centre for the improvement of Mithun and Yak with two major centres, one in Arunachal Pradesh and the other in Nagaland are being sanctioned.

Plans are being finalised for the intensification of research in Ladakh, Sundarbans and Bundelkhand region. Plans are also being finalised for the establishment of Soil Conservation Research and Training Centre in Koraput region of Orissa. The ICAR Research Complex in North Eastern Region comprising the States of Meghalaya, Nagaland, Manipur, Tripura, Mizoram, Arunachal Pradesh and Sikkim is being adequately strengthened during the current five year plan. A number of tribal area research projects which have been received from various Agricultural Universities and other Research Institutes are being processed.

A “Fakhruddin Ali Ahmed Award” for the tribal area research for the biennium 1976-77 was awarded to Dr. Bhag Singh of the National Bureau of Plant Genetic Resources, New Delhi for his excellent work on races of maize in India collected from North-East Himalayan Region.
VIII. RECOMMENDATIONS OF THE REGIONAL COMMITTEES

There has been a growing feeling in the country that there is no balanced growth of research and training facilities in all the regions in the field of agriculture, animal husbandry and fisheries which has led to imbalanced growth in agricultural economy. To identify the gaps and to recommend measures that would lead to narrowing down these gaps, the Indian Council of Agricultural Research has constituted 8 Regional Committees, the regions being defined on the basis of the agro-ecological considerations. The Regions so identified are:—

1. Humid Western Himalayan Region
2. Humid Bengal—Assam Basin
3. Humid Eastern Himalayan Region and Bay Islands
4. Sub-Humid Sutlej-Ganga Alluvial Plains
5. Sub-Humid to Humid Eastern and South-Eastern Uplands
6. Arid Western Plains
7. Semi-arid Lava Plateaus and Central Highlands
8. Humid to Semi-arid Western Ghats and Karnataka Plateaus.

The Director General of ICAR is the Chairman of these Regional Committees and the membership is as follows:

(i) The members of the Indian Council of Agricultural Research (Society) residing in that region.

(ii) Chairman of the Development Councils constituted by the Department of Agriculture, Government of India, located in the region.

(iii) Directors of the Institutes of the Council in the region.
(iv) Scientific/technical representatives of Agricultural Universities, State Departments, Central Institutes and Department of Agriculture of the Union Ministry of Agriculture and Irrigation and

(v) Farmers nominated by the President.

During the year 1978-79, seven out of eight Committees met and after careful and detailed study of the present research and educational status in each of the regions made several recommendations laying emphasis on location specific problems. The following are some of the more important recommendations:

Region No. 1 Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh Hills.

Establishment of an Agricultural University in Jammu and Kashmir State

The Jammu and Kashmir State needs urgently a strong research and training set-up for dealing with problems in horticulture, animal husbandry, soil and water conservation, pasture and range management, post-harvest technology including marketing and agro-forestry. The Agricultural University of Jammu and Kashmir should be developed along problem-solving rather than discipline-centred lines. Inter-disciplinary research teams should be formed to find solutions to the serious problems such as the Apple-scab disease and disease of sheep and cattle. An outstanding Centre of research and training in temperate horticulture should be set up. Processing, packaging and marketing research should receive high priority.

Fighting the menace of Apple scab

The Committee complimented the Jammu and Kashmir Government for the outstanding work done in the control of Apple scab during 1978 through subsidised chemical sprays. It recommended that the Government of India should continue the subsidy during 1979 also. In addition, two major Research and Development Teams should be organised both in Jammu and Kashmir and Himachal Pradesh. One of the Teams will work intensively on Epidemiology and Disease Forecasting. The other group will work on Fungicidal and cultural control. For co-ordinating the work of the two Teams, ICAR should constitute a Standing Technical Advisory Committee headed by Dr. Pushkar
Nath. Before the next spring, spore traps and other devices should be established along with agro-meteorological equipment to monitor and forecast the epidemic.

Pilot Projects based on a Minimum Yield Guarantee in Rice

The area under rice in Jammu and Kashmir State is about 2.5 lakh hectares. The average yield per hectare is 20 quintals of rice. The Committee felt that the average yield can be increased by about 50 per cent even with the currently available technology. In order to demonstrate to farmers in a convincing manner the methods of deriving benefit from this untapped production reservoir, the Committee recommended the organisation of pilot projects covering about 10,000 hectares during 1979 based on a minimum yield guarantee of about 4 tonnes per hectare.

Ecological Security

All the States represented in the Regional Committee should give the highest priority to strengthening ecological security of this region by preventing deforestation and by ensuring community participation in the drive for promoting ecological security. Suitable arrangements should be made in each village for supplying the energy needed for cooking and other domestic purposes.

Promoting Agriculture and Animal Husbandry in Ladakh

The Committee recommended the setting up of a Technical Advisory Committee to ensure the effective implementation of research and development projects in Ladakh. The Committee will also promote training programmes in sheep husbandry, apricot cultivation, fodder production and other areas relevant to the one lakh inhabitants of Ladakh. Mobile training teams should also be organised.

Home Mushroom Gardening

A programme for home mushroom gardening will be initiated as a part of the drive for finding agricultural remedies to nutritional maladies. Spawn and Compost Banks for supplying spawn and compost to low-income groups will have to be established. Biology Departments of Colleges can be involved in this work.

Region No. 2.—West Bengal and Assam.

Assam today imports a wide variety of agricultural commodities. It has to cope with recurrent floods in some areas, drought 16A&I/78—16
in others and soil erosion practically everywhere. Marketing is poorly organised resulting in producers not deriving full benefit from their efforts in production. Animal Husbandry is important to the economy of the State and there are wide variety of problems in animal health care and nutrition which require urgent attention. Also, in spite of the importance of buffalo as a dairy and work animal, practically no research has been done on buffalo disease and breeding.

There is a need for paying particular attention to irrigation and water management in addition to identifying crops and crop varieties which can give maximum yield and income during the flood free season from October to May. More work is needed on deep water rice, particularly on methods of applying fertiliser to such rice.

*Pilot projects for demonstrating alternative crop planning strategies for chronically flood prone areas*

The I.C.A.R. had set up a team headed by Dr. D. N. Borthakur to develop an operational research programme for the riverine lands and the adjoining areas which are chronically prone to flood damage. This project should be initiated without further delay by the Assam Agricultural University. Additional pilot projects based on ground water survey, lift irrigation techniques and the introduction of suitable farming systems may also be developed and initiated particularly in blocks covered under the Integrated Rural Development Programme.

In order to demonstrate the possibility of deriving benefit from the vast untapped production reservoir existing even at current levels of technology, it was decided to initiate a few pilot projects in the I.R.D. blocks based on the Minimum Yield Guarantee Scheme introduced in Maharashtra. The choice of the I.R.D. blocks would facilitate the integration of inputs which will be available under the I.R.D. programme with technical know-how. The aim of these projects should be to improve the entire farming system encompassing both production and post-harvest technologies.

*Marketing Research and Training—Improved processing and marketing techniques would hold the key to improved income for growers. The Assam Agricultural University should hence set up a suitable unit for undertaking relevant marketing research and training programme.*
Soil and Water Conservation & Management.—There is need for a strong centre for research and training in soil conservation as well as water technology. A Department of Water Technology should be set up in the Assam Agricultural University which will go into all problems relating to the effective on-farm management of water.

Seed production.—The seed production programme in the State requires considerable improvement. Jute seeds are not easily available. Wheat seeds have to be purchased from outside the State since the germination capacity gets reduced due to high moisture content. The Assam Agricultural University should establish a Seed Technology Department and link it up with the State seed production agency.

Post-harvest Technology.—There is considerable scope for research and development in post-harvest technology such as drying of paddy, milling of rice, pulses and other crops, and extraction of fibre from pineapple and kenaf using the same machinery which is available for jute fibre extraction.

Animal Husbandry Research.—The on-going programmes of research on cattle, buffalo, poultry and duck are inadequate. There is need for strengthening research on these animals. Dr. M. R. Dhanda, Member, Governing Body of the ICAR, was requested to help the Assam Agricultural University in preparing suitable projects.

Utilisation of Water Hyacinth.—There is enough knowledge now on the utilisation of water hyacinth as animal feed and a source of fertiliser. Gauhati University has demonstrated its use in paper making. Therefore, programmes for the effective utilisation of water hyacinth should be initiated. The A.A.U. could conduct mobile training programmes for this purpose with the help of the Gauhati University.

Human Resource Development and Utilisation.—The Assam Agricultural University has now a large number of scientists who have been trained both within the country and outside. The highest priority, therefore, should be given by the State Government and the Assam Agricultural University for deriving maximum benefit from this important resource, viz., competent scientific manpower.

In addition to the effective utilisation of the trained staff members, the problem of the effective utilisation of the Home Science graduates produced by the University is now facing the
State. Apparently several of them are without jobs. An approach being considered by the State Government is the introduction of Home Science in the curriculum of schools so that Home Science graduates can get employment as school teachers. While this idea should be pursued, it is also essential that much wider benefit is derived from Home Science graduates in imparting relevant skills to rural women.

Knowledge Transfer System.—The training and visit method of intensive extension has been introduced by the Assam Government. It was, however, reported that in this system, input supply and knowledge transfer are not synchronised in time. The effectiveness of the programme may hence be less than what is anticipated. It was, therefore, decided to set up a Task Force to go into the linkage between knowledge transfer and input supply systems in the blocks covered by the intensive extension programme.

Fodder and Feed Production.—There is a great shortage of fodder and feed for farm animals. This aspect, therefore, requires consideration, particularly in milk shed areas which are likely to be covered under Operation Flood Phase II. Dr. B. D. Patil, Director I.G.F.R.I. may be deputed by ICAR to visit Assam to examine the question and prepare a blue print for further research and development.

Region No. 3.—North-Eastern Himalayan States including Sikkim and Andaman and Nicobar Islands

Achieving food self-sufficiency

The Chief Minister of Arunachal Pradesh announced the desire of the State Government to achieve self-sufficiency in food within the next two years. This will imply the production of about 20,000 tonnes of additional grain per year. It was felt that this is a realisable target provided a concerted attempt is made to identify and remove the constraints responsible for the gap between potential and actual farm yields in rice, ragi and other crops. There is also potential for double and multiple cropping in single crop lands. The State Government has already prepared a proposal for increasing production. Pilot projects could be developed during 1979 in a few thousand hectares for increasing the yield of rice; these projects could be on the lines of the Minimum Yield Guarantee Scheme adopted in Maharashtra.
Diversification of cropping patterns and scientific land and water use planning

It was felt that there is great scope in this region for growing high value crops like coffee, cocoa, cardamom, pepper and fruit trees. The Committee felt that the Government of India should develop a National Food Budget which will ensure the supply of the needed quantities of staples to deficit States so that land use planning could be done more on considerations of ecology-comm-economics than on the home needs of the farmers for staple grains like rice and wheat. This will help to increase the income and employment potential of rural people in medium and high elevation areas in the North Eastern Himalayan region through popularisation of horticulture and animal husbandry.

Intensive Rural Development

The ICAR could help in developing a detailed programme for intensive rural development in one of the blocks selected in each of the States in this region. Such a programme should help to maximise the benefits from the ecological endowments of the block and minimise risks and uncertainties. The aim should be the conversion of the blocks into agro-industrial complexes involving integration of production with processing and marketing. Blocks with horticultural potential will particularly be suitable for this purpose.

Horticultural Research

Horticultural research should receive the highest priority. The fruit trees chosen for extensive propagation should be such that can perform best under the given environment. For example, Arunachal Pradesh could specialise in producing high quality apples, while Meghalaya and Sikkim have enormous scope for producing excellent Citrus fruits. The scope for establishing "Horticultural Garden Colonies" could be examined in different States.

Manpower Development.—Each State will prepare a Manpower Development Profile for the next 4 years. This Profile will indicate the number and kinds of training opportunities desired for eligible candidates. The training could be either of short duration or for degree and post-graduate degree programme. Where necessary, arrangements for training abroad in suitable institutions can also be made under different international and bilateral programme.
Research on medicinal and essential oil bearing plants

Research on medicinal and essential oil plants may be stepped up since there is great scope for their development in this region.

Research on Mithun and Yak

The Committee welcomed the decision of the Governing Body of the ICAR to establish research centres for the domestication and improvement of Mithun in Arunachal Pradesh and Nagaland. It also recommended that a suitable research centre for the improvement of yak may be set up in Arunachal Pradesh at an appropriate location. The State Government offered the necessary land and other facilities for establishing a Yak Research Centre near Tawang.

Control of animal diseases

The animal wealth in the north-eastern region is being threatened by various diseases like swine fever, tuberculosis, foot and mouth etc. There is hence need for establishing 'Disease, Diagnosis, Investigation and Control Laboratories' in the different States. Also, mobile disease investigation and control vans should be designed and provided to each of the ICAR centre so that timely help can be rendered at the time of disease outbreaks.

Research Centre for Pigs in Nagaland

Pigs constitute the most important source of meat in Nagaland. The pig population is suffering from different diseases and also nutrition problems. There is hence urgent need for a Pig Research Centre in Nagaland. The State Government offered the necessary facilities for establishing such a Centre.

Fodder and Feed Production

Inadequate nutrition is a major cause of poor animal productivity in the North East region. The intensification of research on fodder, feed and forage crops is hence essential. There is also need for taking up pilot studies on the detoxification of the Eupatorium Weed.

Research on Inland Fisheries

Fisheries research needs to be intensified in this region. The components of the composite fish culture system need to be standardised for cold water conditions. There is also need for fish seed banks and for taking up induced breeding in fishes.
Establishment of Nutrition Gardens

Detailed blueprints have been prepared for establishing Nutrition Gardens in different States of this region. These gardens are designed to provide specific agricultural remedies for the nutritional maladies prevailing in the different parts of this region. These Gardens may also be established in Schools and Colleges.

Agricultural Engineering and Water Management Research

There is need for more extensive testing of improved implements and processing equipment. Appropriate water management devices have also to be introduced.

Sheep Husbandry

There is excellent scope for improving sheep production. Arunachal Pradesh is likely to develop an 'Arunachal Marino' breed of sheep soon. Attention should be paid to the improved management and nutrition of the sheep population.

Special needs of Mizoram

Mizoram has remained even more neglected in different aspects of agricultural improvement. Mizoram has also less than 1 per cent of the total cultivated area under valley agriculture. Therefore, land use planning for the hills and steep slopes is necessary.

Agro-Meteorological Research

There is considerable variability in the hills in climatic conditions related to agriculture. There is hence need for establishing a suitable number of agri-meteorological research stations in all the States of the region so that proper and timely advice can be given to farmers on weather conditions relating to crop production. ICAR and the India Meteorological Department should work out a suitable plan for establishing such a network of centres.

SIKKIM

1. Germplasm Collection

There is a rich variety of rice, maize, ragi, buckwheat, mandarin orange, orchids and other material in Sikkim. These need to be systematically collected, catalogued and utilised.

Maize

There is need for an early maize composite.
Rice

Short-duration and high-yielding varieties as well as cold tolerant varieties ready for harvest by the middle of March are necessary since, otherwise, they will be damaged by rain.

Mustard

There is need for varieties with good yield potential.

Peas

Resistance to powdery mildew should be developed.

Potato

Home quarantine measures should be taken to keep out the possibility of introducing wart disease. There is also need for seed production of varieties like Kufri Jyoti, Kufri Muthu, etc. and for this purpose, breeders' seed farm should be established at Helay and Lachung.

Large cardamom

There is a great scope for improving the yield and production of large cardamoms. For this purpose, disease control is exceedingly important. It would be appropriate if the Virus Research Centre of IARI at Kalimpong is linked with the Sikkim Centre of the North-Eastern Research Complex.

Mandarin oranges

The dieback problem needs critical study. Rootstock trials should be initiated.

Apple

There is need for testing more apple varieties and rootstocks. The appearance of the apple should be attractive so that there is good market.

Vegetable crops

There is a considerable scope for growing vegetables in Sikkim for being sent to the plains of India during the off-season. For this purpose, a good vegetable testing and breeding programme should be developed.

Tapioca and sweet potato

There is need for more trials with high-yielding varieties. This should be organised with the help of the Central Tuber Crops Research Institute, Trivandrum.
**Soil health care**

There is urgent need for protecting the soil of Sikkim from further erosion and degradation. For this purpose, training in soil conservation should be imparted to suitable Sikkimese personnel. Also, more research is needed for developing techniques for correcting soil acidity through the application of locally available material, such as lime stone and Dolomite.

**Water technology**

The entire area of water technology, with particular reference to the hill regions, needs attention. The Water Technology Centre of IARI may be requested to develop suitable proposals.

**Agricultural engineering**

Prototypes of suitable implements should be made for testing and demonstration.

**Animal Husbandry**

**Pasture development**

There is need for considerable research on pasture development at higher altitudes. Pelleted seeds may be helpful.

**Poisonous plants**

There is need for identifying the various poisonous plants doing harm to animals and for developing suitable antidotes. Indian Veterinary Research Institute should help in preparing a suitable programme for such research.

**Helminth parasites**

There is need for developing control measures for various Helminth parasites. IVRA should collaborate with the ICAR Research Centre in such work.

**Monitoring of animal health**

A mobile animal health van for diagnosis and treatment of animal diseases should be provided immediately to the ICAR Research Complex at Gangtok.

**Animal nutrition**

There is need for developing agro-forestry programmes and sylvipastoral systems for improving the availability of feeds and
fodders in Sikkim. The nutrition of animals between 2000' to 6000' is particularly important. Indian Grassland and Fodder Research Institute should help in developing such a programme.

**Horses and mules**

There is need for improving horses and mules in order to remove drudgery to human beings in the transport of agricultural and other products.

**Training**

It would be useful if a special IDD course is organised for Higher Secondary students in order to train them in dairy and veterinary sciences.

**Post-Harvest Technology**

The major aim of all research in hilly areas should be to develop high-value low volume products so that transport costs can be maintained and value-added products prepared in the region where the primary commodity is produced. Therefore, considerable attention has to be paid to post-harvest technology including the processing of straw and cellulosic wastes.

**Floriculture**

More than 600 species of orchids occur in Sikkim. These need to be conserved and multiplied. Facilities for meristem and tissue culture should be developed. For this purpose, a Centre under the All-India Co-ordinated Floriculture Programme of ICAR should be established in Sikkim.

**Medicinal Plants**

Planting material of *Dioscorea deltoidea* and *D. floribunda* should be supplied by the Indian Institute of Horticultural Research, Bangalore to Sikkim. There is also need for more research and testing of Pyrethrum. The Division of Agricultural Chemicals of Indian Agricultural Research Institute can take up a suitable programme in collaboration with the ICAR Research Complex.

**Fisheries**

A survey for the establishment of Trout fisheries should be conducted. Central Inland Fisheries Research Institute should be requested to organise this.
Agro-meteorology

The India Meteorology Department has already sanctioned a scheme for establishing Meteorological Centres in 9 major agro-ecological regions of Sikkim. This network should be gradually developed and linked to Agricultural Stations. India Meteorology Department should also set up suitable Centres in all the ICAR Research Stations in the North-Eastern Himalayan region. Unfortunately, due to lack of local radio stations, it is difficult to transmit to farmers the latest weather information. A suitable method of collection will have to be developed in order to help farmers to derive benefit from agro-climatological research. ICAR and IMD should jointly organise a seminar on Agro-climatology in the North-eastern Himalayan region.

MEGHALAYA

(a) Jhum control

Now that some technology for Jhum control is available, an Operational Research Project should be undertaken to demonstrate how soil fertility of degraded lands can be restored.

(b) Agro-forestry

There is need for research on agro-forestry involving silviculture and animal husbandry.

(c) Weed Control

Weed control research should also be intensified with particular reference to Mecania.

(d) Germplasm

The work on collection and conservation of germplasm including the cotton types occurring in Garo Hills should be intensified.

ANDAMAN & NICOBAR ISLANDS

Animal Husbandry

There are a large number of problems in animal husbandry in these islands which need greater attention. The research institute being set up by ICAR should take investigations on the appropriate breeds in these islands the suitability of frozen semen technique and the control of dermititis. Also a decision to establish an Offshore Quarantine Station should be implemented during 1978-79.
General Problems of the North-Eastern Region

Human Resource Development

Inadequacy of trained manpower is a serious constraint in attempts to convert the natural endowments of the area into wealth meaningful to the people. Therefore, ICAR should give the highest priority to developing a Manpower Training Programme for the entire region. Suitable number of seats should be reserved in appropriate agricultural universities for candidates sponsored by NEC. Since there are not adequate number of candidates with PUC qualifications, reservation should be done in universities which admit Matriculates.

Seed Potato production

It is important that Central Potato Research Institute Station in Upper Shillong undertakes certification work and also organises training courses for the personnel of Seed Potato Farms of State Governments. NEC can bear the cost of such programmes.

Storage of foodgrains

The problems of rural home storage of foodgrains under conditions of high humidity need to be gone into in greater depth. ICAR should constitute its survey teams and identify major problems and initiate suitable research and demonstration programmes.

Region No. 4:—Punjab, Part of Uttar Pradesh and Bihar

Diara lands are extensively found in eastern U. P. and Bihar lying adjacent to perennial rivers. They can be utilised for growing common crops in rabi season. It was, therefore, recommended that a new set of cropping pattern involving development of suitable varieties and agronomic practices capable of increasing crop yields may be devised for these lands.

There has been a significant fall in pulse area and production in the present decade in this region. It was recommended that cropping pattern should be recast to provide more room for pulse crops. Steps should be taken to control pests and diseases especially mosaic which is proving deterrent for its production. Mosaic resistant high yielding varieties are to be evolved. Intercropping of pulse crops with sugarcane especially autumn planting, fallow rabi fields and winter harvested sugarcane fields may provide extra land for pulse crops production.
Owing to the perishable nature of fruits and vegetables, these commodities are subjected to losses during transit period from the place of production to the point of consumption. It was recommended that marketing system, methods for transport, collection and disposal for these commodities through co-operatives, if possible, should be developed so that growers may get reasonable price for their produce and consumers may purchase these commodities on competitive price. Storage facilities should also be created.

It was recommended that (a) Murrah and Bhadwari breeds famous for their milk and fat content should be developed. Facilities for animal treatment should be available in the villages. It was also recommended that arrangements should be made well in advance for timely availability of medicines to vaccinate the animals in flood prone areas so as to save huge loss of cattle wealth due to floods. (b) development of pasture lands should be taken up, (c) the fodder supplying power of forests should be studied and leaf fodder should be tried.

Hilsa fish live in the sea which come to up stream of Ganga for breeding. But due to construction of Farraka Barrage fishes are unable to cross the Barrage. Hence availability of Hilsa fish in up stream of Ganga is dwindling. It was recommended that a separate slip-way should be made for hilsa fishes to cross over the barrage and come to up stream of Ganga for breeding. Also the induced breeding of Hilsa should be tried to overcome natural breeding in up stream of Ganga.

Satluj-Ganga alluvial plain is an endemic flood region in general and eastern U. P. and north Bihar in particular. The floods bring misery to human and cattle lives. It was recommended that (a) the steps should be taken to control floods and improve drainage, (b) evolution of suitable crop varieties especially sugarcane for waterlogged area, (c) evolution of sugarcane varieties which are high sugared and suitable for drought conditions in south Bihar.

Vast areas of usur land are lying in this region. Though Pyrites and Gypsum are known to be helpful in reclaiming usur land, these are costly and also not easily available to the farmers. It was, therefore, felt desirable that alkali tolerant varieties be evolved and tested on such land.

Committee felt that the composite fish culture trials should be demonstrated to research and extension workers of the States to get maximum benefit out of it.
Operational Research Programme should be started for development of ‘Kandi’ areas of Punjab.

There is huge loss of valuable nutrients from the soil every year due to soil erosion in the sub-mountainous region of Himalaya in Punjab, Uttar Pradesh and Bihar. It was, therefore, recommended that steps should be taken to check the soil erosion with the help of afforestation and adopting soil conservation and water management practices.

Region No. 6.—Gujarat, Rajasthan and Haryana

Agricultural Planning for the Delhi Market Shed

The Haryana Government has already decided to develop a 40 mile radius around Delhi as a green belt for catering to the needs of the Delhi Market. Scientific market shed planning is exceedingly important in order to make the best use of the soil, water and human resources available near large urban centres. The Regional Committee recommended that an inter-disciplinary Task Force may be set up for developing a detailed blue print for land and water use planning for the Delhi market shed. The group will make specific recommendations for increasing the income of landless labour by involving them in activities like poultry, pig rearing, dairy, mushroom production and other methods of increasing income and employment. Another important aspect of the Delhi market shed planning will be emphasis on the provision of vegetables, fruits and animal products of good quality at low prices in the low income colonies including jhuggi colonies. Thus the primary aim of the programme will be to assist both low income producers and consumers. In addition, the Task Force will look into the problems of water and pest management and post-harvest technology, since some tests have shown a high incidence of pesticide residues in the vegetable material sold in Delhi. The Task Force will also make recommendations on the packages of technology, services and public policies essential for creating a prosperous market shed community. On the basis of the Delhi market shed plan, similar exercise may be undertaken for other major cities in India like Calcutta, Bombay, Madras, Ahmedabad, etc.

Scientific Management of the Aquifer

A serious threat to the future of agriculture in North-West India is the rising water table on the one hand and increasing content of salt in water the other. The Regional Committee recommended the setting up of a Task Force to prepare suitable
projects for the management of the sub-soil water and for the utilisation of saline water. The programme will be jointly taken up by the Central Soil Salinity Research Institute of ICAR and the Haryana Agricultural University. Similar studies will also be undertaken in Gujarat both with reference to coastal salinity and inland salinity. The Regional Committee emphasised that unlike in the case of alkalinity where an individual farmer can adopt remedial measures, in the case of saline soils, only a group of farmers in the entire village can take corrective steps. Therefore, the social organisation needed for reclaiming and managing saline soils should be developed.

National Research Centre for Camel

There are nearly a million camels in India, but the problems of camel nutrition, health care and breeding have not received adequate attention. It was, therefore, suggested at the meeting that a National Research Centre on Camel may be established at Bikaner in Rajasthan.

Agro-forestry

Much of the time of rural women in all the three States has to be spent on collecting sources of energy like twigs and cow dung and drinking water. Also the cultivation of annual crops is not a desirable practice in many of the arid areas. It was hence suggested by the regional committee that the Haryana Agricultural University, Gujarat Agricultural University and the Udaipur University should develop strong schools of agro-forestry research which will help to develop suitable sylvipastoral systems, sylvi-horticultural system, energy plantations and gasoline agriculture.

Region No. 7:—Maharashtra and Western Parts of Madhya Pradesh

Dry Farming Research

The ICAR has to initiate a few more Operational Research Projects particularly for flat black soils both under the Haveli and non-Haveli management systems.

Soyabean utilisation

Action on the setting up processing plants for Soyabean in Madhya Pradesh should be expedited in view of the growing interest among farmers in cultivation of this crop.
Pulses and oilseeds

The Jawaharlal Krishi Vishwa Vidyalaya, Jabalpur has been requested to intensify research on pulses and oilseeds under the National Agricultural Research Project.

Research on minor millets like Kodo

ICAR has initiated a project with support from IDRC of Canada for strengthening research on minor millets. The Jawaharlal Nehru Krishi Vishwa Vidyalaya has been requested to implement this project speedily and effectively.

Techniques for animal nutrition for small farmers

Research on Sylvi-pastoral systems, grass-legume mixtures and fortified fodder production will be further intensified in this area. For preservation of the Badavari breed, steps will be taken under the National Bureau of Animal Genetics Resources to preserve this breed of buffaloes and take up further improvement of its pedigree.

Agro-forestry

It is proposed to promote more intensive work on leguminous shrubs and trees which can provide fuel, fodder and feed in addition to fixing nitrogen in the soil.

Region No. 8: Kerala, Tamil Nadu and Karnataka

Rice based farming systems have been predominant in the region. But the productivity realisation of rice in the region around 2.5 tonnes per hectare is only second to that obtained in the North-West of India where the large rice cultivation is a recent advent and the yields are around 3 tonnes per hectare. Hence there is an urgent need to tackle the yield constraints.

Water Management problems in the region pose a challenge. Some studies have been made in water management research. These results should be rapidly adopted with appropriate modifications to suit various regional conditions in order to improve the water-use-efficiency since water in many areas of this region is scarce and precious commodity as for example Coimbatore District. Operational research projects on water shed basis should be initiated immediately to demonstrate the viability of the available water management technology and also to impress
upon the farmers to take to new methods of conserving water and its best utilisation to maximise the benefits from a unit of water.

The rural youth, school dropouts, etc. are a tremendous force in the rural areas whose involvement in agricultural vocation after appropriate training in farming and rural skills would be a great asset. The Agricultural Universities in the region should think more of such innovative educational programmes to build up a cadre of skilled workers and enlightened youth movement to improve the farming efficiency.

Modern agriculture is highly location specific. Hence there is a great need to develop research stations in the states with a strong regional bias.

More than sixty percent of the area in the region is rainfed. Hence viable technology package is very essential to stabilise production in dry land areas. To improve the economy of the dry farming areas it is very essential to blend agriculture with livestock production, agroforestry and processing of farm products in situ and transporting the value added products out of region instead of sending out the unprocessed farm produce with much reduced economic value etc. The agricultural Universities should start more operational research projects on integrated farming systems in dry farming areas.

Farming in the region is becoming resource use oriented and market oriented. The farming systems research should, therefore, emphasise the need for careful planning and management of scarce resources to derive maximum benefit. To do so it is necessary to develop a package of farming systems to provide ample choice for the farmer to select the best suited to his conditions such as agro-ecological, market preference to commodities and his level of management. This should form an excellent Inter-University Research Programme in the region.

Post-harvest technology is one of the weakest links in the production systems in all the states in the region. This lacuna has to be made good soon.

Agricultural Universities should involve themselves in programmes of transfer of appropriate technology to rural areas to produce larger outputs, greater employment opportunities and more equitable distribution of benefits.
Integration of research and development agencies at the states level to the mutual advantage of each other is most important and urgent. While some amount of interlinkages does exist at the moment, it is not enough. It is therefore, necessary to evolve a set of guidelines detailing how this could be systematically made effective to blend R & D efforts to the greater advantage of the country.

In dryland areas of Coimbatore District and similar situations in other states in the region, cultivation of Agava sisalans as a fibre crop has a great scope. Jute Agricultural Research Institute, Barrackpore offered to supply planting material. Rope making, brush making etc. from agave fibre would provide ample sparetime employment opportunities to the peasantry in the region.

Dry areas of Coimbatore District are ideally suited for the production of quality jute seed. Tamil Nadu Agricultural University may initiate programme to standardise the seed production technology.

Early maturing canes developed recently have opened up the possibilities of growing three cane crops in two years. They ideally fit into multiple cropping pattern. Advantage of these varieties might be taken of by the developmental agencies to popularise their cultivation. While it is true that these varieties mature in relatively shorter period the yield in terms of cane is rather low. But the recovery is high. Hence it is important to adopt a policy of pricing of cane on the sugar content rather than on the cane yield. Unless it is done, there is very less chance of these varieties becoming popular with the farmers.

Grassy-shoot disease and scale insects are acquiring new significance in the Southern region. While the grassy-shoot could be controlled through heat therapy, research on scale insect control needs to be intensified.

Integrated pest management system in cotton has indicated an utmost economy in the pesticide use together with reduced environmental hazard. This system needs to be popularised expeditiously.

In order to save the crop of casava from mosaic disease infection, it is not only necessary to adopt the disease resistant varieties but also to stop the indiscriminate introduction of planting material. Two hybrids/varieties have been developed with high yielding ability for edible purpose.
new hybrids and varieties could be taken to promote the production of cassava in Tamil Nadu. Similarly a high yielding variety for industrial purpose has been developed. Multiplication of the planting material is a difficult problem. States Depts. should make arrangements to develop seed nurseries. Mixed cropping of cassava with onion and groundnut, has yielded excellent results. This may be popularised. The leaves of cassava can be used for feeding Iri Silk worm.

To Control bunchy top of banana strict quarantine measures have to be followed to prevent the introduction of disease-prone planting material. It is necessary to intensify research on the control of vector and also to adopt the cross-protection techniques.

Improved management of Citrus orchards has revived the declining orchards. This needs to be widely popularised. Cross protection technique is becoming popular with khazilime to control citrus virus disease.

Cocoa is becoming an important crop in the country. But hardly any information is available on its management. Indiscriminate use of planting material of all kinds in all types of soils is likely to ruin the prospects of crop. This is an important problem. The question of starting a coordinated programme on the improvement of coco cultivation may be examined.

Research on all aspects of water use and water management should be started immediately in all the universities in the region, especially in Coimbatore District where the problem in becoming acute.

Az ola and Blue green algae are now known to harvest atmospheric nitrogen. More research on them needs to be done.

Extradiction of aquatic weed Salvenia physically is very expensive, Chemical controls are not practicable because of the environmental hazards. Hence biological control methods needs to be explored in an intensive manner.

This region is ideally suitable for the production of forage seeds. Suitable seed production farms may be started in the region.

It is necessary to organise training for the inservicemen on the cultivation of forage crops, their processing and utilisation. It is also necessary to arrange training programmes for the master
trainers about the production of fortified live stock feed by utilising the farm and cellulosic waste material.

Foot and mouth disease typing work is not adequate. It should be strengthened.

Research on Agricultural by product utilisation as poultry feed needs strengthening.

Strict quarantine measures should be imposed against the indiscriminate introduction of semen into the country.

Infertility among the cattle particularly in Kerala is increasing. The research on this problem needs to be strengthened at the Kerala Agricultural University.

Pneumonia in goats is becoming serious. Suitable preventive and curative measures have to be developed soon.

Necrosis of the extremeties, tail and legs of the cattle are reported to be due to the fungal infection carried by the straw of high yielding rice varieties. This needs to be investigated.

Lack of sufficient seed material is posing as a constraint for the development of reverine, reservoir and brackish water fish farming. Same is true with prawn culture.

Operational research project at Kovalam is doing excellent work on mussel culture. It is a joint venture of nearly 100 farms; small training programmes for the boys have been organised to train them for catching prawn seed, appropriately pack and transport to longer distances. Lobster culture is also introduced. It is proposed to introduce product processing at this centre so that the value added products are developed and sent out of the area for marketing. It is also proposed to integrate sea-farming with the planting of economic trees like cashew, coconut, casurina etc. Kovalam village is about 30 Km. south of Madras and the states in the region can take advantage of this centre and start similar centres in their respective regions to gain from the experiences of the Kovalam centre.

Nearly 300 million fish seed is required in Tamil Nadu alone to develop fisheries which in turn require about 300 hectares of water area for the fish seed production. A number of fish seed production farms have been set up in Andhra Pradesh and elsewhere. But if the movement initiated in this direction were to be successful more educational programmes in fish seed production technologies need to be developed.
To avoid spoilage in the boats and on shore a number of techniques have been developed and training programmes have been initiated for the benefit of those involved in these operations. These methods have been gaining popularity since it improves the quality of products particularly with prawns and lobsters since they have a tremendous export potential.

Forest research, particularly on sandal which is an important foreign exchange earning tree plantation needs to be intensified in Karnataka and Tamil Nadu.

Sericulture and apiculture also require pointed attention.

Babul (*Acacia arabica*) plantations should be developed since they provide both fire-wood as well as timber for farm implements. Similarly Casuarina is on excellent fire-wood.

Cuba's system of forestry research and education could be followed in the Agricultural Universities. A report written by Dr. Richardson, FAO expert on Forestry Research could be consulted for the details.
IX. INTERNATIONAL CO-OPERATION

Agreements and Protocols

Amendment to the Memorandum of Agreement relating to the establishment of ICRISAT in India at Hyderabad

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was established in India at Hyderabad under an agreement dated March 28, 1972 between the Government of India and the Ford Foundation acting on behalf of the Consultative Group on International Agricultural Research. A document on the amendment to this earlier agreement was signed on February 17, 1978. This document provides to cover the extension of ICRISAT's programme to include work on groundnut and specifically provides for co-operative arrangements within India and also with other countries/international centres etc.

Assistance to the Socialist Republic of Vietnam in the field of Agricultural Research.

In September 1977, the letters exchanged between the Government of Republic of India and the Government of the Socialist Republic of Vietnam provided for the establishment of a Rice Research Institute and a Buffalo Breeding and Research Centre in Vietnam with Indian assistance. This was subsequently followed by an agreement for cooperation in the field of agricultural research between the two Governments signed at New Delhi on February 26, 1978 during the visit of H. E. Mr. Pham Van Dong, the Prime Minister of Socialist Republic of Vietnam.

According to the agreement, the Indian side is to meet all expenditure under the ITEC Programme of the Ministry of External Affairs on the supply and transportation of equipment, for establishment of Rice Research Institute and Buffalo Breeding and Research Centre including livestock for the Buffalo Breeding and Research Centre, required for the two projects in Vietnam. It has also to meet the cost of training Vietnamese experts in India, including the cost of their accommodation, maintenance and local transport. In addition, the Indian side has also to make available the services of Indian experts for the establishment of
the two projects. The work for the establishment of the Institute and the Centre in Vietnam was assigned to the ICAR.

As a follow-up, 500 buffaloes for the Centre were supplied to Vietnam during the year under report and action on other items is in progress.

**Indo-ARE Protocol on Technical and Scientific Co-operation in the field of Agriculture**

Based on Article I of the Protocol between the Government of India and the Government of the Arab Republic of Egypt signed in New Delhi on March 19, 1969, the Joint Advisory Committee between the two Governments held its third session in Cairo during May 10-14, 1978. The Joint Communique signed on the conclusion provides for cooperation between the two countries in regard to mutual exchange of visits of scientists and experts, exchange of information, documentation and materials related to agriculture.

**FAO Assistance for Vegetable Growing in Flood-affected Areas.**

A Technical Co-operation Agreement for the provision of financial assistance to the tune of U.S. $1,50,000 for supply of vegetable seeds and seedlings to the growers in areas affected by the floods in India was signed on January 24, 1979 between the Governments of India and the Food and Agriculture Organisation of the U.N. The Agreement stipulated provision of seeds of improved vegetable varieties and also seedlings to the farmers in the flood affected areas of Delhi, Uttar Pradesh, Bihar and West Bengal for planting in about 5,000 hectares as well as for plant protection measures for these nurseries.

**Project Assistance**

(i) The IDRC agreed to provide the amount of $5,50,600 over a period of 3 years to support research on improvement of oil seeds, at four different agricultural universities in India.

(ii) The IDRC agreed to provide an amount of $5,12,000 over a period of two years to support research on minor millets in India at six centres.

(iii) The Swedish International Development Authority (SIDA) agreed to provide an amount equivalent to US $2,456,600 spread over a period of 4 years for the Project on strengthening of nuclear research in agriculture at four centres in India.
Collaborative Activities

Collaboration between the ICAR and the International Maize and Wheat Improvement Centre (CIMMYT), Mexico proceeded in accordance with the Memorandum of Agreement signed in 1974. Nine maize and five wheat scientists working at the various agricultural universities and ICAR research institutes visited CIMMYT, Mexico. During the course of their visit to Mexico, the Indian scientists selected breeding stocks likely to be of use in India. Moreover a number of other breeding materials including genetic sources of resistance to major diseases of economic importance were also received and evaluated at a number of research centres of Co-ordinated Crop Improvement Research Centres in India. Senior scientists of maize and wheat programmes of CIMMYT visited the various crop improvement centres in India to study the breeding materials under evaluation.

The co-operation between ICAR and the International Rice Research Institute (IRRI), Los Banos, The Philippines grew steadily under the agreement signed during 1974. India played a major role in the International Rice Testing Programme, contributing many varieties for testing in the fifteen international nurseries for early, medium, and late rice varieties and tolerance to a wide range of insect, diseases, and adverse physical and chemical environments. Because of the wide range of rice growing conditions in India, 120 IRTP trials were carried out at 41 sites, almost one-third of the total internationally co-ordinated rice trials. Indian scientists participated in several workshops and conferences at IRRI.

In pursuance of the work plan drawn up jointly by the ICAR and the Aquaculture Department of the Southeast Asian Fisheries Development Centre (SEAFDEC) under the agreement signed during 1977, four Indian scientists participated in the Regional Workshop on Aquaculture Development Strategies for Asia organised by SEAFDEC Aquaculture Department from August 6-13,1978 in Philippines. Four more Indian scientists have been deputed for 12 weeks to study the techniques of breeding rematuration, hatchery management and culture techniques of Penaeus monodon in Philippines.

Similarly, in pursuance of the work plan drawn up jointly by the ICAR and the West Africa Rice Development Association (WARDA), Monrovia, Liberia under the agreement signed in 1977, two Indian scientists were deputed to Monrovia for participation in the WARDA Annual Research Review Meeting and also to
study the rice research and training programmes of WARDA thereafter for a total period of two weeks from May 22, 1978. Two scientists from WARDA participated in the Annual Rice Workshop held at the Punjab Agricultural University, Ludhiana during April, 1978. One more scientist from WARDA participated in the Operational Research Project of the ICAR on Rice in India for a month during October-November, 1978. A paper on the topic, "The Indian Experience in Transfer of Rice Technology through various programmes and their impact" was sent to WARDA for presentation in the WARDA Annual Rice Workshop held in Ibadan (Nigeria) from September 25-30, 1978.

During the year under report, eight Indian delegations of Agricultural/Animal Sciences experts as provided in the Indo-USSR Protocol were deputed to those Soviet Union, in various disciplines. The Soviet side deputed to India seven delegations during the same period. A Joint-Indo-Soviet Symposium on 'Buffalo Breeding' was held at Anand (Gujarat) in November, 1978, wherein four Soviet experts led by Dr. Imam Rashidovitch, Deputy Minister of Agriculture, Azerbidjan SSR, participated. In addition, USSR Government deputed two Agricultural Scientists for undergoing training in India for a period of six months each during the year under report, in the fields of "Molecular genetics and cytology in cereal breeding and study of fungus parasites" and "Agrotechnics of the humid tropics crops".

**International Symposia**

The International Symposia held in India during the year 1978 were:

(i) International symposium on Arid Zone Research and Development organised by the ICAR at the Central Arid Zone Research Institute, Jodhpur, from February 14 to 18, 1978;

(ii) V International Wheat Genetics Symposium organised jointly by the Indian Society of Genetics and Plant Breeding and the ICAR, from February 23 to 28, 1978;

(iii) International Seminar on Potato organised jointly by the International Potato Centre and the ICAR, was held at Jullundur from November 20 to 23, 1978 and

(iv) International Cassava Cropping System Workshop organised jointly by the International Development
Research Centre and the ICAR, was held at Trivandrum from November 27 to 30, 1978.

International Training Courses and Participation in International Conference

(i) 2nd FAO/New Zealand Dairy Training Course was held at the National Dairy Research Institute, Karnal, from September 25 to November 3, 1978 and 15 scientists from different Institutes participated.

(ii) FAO/SIDA Animal Reproduction Seminar held at Andhra Pradesh Agricultural University, Tirupati, Hyderabad from 19-11-78 to 8-12-78, and about 12 persons participated from different Agricultural/Veterinary Colleges from India.

(iii) During the year under report, thirty-two Indian scientists from different Research Institutes/Agricultural Universities were deputed for training courses abroad in various agricultural fields under the Ford Foundation Grant and with the assistance of other foreign agencies i.e. FAO, UNESCO, UN Environment Programme and ALEXANDER VON HUMBOLDT FOUNDATION to acquaint with more advanced and recent methods of technique of cultivation to improve the research development in the country.

(iv) 255 Scientists from the ICAR, its research Institutes and from agricultural universities were sent abroad for participation in International Conferences, Seminars, Workshops and on study tours, etc.

Chinese Agricultural Scientists’ Delegation

On the invitation of the Indian Council of Agricultural Research, a 5-member Chinese delegation under the leadership of Dr. Li Chi-Chen visited India during September-October, 1978. During their stay in India, they visited the States of Punjab, Haryana, Gujarat, Uttar Pradesh and Andhra Pradesh to study the research programme of the Agricultural Universities of the States.

The leader of the delegation Dr. Li Chi-Chen explained the present position of agriculture in China. In spite of increased use of chemical fertilizers, organic manures continue to play a
major role in agriculture production in China. Similarly, in spite of mechanisation and use of combine harvesters, human labour plays the most significant part in agricultural operation in that country. The bio-gas plants have solved the problems of fuel shortage in rural community. In China, manure of pig is the main source of raw material for the bio-gas plants and organic fertilizer.

The delegation presented copies of 15 scientific journals to ICAR, which have been passed on to IARI Library for documentation. Seeds of some varieties of Sorghum, Millet and Groundnut were also presented by the Team which have been sent to the National Bureau of Plant Genetic Resources, IARI, New Delhi for their trials in India.

South-Asian Plant Genetic Resources Workshop

A South-Asian Plant Resources Workshop co-sponsored by the National Bureau of Plant Genetic Resources, New Delhi and the International Board for Plant Genetic Resources, was held in New Delhi from May 9-12, 1978. It was inaugurated by Minister for Agriculture and Irrigation, Shri Surjit Singh Barnala. The aim of the Workshop, which was attended by representatives of Bangladesh, Bhutan, Burma, India, Nepal and Sri Lanka, was to discuss the collection, conservation, evaluation, information and other activities in plant genetic resources of South Asia and to agree to further the development of these activities on a regional basis. The Workshop drew up priorities for crops within the region.

The Workshop agreed that crops like rice, oilseed brassicas, maize, citrus species, soybean, cinnaman, medicinal plants required immediate attention for collection and conservation. In addition it noted that priority areas for rice should include rainfed uplands as well as low lands. The meeting also suggested that the long-term seed storage facilities are urgent and essential to serve as a base collection for countries of the region. The function of this storage would be to supply to the active centres seed stock for multiplication and subsequent distribution to breeders. The National Governments were also requested to provide for medium term environment control seed storage facilities to provide at the National level. The Workshop recommended that the species which are threatened in their natural state include Dioscorea spp., Ephedra. Aconitum, Rauwolfia in India and Nepal and wild relatives of sugarcane in N.E. India. These and many others should be preserved in appropriate sanctuaries. The meeting also recommended that appropriate collections be established in participating countries, in
view of essential quarantine barriers which may restrict the transfer of vegetative material between countries. All collections whether seed or vegetative must be duplicate under conditions of long term preservation, in addition to duplication in active collections in various countries.

**Indo-UK Project on the management of heavy black soils**

The work of the Indo-UK Project on the management of heavy black soils, which is under operation at Indore jointly by the ICAR and Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, was reviewed at a meeting held in Indore on Sep. 29, 1978. The project area is traditionally *rabi* crop area and only few farmers were taking *kharif* crops. By introduction of short duration varieties of Jowar, it was possible to escape moisture stress during the years of less than normal rainfall. In the years where there were late rains it was possible to get a second crop of wheat in the same area. Nearly 2/3rd of the project area of 2,000 hectares comprising three villages in Indore Tehsil has been brought under double cropping by this technique. It was possible to obtain yields of about 20 quintals of grains as against only about 5 quintals earlier.

Soil erosion is a major problem in the area and suitable mechanical structures were found to be essential to check soil erosion. For full reclamation and waterway bed stabilisation, non-masonry works, i.e., gabions are being used. This could be built by unskilled village labourers, under simple supervision, with loose stone and G.I. wire netting without needing water or cement and are conveniently repairable. These structures also adjust to the swelling and shrinking of the soils automatically. In view of the excellent impact the project has made on the minds of the farming community and on their income, it was decided to extend its scope to and entire mini-catchment during the next *kharif* season.

**Training of Foreigners**

The Indian Assistance Programmes, commonly known as Technical Co-operation Scheme of Colombo Plan and Special Commonwealth African Assistance Programme (SCAAP) were continued and twenty-nine candidates successfully completed training courses during the year. These were 93 candidates (91 from Nepal and 2 from Afghanistan) receiving training under the Colombo Plan by the end of December, 1978.
There was one trainee under SCAAP by the end of 1978 from African countries. The candidate was from Mauritius and he was receiving training in the field of Tobacco Research.

The procedure for training of students from Nepal financed from Nepal Aid Fund, administered by the Ministry of External Affairs, was streamlined. It was agreed that trainees for postgraduate courses would be covered by Technical Cooperation Scheme of Nepal Aid Fund and students joining undergraduate courses would be eligible for assistance from the TCS of Colombo Plan.

Ad-hoc training in various fields was also provided to 16 nominees of following Governments under U.N.D.P.:

<table>
<thead>
<tr>
<th>Country</th>
<th>Number</th>
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<tbody>
<tr>
<td>Sri Lanka</td>
<td>6</td>
</tr>
<tr>
<td>Mexico</td>
<td>6</td>
</tr>
<tr>
<td>Portugal</td>
<td>3</td>
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<tr>
<td>Nepal</td>
<td>1</td>
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<td><strong>Total</strong></td>
<td><strong>16</strong></td>
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The Screening Committee of the Ministry of Agriculture held two meetings in June and October 1978. It approved 6 proposals for additional funds for the research schemes financed from the US held rupee funds at an estimated total cost of Rs. 3.34 lakhs. Five new schemes of the valuation of Rs. 110.84 lakhs were also approved.

The Government of India had set up a General Research Fund of Rs. 4 crores under the Department of Science and Technology for supporting research projects of relevance to the country. Eighteen schemes were proposed for assistance from this fund. These were considered by the Committee of Scientists in three meetings during the course of 1978. Fifteen projects of the total valuation of Rs. 19 lakhs were approved.

The Government of India had entered into an agreement with USAID whereby USAID would provide training facilities to nominees of the third party for training in India. USAID sponsored 50 candidates for training in various universities in India for different courses, both of short term and long term nature. They had also agreed to the payment of capitation fee
ranging from Rs. 6,000 to Rs. 10,000 per candidate per year for provision of these facilities by the universities. Thirty candidates from Nepal were admitted to various courses in 3 universities.

Since India is a member of the Commonwealth of Nations, they had agreed to accept candidates from developing countries for training in this country under the Commonwealth Fund for Technical Cooperation set up by the Commonwealth Secretariat at London. Five trainees, 3 from Sri Lanka and 2 from Malaysia were admitted to courses in the field of Farm Mechanisation at Panjab Agricultural University Ludhiana during the year under review. Under this programme the entire expenditure on to and fro travel costs as well as boarding and lodging and other related matters is the responsibility of the Commonwealth Secretariat.

An agreement between the Government of India and the Government of United States of America has been signed on the 26th August 1978, whereunder the Government of USA have agreed to provide $2 million for project entitled “Application of Science & Technology for Rural Development”. The amount can be used for purchase of equipment and materials (including prototype hardware) professional services and consultancy, exchange of study tours of personnel and the conduct of joint workshops. Basic research will not be eligible for support under this project.

Areas identified by the sub-commission on Science and Technology of the joint Indo-US Commission will be eligible for assistance under this programme. The guidelines for processing of proposals have been finalised. Proposals on agreed subjects have been invited from the institutes of Indian Council of Agricultural Research and agricultural universities and these will be proposed for sanction during the course of the year.
X. PUBLICATIONS AND INFORMATION

The Publications and Information Division brought out 36 publications during the year, 32 in English and 4 in Hindi. Another 5 publications are in advanced stages of printing, and are expected by the end of March, 1979 (Appendix 4). Among the important publications issued during the year were 'Rice Production Manual', 'Mango', 'Wild Edible Plants' 'Farm Management' (Revised Edition) and 'Statistical Methods for Agricultural Workers' (Revised Edition).

The programme of original books in Hindi made further progress with the arrival of more manuscripts from the authors. About a dozen books in Hindi are in various stages of printing. The seventh volume of agricultural digest, Krishi Chainika was also brought out.

Journals

The Council continued to publish its five journals; viz. The Indian Journal of Agricultural Sciences (Monthly), The Indian Journal of Animal Sciences (Monthly), Indian Farming (Monthly), Indian Horticulture (Quarterly) and Kheti (Hindi monthly). The research journals are being printed in advance.

A new quarterly journal in Hindi Phal Phool was started as a counter-part of Indian Horticulture. Necessary steps were also being taken to issue 'Krishi Chayanika' as a regular Hindi quarterly.

The following special Numbers of journals were brought out. Indian Farming—'Integrated Rural Development' (October-November, 1978 'Cashew' (March 1979); Kheti—'Van Aur Manav' (April, 1978), Gramodaya' (January 1979) Indian Horticulture—'Three Decades of Horticultural Research' (July—September 1978).

Sales and Advertisements

The Council had a revenue of Rs. 5,79,472.00 from the sale of its publications and Rs. 1,71,363.95 from advertisements during the year 1977-78.
Sales promotional activities were continued to step up the sale of the Council's publications. Selected books were sent through the National Book Trust for display at Exhibitions of Indian books in Malaysia, Thailand and Bangladesh, 10th Singapore Festival of Books and Book Fair, Singapore, National Book Exhibition, Ghana, 30th Book Fair, Frankfurt, and 11th International Book Fair, Sofia. The Council participated in 11 exhibitions, book fairs, kisan melas, seminars, etc. during the year.

**Publicity and Public Relations**

The mass media was regularly fed with news items, features, articles on research and development activities of various ICAR Institutes/Projects. Special materials, as required by the media in foreign countries, were collected and provided. Several interviews with scientists by Press, Radio and TV teams were arranged. Facilities were also extended to the representatives of Indian and foreign media to visit ICAR Institutes for on the spot study of our research efforts.

To acquaint the Members to Parliament with the research activities, visits by Members of Parliamentary, Estimates Committee, Consultitive Committee on Agriculture, and Committee on Official Language to various ICAR Institutes/Projects and Agricultural Universities were arranged.

Newsletters and releases in English, Hindi and regional languages on latest research findings in Agriculture, Animal Sciences, Fisheries and other allied fields were also sent regularly to various media units in and outside the country. These dispatches were readily accepted by them.

**Exhibition**

The Council participated in the Indian National Exhibition, held on August-September, 1978 at Moscow. Important accomplishments of research institutes and projects were depicted in the Exhibition, which was visited by very high ranking Soviet public-men, officials scientists and foreign diplomats. The Council's exhibits were one of the most popular displays.

**Films**

At the instance of the Council, the Films Division of the Ministry of Information and Broadcasting continued to show in all the cinema houses in the country at least one item on Agriculture in their weekly Newsreels.
The following four scientific/educational films were under preparation by the Films Division: (i) Water Management, (ii) Mariculture, (iii) Crop-Life Saving Research in Dryland Farming and (iv) Reclaiming Desert Areas. The last mentioned film was ready for general release.

**ICAR Library**

During the year 2,005 publications including books, reports, theses and bulletins were added to the Library. About 2,1000 readers used the Library and 4,236 publications were issued on loan. Inter-Library loan facilities were extended to other Libraries in the country. The list of monthly additions and the list of periodicals received during the week were prepared and circulated among the specialists at the ICAR Headquarters. Films were lent out to the members of the Film library for screening at various occasions. Borrowing facilities extended by the Hindi Library were well availed by its 300 members.

**Agricultural Research Information Services**

The ICAR started a pilot project on the maintenance of Research File in 1958 with a view to building up files of all research projects carried out in India. In 1967, the Research Project File Unit was set up at the Council's Headquarters for collection, collation, indexing, documentation and dissemination of all on-going agricultural research projects in India. The Unit brought out from time to time different indices and lists of on-going research projects, completed research projects classified on the basis of discipline, subject and institution. The information compiled by the Unit was of great help to the Council in the formulation of realistic plans for research in the country. It also helped in avoiding duplication of research efforts while sanctioning new research proposals. Complete information on on-going and terminated research projects was available in the Project Files in the form of proposal, financial outlay, annual and final reports, papers published and abstracts.

In 1974, the Government of India nominated the ICAR to act as the National Input Centre for supply of bibliographic information to the AGRIS (International Information System for Agricultural Sciences and Technology) Project of FAO of United Nations through its Research Project File Unit. During the year under report 3700 inputs were sent to the AGRIS Data Base at Vienna (Austria) covering about 200 core periodicals and other non-conventional literature of Indian origin. The Indian Input Centre continued to remain as the third largest National Input Centre next to U.S.A. and Japan in the AGRIS system.
During the year under report, AGRIS magnetic tapes were received from Vienna and every month an updated tape was being received at the Centre. With the help of these tapes, Selective Dissemination of Information (SDI) Service was provided to agricultural scientists in India.

Under a FAO Fellowship, a trainee from Agricultural Documentation Centre, Kathmandu (Nepal) came for 3-month practical training in Information and Documentation Systems at the Agricultural Research Information Centre of the Indian Council of Agricultural Research.
APPENDIX I

REPRESENTATION OF SCHEDULED CASTES AND SCHEDULED TRIBES IN ICAR

The following reservations are in force in favour of the scheduled castes and scheduled tribes in filling vacancies in posts and services under the Government of India:

1. Direct recruitment on an all-India basis:
   (a) By open competition . . . . . . 15% 7 1/2%
   (b) Otherwise than at (a) above . . . . . . 16 2/3% 7 1/2%

2. Direct recruitment to Class III and Class IV posts normally attracting candidates from a locality or a region.

   It is generally in proportion to the population of S.Cs. and S.Ts in the respective States/U.Ts.

These reservation orders have been made applicable to the I.C.A.R. & its research institutes. The position regarding the percentage of scheduled castes and scheduled tribes in the ICAR Hqrs. and its institutes as on the 30th September, 1978 is indicated below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Category of posts</th>
<th>% of S.C.</th>
<th>% of S.T.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Scientific Posts</td>
<td>5.15%</td>
<td>0.53%</td>
</tr>
<tr>
<td>2.</td>
<td>Technical Posts</td>
<td>14.89%</td>
<td>3.50%</td>
</tr>
<tr>
<td>3.</td>
<td>Administrative Posts</td>
<td>13.63%</td>
<td>3.01%</td>
</tr>
<tr>
<td>4.</td>
<td>Supporting Staff</td>
<td>24.31%</td>
<td>3.51%</td>
</tr>
</tbody>
</table>

The position regarding reservation of posts in the category of scheduled castes is satisfactory except in scientific posts. This is because the reservation orders for this category have been implemented only 2-3 years back and prior to this reservation orders were not applicable to scientific posts. The position about
scheduled tribes is not satisfactory. This is mainly because suitable candidates belonging to this community are not easily available. However, efforts are being made to make good the quota reserved for Scheduled Tribes in filling vacancies reserved for them.

A statement showing the total number of employees in the I.C.A.R. and its research institutes and the number of scheduled castes and scheduled tribes amongst them as on 30th September, 1978 is appended.
Statement showing the total number of employees in the ICAR and its Research Institutes and the number of Scheduled Castes/Scheduled Tribes amongst them as on 30th September, 1978

<table>
<thead>
<tr>
<th>Class No.</th>
<th>Total No. of employees</th>
<th>Total No. of Sch. Castes among them</th>
<th>Percentage to total employees</th>
<th>Total No. of Sch. Tribes among them</th>
<th>Percentage to total employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>1. Scientific</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
<td>605</td>
<td>54</td>
<td>8.91%</td>
<td>7</td>
</tr>
<tr>
<td>S-1</td>
<td></td>
<td>2283</td>
<td>131</td>
<td>5.74%</td>
<td>12</td>
</tr>
<tr>
<td>S-2</td>
<td></td>
<td>748</td>
<td>16</td>
<td>2.14%</td>
<td>2</td>
</tr>
<tr>
<td>S-3</td>
<td></td>
<td>431</td>
<td>10</td>
<td>2.32%</td>
<td>1</td>
</tr>
<tr>
<td>S-4 and above</td>
<td></td>
<td>68</td>
<td>2</td>
<td>2.94%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4136</td>
<td>213</td>
<td>5.15%</td>
<td>22</td>
</tr>
<tr>
<td>2. Technical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category-I</td>
<td></td>
<td>3215</td>
<td>552</td>
<td>17.17%</td>
<td>134</td>
</tr>
<tr>
<td>Category-II</td>
<td></td>
<td>1094</td>
<td>102</td>
<td>9.32%</td>
<td>21</td>
</tr>
<tr>
<td>Category-III</td>
<td></td>
<td>144</td>
<td>9</td>
<td>6.25%</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4453</td>
<td>663</td>
<td>14.89%</td>
<td>156</td>
</tr>
</tbody>
</table>
3. Administrative

<table>
<thead>
<tr>
<th>Section</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.S./U.S./Sr.A.Os./A.Os/Accounts Officers/S.Os.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asstts.</td>
<td>414</td>
<td>35</td>
<td>8.45%</td>
<td>5</td>
<td>1.21%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenographers</td>
<td>554</td>
<td>68</td>
<td>12.27%</td>
<td>12</td>
<td>2.17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sr. Clerks (U.D.Cs)</td>
<td>490</td>
<td>29</td>
<td>5.92%</td>
<td>5</td>
<td>1.02%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jr. Clerks (L.D.Cs)</td>
<td>859</td>
<td>143</td>
<td>16.65%</td>
<td>20</td>
<td>2.23%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1300</td>
<td>218</td>
<td>16.77%</td>
<td>67</td>
<td>5.15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3617</td>
<td>493</td>
<td>13.63%</td>
<td>109</td>
<td>3.01%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Supporting Staff

<table>
<thead>
<tr>
<th>Grade</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade-I</td>
<td>6001</td>
<td>1534</td>
<td>25.56%</td>
<td>208</td>
<td>.35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade-II</td>
<td>1580</td>
<td>366</td>
<td>23.16%</td>
<td>55</td>
<td>3.48%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade-III</td>
<td>1051</td>
<td>222</td>
<td>21.12%</td>
<td>44</td>
<td>4.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade-IV</td>
<td>246</td>
<td>36</td>
<td>14.63%</td>
<td>5</td>
<td>2.03%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8878</td>
<td>2158</td>
<td>24.31%</td>
<td>312</td>
<td>3.51%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Auxiliary

<table>
<thead>
<tr>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX II

PROGRESSIVE USE OF HINDI IN THE OFFICE OF THE DARE AND ICAR

The main objective of the Indian Council of Agricultural Research is to undertake, aid, promote and co-ordinate agricultural and animal husbandry education and research and to act as a clearing house of information relating to these subjects. Most of the work done in the Council is of scientific and technical nature. Although the implementation of Hindi is deemed to be difficult in the offices dealing with the scientific work, yet maximum efforts have been made to implement the policies and programmes for the progressive use of Hindi in the Council and to implement the Official Language Act and Rule 1976 as well as various instructions issued by the Department of Official Language, Ministry of Home Affairs.

In ICAR work relating to the implementation of progressive use of Official Language is looked after by the Hindi Section which consists of one Senior Hindi Officer, two Hindi Translators, one Hindi Assistant and one typist each for Hindi and English. The posts of one Senior Hindi Translator and one Hindi Stenographer have also been created w.e.f. 29th March, 1978 but the same have not yet been filled. A cell of two Hindi Typists is also working under the supervision of Senior Hindi Officer to type the drafts originally prepared by the officers or sections in the Headquarters of the Council.

The Council has 62 Sections and 144 Senior Officers. In addition to that, 32 Research Institutes are also working under the Council and the responsibility for co-ordination of the implementation of progressive use of Hindi in all these offices lies on the Hindi Section of the Council. In view of all this the staff strength of the Hindi Section is meagre but even with its limited resources the Hindi Section could do the following work during the year.

Creation of new posts.—The following posts were created for Hindi work during the year: One Hindi Officer, one Hindi Translator and one Hindi typist for the Hindi Section at the
ICAR Headquarters, New Delhi, one Hindi Translator and one Hindi typist for the Indian Lac Research Institute, Ranchi, one Hindi Translator for the Indian Sugarcane Research Institute, Lucknow, one Hindi Assistant at the All India Co-ordinated Research Project for Dryland Agriculture, Hyderabad, one Hindi Translator and one Hindi Typist for the Indian Veterinary Research Institute, Izatnagar, one Hindi Translator and one Hindi Typist for the Indian Veterinary Research Institute, Mukteshwar, one Hindi Translator and one Hindi Typist for the Central Staff College for Agriculture, Hyderabad, one Hindi Translator and one Hindi Typist for the Sugarcane Breeding Institute, Coimbatore. In addition to this the post of a Hindi Officer at the Headquarters was upgraded as Senior Hindi Officer, and one post of Senior Hindi Translator and one post of Hindi Stenographer were also created. Several proposals for creation of posts for Hindi work in Central Institutes were under consideration at various levels.

_Distribution of literature for guidance._—The Hindi Section distributed “A compilation of orders regarding the use of Hindi” published by the Department of Official Language, Ministry of Home Affairs to all sections and officers of the Council. In addition, the Hindi Section distributed a Consolidated Glossary of Administrative Terms” (English-Hindi) published by the Central Hindi Directorate and one set of 12 useful books published by the Kendriya Sachivalaya Hindi Parishad to all sections and officers of the Council. Moreover, some copies of English-Hindi dictionary compiled by Father K-Bulcke was also distributed to some of the Senior Officers so that they could use Hindi with the help of the dictionary. In this way, the Hindi Section was doing its best to assist all the sections/officer of the Council by arranging all essential help literature for the progressive use of Hindi. Secondly, the Hindi Section also circulated copies of Official Language Act, 1963 and Rule, 1976 to all sections Officers/institutes for necessary action. All the orders issued by the Department of Official Language were circulated immediately to all the concerned offices/officers.

_Official Language Implementation Committee._—A Joint Official Language Implementation Committee was set up for the Department of Agricultural Research and Education and the ICAR. The meetings of the said Committee were held from time to time to consider the problems regarding progressive use of Hindi. Since last year, three meetings of this Committee were held. Such committees have also been constituted in most of the Institutes working under the Council.
Hindi Teaching and training of Hindi stenography/Hindi typing.—Hindi Section makes efforts to send the maximum number of employees/officers of the Council for various courses of Hindi teaching and training. This year nine employees/officers were nominated for Hindi teaching, two for Hindi Stenography training and 14 for Hindi typing during January, 1978 session and 13 during July, 1978 session.

Bilingual printing of forms.—All the forms which are used in DARE and ICAR were printed both in Hindi and English. Accordingly, the forms for Senior/Junior fellowships and all the forms connected with Agricultural Scientists Recruitment Board were printed in both the languages. The Manual of the Council was also translated into Hindi.

Incentives to Hindi typists.—The Efficiency Bonus Scheme initiated by the Department of Personnel and Administrative Reforms was implemented in the DARE and ICAR and its various Institutes all over India. Incentives to Hindi stenographers. The incentive scheme for Hindi stenographers was enforced in the DARE and ICAR. Under this scheme an advance increment is given to those Hindi stenographers who take dictation at a speed of 100 words per minute and two advance increments to those who can take dictation at a speed of 120 words per minute.

Devnagri typewriters.—The DARE, being a small Department, has got one Hindi typewriter, but the Council is having 19 Devnagri typewriters at present at its Headquarters and 20 more typewriters have been indented. Eighty-seven Hindi typewriters are also available in its several institutes/centres. The institutes/centres which are not having it have been advised to purchase the Hindi typewriters.

Hindi library.—The Hindi Library of the ICAR is having 2787 Hindi books. In addition to it, two Hindi weeklies and two Hindi dailies were regularly being kept in the Library and thus 40-50 persons were being benefited from these periodicals daily.

General orders.—Effort was made to issue all general orders bilingually.

Correspondence.—Replies to letters received in Hindi from Hindi speaking states were given in Hindi.
Noting on files.—According to the information received from time to time in the Hindi Section, noting in Hindi was being done by some of the sections at present. In the Hindi Section and Hindi Editorial Unit of the ICAR, the noting was done almost in Hindi.

Reports.—Reports published by the DARE and the ICAR and which were required to be placed on the tables of both the Houses of the Parliament, were invariably published in Hindi as well as in English.

Hindi periodicals and other publications.—The Council brought out Kheti monthly in Hindi. The select articles and digests of important articles were published in “Krishi Chayanika”. To publish articles relating to fruits, vegetables and floriculture, a quarterly magazine named Phal Phul was started. The Hindi Editorial Unit was responsible for these publications in Hindi. The Unit was also making arrangements to get books on agriculture written in Hindi in original.

Hindi addressographer.—For sending Kheti and Phal-Phul to the subscribers, a Hindi embossing machine was purchased and now all the addresses of the subscribers were being printed in Hindi.

Prizes.—The Council is awarding “Dr. Rajendra Prasad Puraskar” annually since 1974 for the books originally written in Hindi on agriculture and animal husbandry. Under this prize scheme the amount of the first prize is Rs. 5000 and that of the Second prize is Rs. 2,500. Moreover, the Council also gives two prizes annually for the two best articles in its Hindi monthly Kheti out of which one prize is given for the best article on agriculture and the other for the best article on animal husbandry.

A proposal has been formulated under 6th Five-Year Plan to increase the number of Hindi staff. The following posts have been provided in the Plan: one Director (Official Language) and 2 Hindi Officers, etc. for co-ordinating all the work relating to progressive use of Hindi in the Council and in the various institutes working under the Council. It is expected that with the creation and filling up of these posts much progress will be made in the implementation of the progressive use of Hindi.
APPENDIX III

AWARDS

1. Jawaharlal Nehru Award for Outstanding Post-Graduate Research in Agriculture

With a view to encouraging and according recognition to young scholars and scientists, the ICAR instituted in 1971 an award called "Jawaharlal Nehru Award for Outstanding Postgraduate Research in Agriculture". The award comprises 5 prizes of the value of Rs. 5,000 each. In 1978, 5 awards, seventh in the series, were given to 5 outstanding scientists for their contributions in the disciplines of Agriculture and Animal Sciences.

2. Fakhruddin Ali Ahmed Award for Agricultural Research in the Tribal Areas for the Biennium 1976-77

The ICAR had instituted in 1977 an award entitled "Fakhruddin Ali Ahmed Award for Agricultural Research in Tribal Areas" for outstanding research in the field of Agriculture and Animal Sciences. The award has been named after late Shri Fakhruddin Ali Ahmed, who was President of the Council during the period 1971-74. The purpose of the award is to create incentive for promoting Agricultural Research in tribal areas. Under this award 2 prizes of the value of Rs. 10,000 each are given once in two years. The first award for the biennium 1976-77 was given to a distinguished scientist for his outstanding contribution in tribal areas in the field of Agricultural Science.

3. Kheti Puraskar

With a view to attracting writers in Hindi in various disciplines of Agriculture, the Council set up an award called "Kheti Puraskar". Under this award two prizes of Rs. 500 each are given for writing outstanding articles in Hindi in the Council's monthly journal "Kheti". Two prizes, the fourth in the series, were awarded to 3 distinguished writers jointly during 1978.

5. Dr. Rajendra Prasad Award 1978.


7. Hari Om Ashram Trust Award for the year 1976-77.
APPENDIX IV

PUBLICATIONS PRINTED DURING 1978-79

A. Publications Division, ICAR, New Delhi

Books

1. Handling and Storage of Foodgrains
2. Mango
3. Annotated Compendium on Wheat Diseases in India.
5. Soil Fertility Theory and Practice
7. Feeding of Dairy Cattle and Buffaloes

Bulletins

8. Micronutrient Research in Soils and Plants in India.
10. Wild Edible Plants of India.
13. Fertilizer containing Partially Water-soluble or No Water-soluble Phosphates.
14. Farm Management.
15. Physiological Losses of Buds and Bolls in Cotton
17. An Econometric Model of Returns to Investments in Agricultural Research in India.

Reports

Miscellaneous
26. 'Training Course in Administrative Vigilance'.
27. Second Appreciation Course on Improvement of Administrative Efficiency.
31. Integrated Rural Development—Indian Experience.
32. Directory of Agricultural Research Service Scientists.

Publications printed in Hindi
33. Krishi Chayanika (No. 7).
35. Krishi Vigyan Kendras.

Publications Expected by 31-3-1979
1. Livestock Feeding.

3. Fodders and Grasses.

4. Diagnosis of Tuberculosis in Animals.

5. Planning and Planting Designs of Home Gardens.

B. IMPORTANT PUBLICATIONS BROUGHT OUT BY CENTRAL INSTITUTES/LABORATORIES

INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI

Research Bulletins

1. Algal Technology for Rice.
2. Summer Mung Technology.

Report


CENTRAL ARID ZONE RESEARCH INSTITUTE, JODHPUR

Monographs/Books

1. Desert Ecosystem and its Improvement. H. S. Mann
2. Land Use Classification System in Indian Arid Zone. A. K. Sen.

Bulletin


Report


Other Publications

5. Twenty-Five Years of Arid Zone Research (Souvenir).
COTTON TECHNOLOGICAL RESEARCH LABORATORY, BOMBAY

Reports
2. Reports on Trade Varieties of Indian Cottons 1976-77.

JUTE AGRICULTURAL RESEARCH INSTITUTE BARRACKPORE

Bulletins

Report

INDIAN INSTITUTE OF HORTICULTURAL RESEARCH, BANGALORE

Bulletins
1. Vegetable Cultivation in South India
2. Diseases of Horticultural Crops
3. Passion Fruit

Report
1. Annual Report—1976

CENTRAL POTATO RESEARCH INSTITUTE, SIMILA

Books
1. Potato in India
2. Bharat Mein Alu (Hindi)
Report

3. Annual Report of Central Potato Research Institute 1977

CENTRAL RICE RESEARCH INSTITUTE, CUTTACK

Book

1. Increasing Rice Yield in Kharif

Report

2. Report of Production Oriented Survey on Rice in Problem Areas of Bihar, Orissa and West Bengal

Journal


CENTRAL SOIL SALINITY RESEARCH INSTITUTE, KARNAL

Bulletins


Report


INDIAN INSTITUTE OF SUGARCANE RESEARCH, LUCKNOW

Bulletin

1. IIISR Implements and Machinery for Sugarcane and Sugarbeet Cultivation

SUGARCANE BREEDING INSTITUTE, COIMBATORE

Books

CENTRAL TOBACCO RESEARCH INSTITUTE, RAJAHMUNDRY

Bulletins

1. Fertility Status of Soils growing FCV Tobacco in District, Prakasam (A.P.). Surajbhan and N. C. Gopalachari


Report


CENTRAL INSTITUTE OF AGRICULTURAL ENGINEERING, BHOPAL

Bulletins

1. Weeding Tools and Implements of India—A Review
2. Harvesting Equipment Developed in India—A Review

Report

3. Report on Evaluation of Field Performance of Sickles on harvesting of Wheat Crop

NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL

Bulletins

1. Humanization of Buffalo Milk
2. Chemistry of Buffalo Milk
3. Silage Making
4. Lush Green Fodder Fields
5. Para Grass
6. Buffalo World
7. Management Practices for Goats
8. Save Your Animals from Degnala Disease
287

Report


Periodicals

10. NDRI Newsletter
11. Dairy Samachar

CENTRAL INLAND FISHERIES RESEARCH INSTITUTE, BARRACKPORE

Report

1. Annual Report of Central Inland Fisheries Research Institute, Barrackpore—1977

Journal

2. CIFRI Newsletter, 2(3-4) and 3(1 and 2), 1978

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE, COCHIN

Monographs/Books

1. Mariculture Research and Developmental Activities
2. Summer Institute on Breeding and Rearing of Marine Prawn
3. Economics of the Indigenous Fishing Units at Cochin
4. Abstracts of Papers for Seminar on the Role of Small Scale Fisheries and Coastal Aquaculture in Integrated Rural Development

Reports

5. CMFRI Activities, Achievements and Future Programmes (English and Hindi)
6. Present Status of Small-scale Fisheries in India
8. CMFRI Annual Report—1977
Periodicals

9. Indian Journal of Fisheries, Vol. 23 (1 and 2)
10. CMFRI Newsletter No. 7
11. Krishi Vigyan Patrika: Mariculture Series-1 (English and Malayalam)

CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY,
COCHIN

Reports

2. CIFT Activities and Achievements

Periodical

3. Fish Technology Newsletter—Vol. 1, No. 1 (English and Hindi) and Vol. 1, No. 2 (English)

CENTRAL SHEEP AND WOOL RESEARCH INSTITUTE,
AVIKANAGAR

Bulletin

1. Achievements of CSWRI, Avikanagar

Reports

3. Proceedings of the Seminar on “Problems of Carpet Wool in Rajasthan” held at Jaipur from 22nd to 24th December, 1978

INDIAN AGRICULTURAL STATISTICS RESEARCH INSTITUTE, NEW DELHI

Monographs/Handbooks

1. A monograph on Crop Response to Micronutrients. C. R. Leelavathi, K. S. Krishnan and Shanti Sarup


Report


Periodical

5. IASRI—Statistical Newsletter, Vol. 3, No. 4, October—December 1977; Vol. 4, Nos 1 to 4

ALL INDIA CO-ORDINATED RESEARCH PROJECT FOR DRYLAND AGRICULTURE, HYDERABAD

1. Dryland Farming. J. Venkateswarlu


ICAR RESEARCH COMPLEX FOR N.E.H. REGION, SHILLONG

1. Agricultural Research for the North Eastern Hill Region (Bulletin)


3. ICAR Research Complex Newsletter (Four issues)

ALL INDIA CO-ORDINATED RICE IMPROVEMENT PROJECT, HYDERABAD

1. AICRIP Progress Report—Kharif, 1977

2. AICRIP Progress Report—Rabi, 1977
APPENDIX V

LIST OF ICAR RESEARCH INSTITUTES AS ON 31-12-1978

1. Indian Agricultural Research Institute, New Delhi 110012.
2. Central Rice Research Institute, Cuttack 753006.
3. Central Potato Research Institute, Simla 171001.
4. Central Tuber Crops Research Institute, Sreekariyam, Trivandrum 695017.
5. Sugarcane Breeding Institute, Lawley Road, Coimbatore 641007.
6. Indian Institute of Sugarcane Research, P.O. Dilkusha, Lucknow 226002.
7. Central Plantation Crops Research Institute, Post Kudlu, Kasaragod 670124.
10. Cotton Technological Research Laboratory, Adenwala Road, Matunga, Bombay 400019.
11. Jute Agricultural Research Institute, 24-Parganas, P.O. Barrackpore 743101.
13. Central Tobacco Research Institute, Rajahmundry 533101.
14. Indian Lac Research Institute, P.O. Namkum, Ranchi 834010.
15. Central Soil and Water Conservation Research and Training Institute, 218 Kaulagarh Road, Dehra Dun 248195.

16. Central Soil Salinity Research Institute, Karnal 132001.


18. Indian Grassland and Fodder Research Institute, Gwalior-Jhansi Road, Jhansi 284001.


21. Indian Veterinary Research Institute, Izatnagar 243122.


23. National Dairy Research Institute, Karnal 132001.

24. Central Sheep and Wool Research Institute, P. O. Avikanagar 304501.

25. Central Marine Fisheries Research Institute, P. B. No. 1912, Vincent Road, Cochin 682018.

26. Central Inland Fisheries Research Institute, Barrackpore 743101.

27. Central Institute of Fisheries Technology, P. O. Matsyapur, Cochin 682029.

28. Indian Agricultural Statistics Research Institute, Library Avenue, New Delhi 110012.

29. ICAR Research Complex for North-Eastern Hills Region, Amrit Bhavan, Shillong 793001.

30. Central Arid Zone Research Institute, Jodhpur 342001.

31. Central Agricultural Research Institute for Andaman and Nicobar Group of Islands, Port Blair 744101.

32. Central Staff College of Agriculture, Rajendranagar, Hyderabad 500030.
APPENDIX VI

LIST OF AGRICULTURAL UNIVERSITIES AS ON 31-12-78

Andhra Pradesh

1. Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad 500030.

Assam

2. Assam Agricultural University, Jorhat 785013.

Bihar

3. Rajendra Agricultural University, Veterinary College Campus, Patna 800014.

Gujarat

4. Gujarat Agricultural University, Sardar Krishi Nagar, Post Dantiwada, District Banaskantha.

Haryana

5. Haryana Agricultural University, Hissar 125004.

Himachal Pradesh

6. Himachal Pradesh Agricultural University, Palampur 176061.

Karnataka

7. University of Agricultural Sciences, Hebbal, Bangalore 560024.

Kerala

8. Kerala Agricultural University, Mannuthy 680651.

Madhya Pradesh


Maharashtra

11. Mahatma Phule Krishi Vidypeeth, Rahuri 413722, District Ahmednagar.

12. Marathwada Agricultural University, Parbhani 431401.

13. Punjabrao Krishi Vidyapeeth, Krishi Nagar, Akola 444001.

**Orissa**

14. Orissa University of Agriculture and Technology, Bhubaneshwar 751003.

**Punjab**

15. Punjab Agricultural University, Ludhiana 141004.

**Rajasthan**


**Tamil Nadu**

17. Tamil Nadu Agricultural University, Coimbatore 641003.

**Uttar Pradesh**

18. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208145.

19. Govind Ballabh Pant University of Agriculture and Technology, Pantnagar 263145.

20. Narendra Dev University of Agriculture and Technology, Faizabad 224001.

**West Bengal**

APPENDIX VII(a)
LIST OF PROJECT-DIRECTORATES

1. Rice.
2. Wheat.
3. Pulses.
4. Oilseeds.
5. Dryland Agriculture.
APPENDIX VII(b)

ALL-INDIA CO-ORDINATED RESEARCH PROJECTS

A. Agriculture

(i) Food Crops
1. Barley.
2. Maize.
4. Millets.
5. Forage crops.
6. National seed project.

(ii) Commercial Crops
1. Sugarcane.
2. Sugarbeet.
3. Cotton.
4. Jute and allied fibres.
5. Soybean.
6. Tobacco.

(iii) Horticultural Crops
1. Fruits.
2. Citrus.
3. Tuber crops.
4. Potato.
5. Vegetables.
6. Medicinal and aromatic plants.
7. Floriculture.
8. Spices and cashewnut.
9. Coconut and arecanut.

(iv) Soil Science and Water Management.
1. Water management and soil salinity.
2. Use of saline water in agriculture.
3. Water management in high rainfall areas and temperate hill zones.
4. Investigation on correlation of soil test with crop response.
5. Microbial decomposition and recycling of farm and city wastes.

6. Improvement of soil physical condition to increase agricultural production in problematic areas.

7. Micronutrients of soil and plants.

8. Advance centre for research on black cotton soils.

(v) Agronomic Research
1. All-India Co-ordinated agronomic research project.

(vi) Agricultural Engineering
1. Research and development of farm machinery, implements production of prototypes and evaluation.

2. Optimisation of ground water utilization through wells and pumps.


4. Post-harvest technology.

(vii) Operational Research (including national demonstration and integrated pest-control projects).

B. Animal Sciences and Fisheries

(i) Animal Sciences
1. Cattle breeding.

2. Buffalo breeding.

3. Sheep breeding.

4. Poultry breeding.

5. Goat breeding.

6. Pig breeding.

7. Agricultural by-products and industrial waste materials.

8. Specialised dairy farming (economics of milk production under intensive dairy farming conditions).


(ii) Fisheries
1. Composite culture of Indian and exotic fishes and riverine fish seed production.
2. Propagation of air-breathing fishes in swamps.
4. Utilisation of fresh fish and transportation of fresh fish.
5. Brackishwater fish farming.

C. Miscellaneous

1. Agro-industrial complex in Karnataka and Bihar (Indo-Bulgarian Joint Programme (sanctioned from cess funds).

All-India Co-ordinated Research Programmes

1. Biological control of crop pests.
2. Nematode pests and their control.
3. Rodent control.
4. Algae.
ABBREVIATIONS

AAU—Assam Agricultural University
AGPT—Agar-gel precipitation test
AGRIS—International Information System for Agricultural Sciences and Technology
AICPIS—All-India Co-ordinated Project for the Improvement of Sugarbeet
AICRIP—All-India Co-ordinated Rice Improvement Project
AICRPBCCP—All-India Co-ordinated Research Project on Biological Control of Crop Pests
AICSIP—All-India Co-ordinated Sorghum Improvement Programme
AICRIP—All-India Co-ordinated Rice Improvement Project
APEID—Asian Programme of Educational Innovation for Development
ARE—Arab Republic of Egypt
ASRB—Agricultural Scientists Recruitment Board
BCKVV—Bidhan Chandra Krishi Vishwa Vidyalaya
CAW—Citric acid whey
CAZRI—Central Arid Zone Research Institute
CFTRI—Central Food Technological Research Institute
CICR—Central Institute of Cotton Research
CIMMYT—Centro Internacional de Mejoramiento de Maiz y Trigo, A
CMI—Cell-mediated immunity
CPCRI—Central Plantation Crops Research Institute
CRA—Crease-recovery angle
CRRI—Central Rice Research Institute
CSAUAT—Chandra Shekhar Azad University of Agriculture and Technology
CSSRI—Central Soil Salinity Research Institute
CTRI—Central Tobacco Research Institute
CTRL—Cotton Technological Research Laboratory
CVRC—Central Variety Release Committee
DCP—Digestible crude protein
DE—Digestible energy
DM—Digestible matter
ESCAP—Economic and Social Commission for Asia and the Pacific, Bangkok
FAO—Food and Agriculture Organization
FFE—Feather follicle epithelium
FPP—Ferric polyphosphate
FSR—Foundation of Scientific Research, Iraq
FYM—Farmyard manure
HAU—Haryana Agricultural University
HMP—Hexametaphosphate
HPKVV—Himachal Pradesh Krishi Vishwa Vidyalaya
HPU—Himachal Pradesh University
IAEA—International Atomic Energy Agency
IARI—Indian Agricultural Research Institute
IASRI—Indian Agricultural Statistics Research Institute
IBP—Indo-Bulgarian Project
IBPGR—International Board of Plant Genetic Resources
IBRD—International Bank for Reconstruction and Development
ICAR—Indian Council of Agricultural Research
ICRISAT—International Crops Research Institute for the Semi-Arid Tropics
ICSSR—Indian Council of Social Sciences Research
IDA—International Development Association
IDRC—International Development Research Centre
IIHR—Indian Institute of Horticultural Research
IIRI—Indian Lac Research Institute
IRD—Integrated Rural Development
ISRO—Indian Space Research Organization
IUCN—International Union for Conservation of Nature
IVRI—Indian Veterinary Research Institute
JNKVV—Jawaharlal Nehru Krishi Vishwa Vidyalaya
KAU—Kerala Agricultural University
KVK—Krishi Vigyan Kendra
LPG—Larvae per gram
MAU—Marathwada Agricultural University
MD—Marek’s disease
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<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>MDV</td>
<td>Marek's disease virus</td>
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<tr>
<td>ME</td>
<td>Metabolizable energy</td>
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<tr>
<td>NBAFGR</td>
<td>National Bureau of Animal and Fish Genetic Resources</td>
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<td>NBDIN</td>
<td>National Barley Diseases and Insect Nursery</td>
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<td>NBPGGR</td>
<td>National Bureau of Plant Genetic Resources</td>
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<td>NBSSLUP</td>
<td>National Bureau of Soil Survey and Land Use Planning</td>
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<td>NDRI</td>
<td>National Dairy Research Institute</td>
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<td>NHGP</td>
<td>National Hybridization Garden Programme</td>
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<td>NRCGD</td>
<td>National Research Centre for Goat Development</td>
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<tr>
<td>NSC</td>
<td>National Seeds Corporation</td>
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<tr>
<td>ORP</td>
<td>Operational Research Project</td>
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<td>PAU</td>
<td>Punjab Agricultural University</td>
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<td>RAU</td>
<td>Rajendra Agricultural University</td>
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<tr>
<td>RID</td>
<td>Radial immunodiffusion test</td>
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<tr>
<td>RNA</td>
<td>Ribonucleic acid</td>
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<td>RNAM</td>
<td>Regional Network for Agricultural Machinery</td>
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<td>SCAAP</td>
<td>Special Commonwealth African Assistance Programme</td>
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<td>SIDA</td>
<td>Swedish International Development Authority</td>
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<td>SRS</td>
<td>Sugarcane Research Station</td>
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<tr>
<td>SWWF</td>
<td>Soya-whey weaning food</td>
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<tr>
<td>TDN</td>
<td>Total digestible nutrients</td>
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<td>TNAU</td>
<td>Tamil Nadu Agricultural University</td>
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<tr>
<td>TRS</td>
<td>Tobacco Research Station</td>
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<td>UNDP</td>
<td>United Nations Development Programme</td>
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<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organisation</td>
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<td>UNICEF</td>
<td>United Nations International Children's Emergency Fund</td>
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<td>VPKAS</td>
<td>Vivekananda Parvatiya Krishi Anusandhan Shala</td>
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<td>WARDA</td>
<td>West African Rice Development Association</td>
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<td>WHO</td>
<td>World Health Organization</td>
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<td>WTRC</td>
<td>Water Technology Research Centre</td>
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