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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.

In the area of research, following the announcement of the Finance Minister in his budget speech of the overriding priority accorded to agriculture in resource allocation, additional funds were provided to the ICAR for initiating an intensive programme of research on rainfed rice. For this purpose steps were taken to establish a research centre under the Central Rice Research Institute in a farm near Patna. Steps were also taken to review the on-going programmes of research in pulses and oilseeds and intensify research in these crops. As a part of the strategy for the diversification of the varietal pattern so as to minimize risks from disease epidemics, the various all-India workshops dealing with crops identified additional varieties for pre-release testing and multiplication. While identifying varieties for release or pre-release multiplication, particular attention was paid to their reactions to pests and diseases.

In horticulture, a project for the improvement of fruit trees suitable for cultivation in semi-arid and arid areas was initiated at several centres. A team was sent to a few countries where date palm is grown extensively on a commercial scale for identifying suitable material for introduction and for developing a plan for more extensive cultivation of date palm in suitable areas in our country. To collect and maintain the germplasm of mango, the Mango Research Centre in Lucknow was suitably assisted. A centre of the Indian Institute of Horticultural Research is being established in Gujarat for the collection, maintenance and improvement of fruit trees suitable for cultivation in the western part of the country. Steps have to be taken to develop a similar centre in south Bihar.

In animal sciences, research on broilers led to the identification of a strain with good production potential. Steps were taken to develop the National Goat Research Centre near Mathura. The Karakul Sheep Breeding Centres at Bikaner and Kargil made
further progress. Steps were taken to review the on-going research in buffalo and develop plans for strengthening research on this important dairy animal.

The Central Institute of Agricultural Engineering at Bhopal and the Central Institute of Cotton Research at Nagpur, established during the Fifth Plan, made further progress in developing the necessary infrastructure for research. The National Bureau of Plant Genetic Resources moved to a separate building within the campus of the Indian Agricultural Research Institute and also acquired a farm of about 40 hectares in the Delhi State.

Agricultural universities were assisted in improving their educational and research facilities as per the recommendations of the Norms and Accreditation Committee of the ICAR. A committee headed by Dr M. S. Randhawa, former Vice-Chancellor, Punjab Agricultural University, was set up to review the educational programmes of agricultural universities and make recommendations on:

(a) methods of reorientating the educational programmes in such a way that they could lead to the training of non-elite farm graduates capable of taking to a career of self-employment, and

(b) reorientation of home science education so as to serve the needs of rural women.

The committee is expected to submit its report shortly.

In the area of extension education, a chain of Krishi Vigyan Kendras was set up. The Kendras are based on the principle of learning by doing and, therefore, literacy is not a prerequisite for admission to the Kendras. Trainers’ Training Centres have been set up in order to train teachers who are capable of imparting the latest skills to farmers and fishermen in agriculture, animal husbandry and inland and coastal aquaculture.

Further progress was made by the operational research projects of the ICAR designed to identify the operational constraints which have to be overcome before the untapped production reservoir existing in different parts of the country at current levels of technology can be tapped. Review committees were set up to assess critically the results accomplished so far under the different operational research projects.
Direct recruitment to the S-1 cadre of the Agricultural Research Service is done through an all-India competitive examination held by the Agricultural Scientists' Recruitment Board, which functions as an autonomous recruitment agency for the ICAR. The third all-India examination was held during February 1978. The five-year assessment procedure for scientists was introduced and a large number of scientists in different institutions were granted, on the recommendations of the ASRB, either promotion to the next higher scale or advance increments. The major aims of the Agricultural Research Service are:

(a) Foster co-operation in the place of unhealthy competition.

(b) Enable scientists to get the highest salary possible within the system while remaining rooted to work in their respective discipline/field, thereby eliminating both the undue importance attached in the past to research management posts and the quest for such positions purely for advancement of salary.

(c) Promote an outlook where solving a specific field problem through inter-disciplinary team-work is regarded as the primary goal of research rather than the worship of a discipline or publication of papers.

(d) Promote horizontal and vertical mobility and pay adequate attention to neglected and backward areas.

(e) Link rights and responsibilities and instil through the five-year assessment system the conviction that dedicated and efficient discharge of responsibilities alone would be the means of securing professional advancement.

The ICAR has also introduced the 5-year assessment system for technical services.

Both the research and popular journals of the ICAR were brought up to date. Steps were taken to start a new journal in Hindi, Phal-phool. A special publication on the control of desertification was brought out on the occasion of the UN Conference on Desertification held at Nairobi in August—September 1977. A few awards were won by the Publications Wing of the ICAR for its books and journals.

In scientific work, interaction with scientists and scientific institutions working on allied problems in different parts of the
world leads frequently to purchasing time in the matter of improve-
ment of production technology. In addition to the on-going collabora-
tive programmes with several countries and international re-
search institutes, the ICAR also entered during the year into col-
laborative agreements with the Philippines Council of Agri-
cultural Resources Research, the West African Rice Development
Association and the South-East Asian Fisheries Development
Centre. Two new features were introduced in the collaborative
programme with the USSR which will enable:

(a) a few Ph.D. students from agricultural universities
and the Indian Agricultural Research Institute to do
part of their thesis work in selected fields like cotton
improvement, research on fruit trees, etc., in suitable
institutions in the USSR, and

(b) undertaking joint expeditions for collecting plant
material.

The ICAR has been asked by the Government of India to
render help to Viet Nam in the establishment of a Rice Research
Institute and a Buffalo Research Centre. A team of scientists
visited Viet Nam to finalize the details.

The devastating effects of the cyclone in Andhra Pradesh and
Tamil Nadu were analysed by teams of scientists and an intensive
programme of survey and assistance was launched in the follow-
ing areas:

(a) technical assistance in methods of drying soaked
grains,

(b) screening of the fungal load in grains which were saved
from total loss with a view to examining the possi-
bility of development of mycotoxins in them, leading
to liver ailments,

(c) technical advice on cropping strategies which can
help to take quick-yielding crops and derive a
higher return,

(d) reducing damage to soil fertility as a result of inun-
dation with sea water as well as sand deposition,

(e) introduction of techniques of fortification of locally
available cellulosic wastes in order to provide the
minimum essential nutrition to farm animals, and

(f) monitoring the build-up of rodent population.
A publication containing a summary of the main findings of the Study Teams was brought out by the Andhra Pradesh Agricultural University.

Approach to Agricultural Research and Education in the Medium-Term Plan

The Working Groups on Agricultural Research and Education have made the following major recommendations for intensifying agricultural research and education activities during the Medium-Term Plan starting in April 1978.

The major thrust of agricultural research in the next Plan period will be on the development of techniques for bringing about a further improvement in terrestrial and aquatic productivity without detriment to the long-term production potential of soil and water. In addition to the stress on productivity improvement, work on imparting greater stability to production through intensive research on agro-meteorology and pest management will be undertaken. Early warning system for pest outbreaks and alternative cropping systems to suit different weather models will be developed. Contingency plans supported by appropriate seed reserves will be introduced to insulate to the extent possible crop production from weather aberrations. Improvements in agricultural productivity in the past have been often associated with an increasing demand of non-renewable forms of energy. Since energy is likely to be a critical limiting factor in improving crop and animal productivity in the coming years, more intensive research on the use of recycling techniques, solar energy and integrated nutrient supply and pest-management systems will be undertaken. In keeping with the national goal of making agriculture a potent instrument of not only meeting the food needs of our people but also of generating greater opportunities for gainful employment in the villages and thereby assisting in improving the purchasing power of those below the poverty line, research on all aspects of post-harvest technology will be greatly intensified. It is only through improved post-harvest technology that value-added products can be prepared in the village itself besides avoiding quantitative and qualitative losses to the harvested produce. Also, through improved post-harvest technology all organic wastes and cellulosic material like straw can be enriched and made into complete food for farm animals, thereby helping in the establishment of fodder and feed banks to support the animal husbandry programmes introduced for the benefit of marginal farmers and landless labour.
The organization of research during the next Plan will be through agricultural universities now numbering 21 in the country, central institutes managed by the Indian Council of Agricultural Research (ICAR) and all-India co-ordinated research projects. Agricultural universities will be the principal agents for conducting research on all aspects of crops, farm animals, fisheries and forestry in relation to the major farming systems of each State. Research in the area of agro-forestry involving sylvi-pastoral systems and sylvi-animal husbandry or sylvi-aquaculture systems will receive particular emphasis. The breeding of quick-yielding leguminous shrubs and trees for providing fodder, fuel and fertilizer, through the fixation of atmospheric nitrogen, will receive particular attention in the agricultural universities. It is proposed to set up a National Agricultural Research Fund, with support from the International Bank for Reconstruction and Development, to enhance the capability of agricultural universities to carry out location-specific research in the major agro-ecological zones of each state. State Governments will be requested to assume greater responsibilities in supporting research and educational institutions. They will be requested to specifically earmark the budget for agricultural research and education in the overall budget for agriculture and rural development.

The conservation, cataloguing and utilization of our major agricultural assets will receive added attention. For this purpose, the National Bureau of Soil Survey and Land Use Planning and the National Bureau of Plant Genetic Resources will be strengthened.

In addition, it is proposed to organize a National Bureau of Animal and Fish Genetic Resources. Through these agencies, steps will be taken to prevent the erosion of valuable genes, thereby preserving for posterity the fruits of thousands of years of natural and human selection. In addition to the on-going research programmes on the reclamation of alkaline soils, research on the improvement of the productivity of areas affected by soil and water salinity will be intensified. Acid soils will also be given greater attention.

The central institutes of ICAR will be suitably strengthened for enabling them to carry out mission-orientated basic research, applied research and appropriate educational and training programmes. Important farm animals like the buffalo and goat which did not receive adequate scientific attention in the past will
be given special attention through the establishment of new central institutes. In addition, a central institute for research on all aspects of soil health care and fertility will be established. All aspects of water-management research will receive added stress, in the light of the vastly expanded programme for irrigation. It is also proposed to establish a Centre for Agricultural Economics for assisting in carrying out a micro-level constraints analysis through agricultural universities on the biological and socio-economic constraints which are responsible for the vast untapped yield reservoir existing even at current levels of technology in most farming systems. While the Central Institute of Cotton established during the Fifth Plan at Nagpur will intensify research on improving the yield potential of rainfed cotton, including the development of hybrids of short and medium-staple varieties, the National Centres for Research on Major Oilseeds like groundnut and pulses will be established at suitable agricultural universities or central institutes. Work on achieving a yield breakthrough in jute, possibly through hybrid jute, will be explored.

Farming systems research will receive intensive attention through multi-disciplinary operational research projects. The major systems to be studied will include:

(a) multiple and relay cropping in irrigated areas,
(b) rainfed farming in semi-arid and arid conditions involving water harvesting and run-off recycling on a watershed basis,
(c) inter-cropping and mixed cropping,
(d) mixed farming involving crop-livestock, crop-fish and crop-livestock-fish integrated production system,
(e) kitchen gardening including home fish gardening in appropriate areas,
(f) three-dimensional cropping in garden lands involving an optimum use of the cubic volume of space available, and
(g) integrated sea-farming involving a suitable blend of culture and capture fisheries.

In addition to giving immediate attention to techniques which can help our farmers and fishermen to derive benefit from existing technology steps will be taken to strengthen mission-orientated basic research through the establishment of National Research
Centres of Excellence headed by professors of eminence. Such national research centres will pay attention to basic research in areas such as photosynthesis, nitrogen fixation, animal reproduction, animal nutrition, organic recycling, phosphorus management, integrated pest management, and the other fields recommended by the National Commission on Agriculture.

In the field of agricultural education, stress will be on training farm graduates who can return to a career in farming. Additional Krishi Vigyan Kendras will be developed to spread the latest technical skills to farmers and fishermen through the process of learning by doing. In addition to formal and non-formal education through agricultural universities and Krishi Vigyan Kendras, training programmes for developing cadres of self-employed soil-health-care, plant-health-care and animal-health-care workers will be promoted. The major training strategy in such programmes will be to combine certain universal principles of soil health, animal and plant health etc. with the unique practical problems faced by the farmers in the particular village from where the trainee comes from. Extension education programmes will be strengthened by enlarging the National Demonstrations Programme so as to include both systems and factor demonstrations. Mixed farming, freshwater aquaculture and mariculture demonstrations will be new features of the next Plan. Operational research projects will be developed in command areas so as to demonstrate the latest techniques of water technology.

International collaboration in research will be strengthened in an appropriate manner within the context of technological self-reliance. Technical co-operation among developing countries in agricultural research will be fostered.

Linkages between research and development agencies will be strengthened through appropriate institutional devices. A special quota will be provided in the Agricultural Research Service of the ICAR for secondment to development projects on the basis of felt-needs. Manpower training will be accorded the highest priority. Wherever training institutions are not available, steps will be taken to set up appropriate institutions. Thus an Agricultural College will be set up in Nagaland specifically for carrying out research and training in the area of jhum control and other specific problems of the north-eastern Himalayan region. Research will also be strengthened in Jammu and Kashmir so as to assist in solving serious problems like apple scab and for promoting pasture and sheep development.
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.

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 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 co-ordinating and directing a well-organized national grid of co-operative research. In this system four sets of institutions are involved, viz. 21 agricultural universities, 30 central institutes, 4 project directorates and 52 all-India co-ordinated research 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, 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 are headed by the Director-General, ICAR, and 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**

An Agricultural Research Service has been introduced with effect from 1-10-1975 for the scientists working under the Council. The salient features of the Service are that it is a scientist-oriented Service rather than post-oriented. The Service has 3 main grades of scientists, viz. S-1, S-2 and S-3, in the pay scales of Rs 700-1300, Rs 1100-1600 and Rs 1500-2000 respectively. Currently, there is also a grade 'S' in the service in the scale of Rs. 550—900. As soon as the existing grade 'S' scientists are absorbed in grades S-1 and above, there will be no 'S' grade in the service. The scientists in the Service are eligible for assessment
for promotion/advance increments after completion of 5 years’ service in a grade irrespective of the occurrence of vacancies, the assessment being done by the ASRB with the help of eminent outside experts.

**Agricultural Scientists’ Recruitment Board (ASRB)**

Recruitment to different grades in the Agricultural Research Service (ARS) and the Technical Service is made through the ASRB. The ARS was initially constituted with 2,312 scientists drawn from employees recruited before 1 October 1975 and the number of scientists so far inducted into Agricultural Research Service is 3,100. Direct recruitment to the Agricultural Research Service in grade S-1 (Rs 700–1300) was made through an all-India open competitive examination and 897 scientists were so recruited in 1976 and 1977. A total of 647 posts have been advertized for recruitment through the examination held in early February 1978. In the first Five-Yearly Assessment, the ASRB has recommended 1,301 scientists for promotion to the next grade/grant of advance increments.

For the research-management positions, which are at the institutes and ICAR Headquarters, the grades S-4 (Rs 1800–2250), S-5 (Rs 2000–2500), S-6 (Rs 2500–3000), S-7 (Rs 3000 fixed) and S-8 (Rs 3500 fixed) have been provided, which comprise the posts of Director-General, Deputy Director-General, Directors of the Institutes, Project Directors, Joint Directors and Assistant Director-General. The posts in grades S-4, S-5 and S-6 are filled by advertisement and selection by Agricultural Scientists’ Recruitment Board on a tenurial basis, and are outside the Agricultural Research Service.

The Council has restructured its personnel policies also towards other categories of the staff, viz. technical, administrative and supporting, for which recruitment and promotion rules have been rationalized to provide for better prospects of career advancement. A 5-year assessment procedure has also been introduced for members of the technical services.
III. CONSERVATION OF RESOURCES

Plant, animal, soil and water constitute the important and essential basic resources of agriculture. Their systematic conservation and scientific management in a planned manner are as important as the management of agriculture itself in its varied facets. The National Bureau of Plant Genetic Resources, National Bureau of Soil Survey and Land Use Planning and the Water Technology Research Centre of the Indian Agricultural Research Institute have been constantly endeavouring to study and develop methods which would lead to better management of resources so that their productive efficiency could be maintained over a longer period. So far there has been no centralized agency in the country concerned with the conservation and management of animal and fish genetic wealth. To overcome this lacuna, it has been planned to set up shortly a National Bureau of Animal and Fish Genetic Resources. Some of the highlights of the work done in this sphere are summarized below.

Plant Genetic Resources

The National Bureau of Plant Genetic Resources supplied 10,000 certified seed samples to outside agencies. Over 76,000 samples of various crops and their closely related species were collected through its organized plant-exploration activities within the country.

The exotic material collected by the Bureau belonged to the national and international trials for breeding and testing of improved varieties of wheat, rice, maize, soybean, barley, sorghum, sugar beet, greengram, tomato, onion, potato, tapioca, safflower, coconut, temperate fruit plants and other crops.

More than 65 per cent of the exotic samples were found infested, and hence were given suitable treatments before their release to actual users. Besides, 3,280 imported samples were subjected to X-ray screening and hidden infestation by pests was detected in 151 samples. A new procedure was developed to import lac-insect germplasm in the form of brood lac. Literature on the world pests, nematodes and pathogens of selected pulse crops and coconut was compiled to identify the species not so far reported to occur in India and to list those involving quarantine risks for the country.
Plant exploration was undertaken in various parts of the country to augment germplasm variability, and over 4,000 collections were added to the germplasm pool of the country. Gujarat and Rajasthan were surveyed for the collection of local wheats, particularly the types adapted to salinity and drought. Germplasms of *Triticum aestivum*, *T. durum* and *T. dicoccum* showing variability were collected. The tribal-dominated tracts of Tripura and Garo Hills and of Meghalaya were explored for collection of traditional or local types in cotton, jute and mesta. The regions of north-eastern India, Himachal Pradesh, central, eastern and southern India (parts of Madhya Pradesh, Bastar, Bihar, Orissa, Tamil Nadu and Kerala) were surveyed for ginger germplasm. The forests of Kanara Ghats in Karnataka were surveyed for germplasm of the medicinal plant *sarpagandha* (*Rauvolfia serpentina*). Varieties of medium-coarse-grained rice (including local glutinous rices), popcorn and other maize types, *Setaria, Coix*, tall form of sorghum, soybean and other pulses, sesame, *Solanum* spp. and cucurbits were collected from Tripura and the Garo hills. From eastern India, sorghum, finger millet (*ragi*), minor millets, niger, sesame, *Brassica* spp., horsegram, rice-bean and other legume germplasms were collected.

Among the exotic introductions, the greengram selections 'PIMS 1', 'PIMS 2', 'PIMS 3' and 'PIMS 4' proved highly tolerant to yellow-mosaic virus and gave high yield. Okra (*bhindi*) variety 'Sel 2' showed freedom from yellow-vein-mosaic virus under field conditions. A collection of 72 accessions of Goabean or winged-bean (*Psophocarpus tetragonolobus*) was built up for studying the extent of variability. It is a multipurpose tuber-forming legume species. In clusterbean (*guar*), high-seed-yielding variety 'Sona' and early-maturing variety 'Suvidha' (suitable for growing in rotation with wheat) were recommended for general cultivation as seed-cum-yielding types. For vegetable, 'Sharadbahar' (branched, non-lodging) clusterbean, and 'Assem' and 'Rituraj' cowpea were recommended for release.

**Animal Resources**

India has 175 million cattle, 53 million buffaloes, 42 million sheep, 60 million goats and 9 million other livestock. All these comprise a rich genetic resource, available for exploitation for higher production. Though generations the animals have adapted themselves to the diverse local conditions of climate, soil
feeding and management practices. This genetic base is being augmented through the introduction of exotic germplasm. The introduction of exotic breeds and their utilization to breed better stock of animals might relegate the native stocks into relatively insignificant position, which would ultimately lead to their extinction. This would result in the loss of valuable genes which conferred on the local stock such desirable traits as adaptability to varied agro-ecological and management conditions, disease resistance and other desirable characteristics. Similar is the case with fish. To ensure conservation and preservation of indigenous germplasm resources of different species of animals like cattle, sheep, goats, pigs and poultry as well as fisheries, it is proposed to set up a National Bureau of Animal and Fish Genetic Resources in the next Plan. This Bureau, in addition to being a repository of genetic stocks, will identify species and strains of domestic livestock that have potentialities of economic importance and will supply them for utilization in the current and the future development programmes.

With the introduction of 'Mohair' breed of goat and 'Karakul' sheep, a cross-breeding programme for the improvement of pashmina and pelt qualities in goat and sheep, respectively, was started. It is proposed to introduce fur (mink) animals for the improvement of fur quality and quantity. An Indo-USSR protocol provides for the import of rabbits for meat and fibre (fur) production from the USSR.

Soil Resources

The National Bureau of Soil Survey and Land Use Planning completed the survey and mapping of about 6.3 million hectares in Punjab, Maharashtra, Gujarat, Karnataka, Kerala and the north-eastern region. The survey, supported by field correlation and laboratory characterization of bench-mark soils, helped (i) in the delineation of potential areas for agricultural crops like wheat in Delhi, plantation crops like coconut in Karnataka and fruit crops like orange in Maharashtra, (ii) in the preparation of scientific land-use plans for hill areas, integrated rural development districts and national research centre for goat development, and (iii) in making a proper land appraisal for command-area development programmes in Gujarat and resources inventory in the North-Eastern Himalayan Region and Bundelkhand Region (Uttar Pradesh and Madhya Pradesh).

The crop-potential map of Delhi territory has revealed that nearly 40 per cent of the territory has the best potential for wheat.
Productivity studies conducted on fine loamy soils under 3 levels of management showed that differential responses to management are due to differences in soil-moisture relationship and texture. Highest yields were obtained on fine loamy soils under irrigation and assured moisture supply.

In Karnataka, the survey conducted in the Bangalore, Tumkur and Hassan districts has shown that soil properties are correlated with the quality of coconut produced. The quality of coconuts grown in Tumkur and Hassan districts was found to be far superior to that of the coconuts produced in Bangalore district. There was a marked difference in morphological, physicochemical and mineralogical properties of the soils of the two regions.

In Maharashtra the survey was conducted in and around Nagpur to assess the soil characteristics and properties that are responsible for the production of good-quality oranges. The orchards in Panjra soil series were found to be superior to those of Lisga series in fruit quality, yield, growth condition and longevity.

As a part of the resource-inventory preparation for the various districts selected for integrated rural development, surveys were completed for Chandrapur and Wardha districts in Maharashtra, for Cannanore in Kerala and for Tumkur in Karnataka.

**Water Resources**

The total water resources of India amount to 400 million ha-m. Of this, 70 million ha-m are lost as direct evaporation, 115 million ha-m form the surface run-off, 165 million ha-m contribute to the soil-moisture storage and 50 million ha-m contribute to the ground-water storage. The annual ground-water recharge is estimated to be 67 million ha-m, of which 13 million ha-m is extracted for various uses. On full development of water resources of India, the estimated total ground-water extraction comes to 35 million ha-m. The entire utilisable quantum of water resources would be fully developed during the next 25 to 50 years. Our water resources are insufficient to meet the long-term requirement of agriculture, industry and other users, unless their judicious and economic use is ensured. In most of the canal-irrigated areas the available water is less than two-thirds of the amount required for intensive cropping. This calls for concerted efforts to increase the efficiency. Through
conservation, tillage practices and matching crop management, agricultural production may be greatly accelerated in rainfed areas. A major area in increasing irrigation efficiency is an improved conveyance system. Conveyance loss in the canal-irrigated areas is estimated to be about 45 per cent in the canal system including the water courses. There is an additional loss in field channels due to deep percolation, depending on the local agro-climatic situations. Drainage of excess water from the farm, planning of suitable cropping system to increase water-use efficiency and suitable fertilizer-management and plant-protection procedures should go hand in hand with efficient water management. Gradual improvement in the regulation of canal, restricting the canal flows during the rainy season (kharif) and providing water during the winter season (rabi) would greatly accelerate agricultural production in the area. Such studies form a prerequisite for a planned development of water resources of any region.
IV. RESEARCH ACCOMPLISHMENTS

1. CROPS—RICE

New High-yielding Varieties

The Central Subcommittee on Release of Varieties recommended the release of 2 rice varieties, viz. ‘Akashi’ (‘IET 2914’) and ‘Rasi’ (‘IET 1444’). ‘Akashi’ is noted for consistent high yields in the co-ordinated trials by virtue of its earliness and grain dormancy. It is suitable for rainfed upland conditions. Its suitability to multiple cropping programmes and as a substitute for ‘Bala’ with potential for high yield are its other merits. ‘Akashi’ is suited for rainfed upland conditions and situations requiring early varieties in Uttar Pradesh, parts of Madhya Pradesh, Bihar, Orissa, West Bengal and Karnataka. ‘Rasi’ is ideally suited for problem soils, especially those with low phosphate, and for rainfed upland conditions. It is resistant to blast, moderately resistant to tungro virus and bacterial leaf-blight. It has been consistently yielding high in both national and international trials. The variety is comparable to ‘Pusa 2-12’, which however has become unpopular due to susceptibility to blast, despite other merits. It is recommended as an early variety in rainy season (kharif), as summer crop in Telengana region of Andhra Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu, parts of Uttar Pradesh and Koraput district of Orissa, for rainfed upland conditions and for regions with low phosphate in the soils.

The Central Subcommittee on Release of Varieties also recommended 4 promising varieties of local importance for placing before the relevant State Seed Subcommittee for consideration for release in their respective states. The varieties are ‘Prakash’ (‘RP 4-14’) and ‘Surekha’ (‘WL 13400’) for Andhra Pradesh and ‘Garima’ (‘IET 2080’) and ‘Kranti’ (‘R 20222’) for Madhya Pradesh.

Collection and Maintenance of Germplasm

In an attempt to identify suitable donors for the breeding programme, a large germplasm bank of 15,000 varieties from
India and abroad has been built up at the CRRI, Cuttack. The following material showed resistance to pests and other stresses:

- **Stemborer**: ‘ARC 10443’
- **Early submergence**: ‘ARC 12749’, ‘ARC 12751’, ‘ARC 12753’, ‘ARC 12773’

**Breeding Varieties for Different Situations**

Varieties suitable for upland situation.—In the upland situation, short-duration varieties (90–120 days) are preferred. In general, short-duration cultures from *indica* × *japonica* crosses were found highly suitable for direct-seeded upland condition, giving a yield of 4 tonnes/ha. Some new cultures like ‘CR 143-2-2’, ‘CR 141-2-192’, ‘CR 125’-series and ‘RP 79’-series possessed ability to withstand drought and also recover after a drought spell, and thus showed potentiality for zones having rainfall of 900–1,100 mm.

Of a number of cultures developed at the IARI and entered in all-India trials, ‘Pusa 37’, ‘Pusa 4-4-11-1’ and ‘Pusa 44-33’ were found promising. In the mid-early group, ‘Pusa 37’—with a maturity period of 125 days—combines field tolerance to bacterial blight and good cooking quality though it has coarse grains. Its yield is not significantly inferior to ‘IR 8’ or ‘Jaya’. ‘Pusa 4-1-11-1’, a sister selection from ‘Pusa 4-1-11’, has done extremely well in adaptive trials in Tamil Nadu and is likely to be released shortly by the state. Breeding for upland rice led to the identification of 2 promising selections, viz. ‘DC 86’ and ‘DC 89’, from the material received from the International Rice Research Institute.

Varieties suitable for lowland situation.—The lowlands, which form 60 per cent of the rice area in India, can be classified under 2 categories, viz. (i) waterlogged lowland, and (ii) flood-affected lowland. Generally, longer-duration varieties (150 days) are preferred. Highly productive photo-sensitive, non-lodging,
medium-tall lines derived from the crosses 'Jagannath'×'Pankaj', 'CR 70'×'Pankaj' and 'Jagannath' natural crosses have given yields of 4–6 tonnes/ha in waterlogged areas of intermediate water depth of 5–30 cm under average crop management. In the all-India trials, several lines derived from these crosses gave higher yields (up to 4.5 tonnes/ha) than the control in jute-rice rotation under late-planted conditions.

During rainy season (kharif) of 1977, the effect of different levels of waterlogging (10, 30 and 50 cm) on the yield of 8 popular late-duration types/cultures ('Mahsuri', 'CRM 10-22', 'NC 1201', 'CRM 9622', 'Jagannath', 'FR 43B', 'KR 1-14' and 'IR 442-2-58') was assessed. The yield progressively decreased with the increase in water depth. 'Mahsuri' gave the highest yield in all treatments, i.e. 5,155 kg at 10 cm, 4,085 kg at 30 cm and 3,737 kg at 50 cm.

'CRI 141-198' and 'IET 5656' were found suitable for low-lying situations during kharif in parts of Andhra Pradesh, West Bengal and Tamil Nadu.

Varieties suitable for hilly region.—A mutant ('13-14') from 'JBS 508' was found suitable for high-altitude areas, giving a yield of 3,980 kg/ha at Jammu, compared with 2,810 kg/ha of 'Basmati'.

In a preliminary acclimatization study with 64 different fixed hybrids and mutants grown at Gangtok farm, 15 were found suitable for Sikkim, and 3 japonica × indica hybrids proved good for early harvesting.

In the trials conducted at different locations by the ICAR Research Complex for North-East Hill Region, Shillong, 'Pusa 2-21' and 'Pusa 33' showed wide adaptability for this area. At the Vivekananda Pravatiya Krishi Anusandhan Shala, Almora, for the first time a yield potential of 50 q/ha was recorded from 'KH 863' under irrigated conditions.

Breeding Varieties Resistant to Pests and Diseases

Gallmidge-resistant cultures.—Gallmidge is a very severe pest in the monsoon season in Orissa, Madhya Pradesh, Andhra Pradesh, Kerala and Tamil Nadu. The CRRI has recently identified a number of gallmidge-resistant cultures. 'CR 94-CRS 1512-1', 'CR 94-221-3', 'CR 95-46-1', 'CR 94-ORS', '1512-1' and 'CR 95-46-1' were tried in Sambalpur and Angul districts of
Orissa during kharif 1976 and they yielded 4 to 6 tonnes/ha under unprotected conditions, whereas the control ‘Ratna’ yielded only 2.5 to 3 tonnes/ha under similar conditions.

**Brown planthopper-resistant cultures.**—Brown planthopper has become a serious pest of rice in recent years and is causing heavy damage in several parts of the country. Under greenhouse conditions, ‘CR 57-21’, ‘CR 95-13-3’ and ‘CR 190-62-13’ were found moderately resistant to brown planthopper and these are undergoing testing in hot-spots.

**Disease-resistant cultures.**—Two mutants of ‘C 1039’ (‘No. 5-90’ and ‘No. 6-106’) proved resistant to 7 strains of *Pyricularia oryzae*. Mutant ‘No. 6-106’ showed high yield potential too.

‘CR 44’-series and ‘CR 129’-series were highly tolerant to bacterial blight in different states. Some cultures of ‘CR 44’-series yielded nearly 6,000 kg/ha when ‘IR 8’ showed high incidence of diseases and yielded only 4,302 kg/ha.


**Management of Upland Rice**

In an effort to improve the yield of upland rice (10 per cent of total rice area), which is at present only 700 kg/ha, a viable technology ensuring 2.5 tonnes/ha was evolved, the basic characteristics of which are:

(a) where May rains are adequate for land preparation, recourse to drilling with a seed density of 200/m²
as soon as cumulative rainfall of 50-60 mm is received in June,

(b) weeding before the crop is 3 weeks old, and

(c) withholding application of nitrogen at seeding and applying it (30 kg N/ha) in 3 split doses at 21 and 45 days after sowing, and at booting stage, followed by incorporation into soil by a hand-rake or hoe.

**Integrated Nutrient Management**

Under transplanted condition the effect of integrated nitrogen supply through chemical nitrogen (20 and 40 kg/ha) supplemented with organic waste and non-symbiotic N-fixers was evaluated for increasing yield.

(a) At 20 kg N/ha as chemical N, the best method of integrated nitrogen management was to apply 4 tonnes/ha of *Azolla* +3.3 tonnes of slurry from gobar-gas plant as a basal dose, transplanting seedlings dipped in *Azotobacter* for 1 hr and then applying the chemical nitrogen (20 kg/ha) in 2 equal splits at active-tillering and panicle-initiation stages. The total N applied in this case was worked out to 20 kg N/ha as organic+20 kg N/ha as chemical. The yield increase over the unmanured plot was 900 kg/ha, i.e. a grain response of 23 kg per kg N applied.

(b) At 40 kg N/ha as chemical N, the best method was to apply 4 tonnes/ha of *Azolla* as a basal dose, followed by chemical nitrogen (40 kg/ha) in 3 split doses. The total N applied worked out to 50 kg/ha. These plots gave 1,125 kg/ha more yield than the unmanured plots, i.e. a grain response of 22.6 kg N.

(c) An increase in yield (9.40 per cent over the control) equivalent to the application of 30 kg N/ha was obtained with incorporation of a layer of *Azolla* (0.3-0.4 per cent N).

In uplands, rock phosphate acidulated with hydrochloric acid containing 50 per cent of the phosphate in water-soluble form could be successfully used on acid soils. In flooded soils combination of compost to supply 30 kg N/ha applied 2 weeks before shooting, followed to 30 kg N/ha, was beneficial.
Prolonged Seed Viability

The viability of rice seeds is normally lost within 6 to 8 months after harvest. The loss in viability is more rapid during the monsoon season due to high-moisture content in the seed, high humidity and higher temperature. An experiment conducted at the Central Rice Research Institute, Cuttack, showed that seed viability could be prolonged by simple methods like treating the seeds (3-4 months after storage) in disodium hydrogen phosphate (Na₂HPO₄, 20 mg/litre) solution for 6 hr and drying them again to normal moisture. The treated seeds gave more than 80 per cent germination even after 16 months of ordinary storage, whereas the control seeds lost viability completely within 8 months after harvest.

Effect of Hormone Spray

To assess the relative efficiency of commercial hormones (auxin H-61, Planofix, Planovita) and micronutrient mixtures (Agromin and Nusparlin) experiments were conducted at the Central Rice Research Institute, Cuttack, during rainy and winter seasons 1976 and rainy season 1977 with 5 varieties belonging to early, medium and late duration. In general, auxin H-61 (1:2000 dilution) increased the grain yield by 10-15 per cent when sprayed at the maximum-tillering and booting stages.

Photosynthetic Efficiency of Rice Cultures

The photosynthetic efficiency, photorespiration rate and light-saturation point for photosynthesis were determined in 48 popular high yielding and local varieties. In general, 'NC 1281' and 'T 100' showed high efficiency in photosynthesis under low light intensity, and 'Ratna', 'Patnai 23' and 'Peta' showed lower photorespiration value. In most varieties the light-saturation point for photosynthesis was reached at 50 Klux, whereas in 'TR 8' and 'N 22' the rates increased even up to 70 Klux, indicating their efficiency mostly at higher light intensity.

Photosynthetic rate was highly associated with specific leaf weight or leaf thickness, indicating the possibility of the use of this character as a simple and valuable selection index for higher photosynthetic efficiency.

Biochemistry

Biochemical studies in rice showed that drought affects the incorporation of "C leucine in protein and "H uridine in nucleic
acid, and thus affects the rice plants by interacting with genetic control mechanism of the level of nucleic acid and protein synthesis.

**Agricultural Economics**

Studies conducted on the cost of cultivation of rice and marketable surplus in Operational Research Project areas revealed the following:

(i) The cost of cultivation was Rs 1,048/ha for local varieties, Rs 1,340/ha for high-yielding varieties in rainy season, and Rs 2,300/ha for high-yielding varieties in winter season. The cost per quintal of paddy was Rs 45 in rainy season and Rs 65 in winter season.

(ii) Nearly 50 per cent of the small farmers had no marketable surplus and about another 33 per cent had annual sales of less than 5 q of paddy, compared with 20 q/annum sale of large farmers.

**Operational Research Project**

Two Operational Research Projects—one on integrated pest control and another on rice production—revealed the following points:

(a) Before the commencement of the project the farmers of the area on an average gave about 4 sprays during the winter season (rabi). Surveillance and use of economic threshold for application of insecticides reduced the number of applications to 2 only at the time of flowering.

(b) The coverage under high-yielding varieties has increased from 16 to 30 per cent.

(c) No gallmidge-resistant variety was being cultivated in the project area. 'Shakti' and 'CR 94-MR-1550' were introduced during 1975, and within 2 crop seasons these varieties now occupy about 5 per cent of the rice area during the rainy season (kharif).

(d) Water management carried out through farmers’ cooperation increased the area under irrigation by 30 per cent.
(e) For scientific fish culture, 18 tanks (each 0.1 to 0.5 ha) were utilized. The income from the fry-rearing was Rs 200–300/pond and from the fish sale Rs 300–3,000/pond. Under subsidized credit, 12 ‘Jersey’ cross-bred cows were given to small farmers. This gave an additional income of Rs 100–150/month after meeting the cost of food and servicing loan and other charges.

**Pest Control.**

**Control of stemborer.**—For the existing cultivated varieties, in addition to carbofuran, 2 applications of AC 64-475 and San 197 granules @ 1.0 kg a.i/ha in standing water were found promising for controlling stemborer.

**Control of gallmidge.**—Application of AC 64-475 and AC 92-100 (counter) at 20 and 45 days could control rice gallmidge, when applied in standing water @ 1.0 kg a.i/ha.

**Biological control.**—For biological control of rice pests, 13 microbial agents have been identified and purified and in 9 cases pathogenicity has been proved.

In upland rice the diseases caused by root-lesion nematode, lance nematode and root-knot nematode could be successfully controlled by the application of 1 kg a.i/ha of fensulfothion, carbofuran and oxamyl as pre-sowing or pre-planting soil treatment. In root-lesion nematode the control was 68–90 per cent, resulting in a saving of 15.5 to 48.5 per cent in grain yield. The rotation of greengram in rice soils was effective in reducing the nematode infestation in the following rice crop. Soil amendment (5 g/kg soil) with fresh roots or shoots of the weed Eclipta alba effectively controlled the root nematode through root exudates.

Incorporation of *Ipomoea* sp. in soil before planting, as a substitute source of nitrogen, reduced the root-nematode incidence. Complete control of white-tip nematode was achieved by soaking seeds in aqueous solution of 100 ppm carbofuran and oxamyl.

**Disease Control**

**Blast.**—Spray application of systemic fungicide, carben-dazim @ 0.5 kg a.i/ha, effectively controlled the foliar and neck infection of blast. Soil application of the fungicide and soil application through mud-balls were also found equally effective in reducing the blast infestation.
During epidemiological studies, it was found that concomitant occurrence of nycto-temperatures below 26°C, relative humidity above 90 per cent and heavy dew deposition on the foliage were favourable for the spread of blast disease.

*Tungrovirus.*—Studies on tungro virus and vector relationship have shown that the fourth- and fifth-instar nymphs and just-emerged adults of *Nephotettix virescens* were most efficient in acquiring the virus.

*Helminthosporiose.*—Application of nitrogen in split doses or in slow release form (mud-ball) was found to be associated with lower incidence of helminthosporiose. Soil application of potassium, calcium, iron and manganese was effective in reducing the incidence of helminthosporiose.

**WHEAT**

The area under wheat in 1976–77 was 20.1 million ha and production a little over 29.0 million tonnes. This is about 16.5 million tonnes more than that obtained during 1964–65, the best year for wheat production before the Wheat Revolution in India.

**Varietal Identification**

Eight wheat varieties have been identified for release for the conditions and areas indicated below.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Area recommended</th>
<th>Conditions for which recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;HD 2204&quot;</td>
<td>North-Western Plains Zone</td>
<td>Timely sown, irrigated, good-fertility conditions</td>
</tr>
<tr>
<td>&quot;IWP 72&quot;</td>
<td>North-Western Plains Zone</td>
<td>Timely sown, rainfed, low-fertility conditions</td>
</tr>
<tr>
<td>&quot;VL 421&quot;</td>
<td>Northern Hill Zone</td>
<td>Timely sown, rainfed, low-fertility conditions</td>
</tr>
<tr>
<td>&quot;K 7410&quot;</td>
<td>North-Eastern Plains Zone</td>
<td>Timely sown, irrigated, good-fertility conditions</td>
</tr>
<tr>
<td>&quot;HUW 12&quot;</td>
<td>North-Eastern Plains Zone</td>
<td>Timely sown, irrigated, good-fertility conditions</td>
</tr>
<tr>
<td>&quot;HW 657&quot;</td>
<td>Peninsular Zone</td>
<td>Timely sown, rainfed low-fertility conditions</td>
</tr>
<tr>
<td>&quot;HI 617&quot;</td>
<td>Central Zone</td>
<td>Timely sown, rainfed low-fertility conditions</td>
</tr>
<tr>
<td>&quot;HW 147&quot;</td>
<td>Central Zone (mainly for Madhya Pradesh)</td>
<td>Timely sown, irrigated, good-fertility conditions</td>
</tr>
</tbody>
</table>
In addition to 'HD 2204' and 'HW 657' developed at the IARI, New Delhi, 2 varieties, viz. 'HP 1102' and 'HP 1209', developed at the IARI Regional Station, Pusa, were recommended for general cultivation by the Department of Agriculture, Bihar. The IARI Regional Station, Indore, developed 2 promising varieties 'Sujata' and 'Malavraj' for the Central Zone.

The Department of Agriculture, Government of India, continued its effort in the replacement programme with the rust-resistant 'Girija' in the northern hills and 'HD 2135' in the southern hills at higher elevations. In multiline trials, 'Kalyan Sona' multilines 'MLKS 11', 'MLKS 18' and 'KML 7406', and 'Sonalika' multilines 'MISKA 9', 'SKAMI 1' and 'HDML 2' proved promising.

The different approaches being developed for minimizing the risk of rust epidemics are shown in Fig. 1.

Fig. 1. Methods of preventing rust epidemics in wheat

Germlasm Collection

For collection of local germplasm, the National Bureau of Plant Genetic Resources and the All-India Co-ordinated Wheat
Improvement Programme organized 2 surveys in Gujarat and Rajasthan. The collections made were planted in the 1977 summer nursery for initial observations.

**Physiology**

Physiological research indicated that selection based on low tillering habit would be more useful for attaining increase in grain yield under optimal cultural conditions, even under limited fertilizer and water inputs.

**Pathology**

It was recommended that all seeds of the varieties susceptible to loose-smut should be treated with Vitavax or Bavistin, and those susceptible to bunt should be treated with Vitavax (0.2 per cent) or Bavistin (0.075 per cent).

**Entomology**

Termites could be controlled by seed treatment with aldrin @ 400 ml of 30 EC/q of seed. Before application, the insecticide should be diluted with 5 litres of water and the emulsion sprayed over the seed uniformly spread on floor. The seed should be turned over to ensure proper mixing. The treated seed should be left overnight for drying before sowing. Alternatively, aldrin 50 per cent dust may be mixed with seed @ 1.25 kg/q before sowing or aldrin 5 per cent or BHC 10 per cent dust @ 25 kg/ha may be used as soil application. The dust may be applied after final ploughing before sowing.

For the control of termites in the standing crop, aldrin 30 EC @ 1.25 litres/ha may be used with irrigation water. This treatment is also effective for the control of root aphids. Alternatively, the same dose of aldrin may be diluted in 5 litres of water and mixed with 50 kg of sand and broadcast in the field. This is effective for unirrigated crop also.

For avoiding the damage from the attack of shoot-fly, strict adherence to the normal sowing period (mid-November to mid-December) was found necessary.

For the control of brown wheat-mite, spray of the following pesticides was found effective when applied at the first appearance of the pest. Formothion (Anthio 25 EC @ 680 ml/ha) or Phosphamidon (Dimecron 100 @ 250 ml/ha), or oxydemeton
methyl (Metasystox 25 EC @ 650 ml/ha). This treatment also controlled the aphids and jassids. If necessary, the treatment could be repeated after 15 days.

For the control of armyworms, gram caterpillar, semi-loopers and pyrilla, the treatments either dusting with BHC 10 per cent @ 25 kg/ha or spraying with carbyral (Sevin) 50 WP @ 2.5 kg/ha or fenitrothion (Folithion) 1000 @ 500 ml/ha or Sumithion 50 EC @ 1.10 litres/ha or dichlovos (Nuvan) 100 EC @ 500 ml/ha were found effective.

**Nematology**

*Earcockle and tundu disease.*—Use of clean seed free from contamination by nematode galls is the surest way to control both the diseases. Contrary to the earlier thinking, the disease can now be identified in the early stages of growth, and hence the plants found infected at the seedling stage may be rogued out.

*Molya disease.*—(a) In fields showing heavy infection of molya disease, pre-planting application of DBCP (60 per cent EC @ 30 litres/ha) in irrigation water was effective.

(b) Two deep ploughings at an interval of 10–15 days given during summer months helped in reducing the nematode population as a result of exposure to heat.

(c) Raising crops other than wheat and susceptible barley for at least 2 years reduced the nematode population appreciably in the infested fields.

**MAIZE**

*Release of a New High-yielding White Maize Variety*

Composite ‘Moti’ was released for general cultivation. This white-seeded medium-maturing composite has been recommended for cultivation in the Udaipur division of Rajasthan, to replace the local popular variety ‘Malan’.

*Improvement of Composite Varieties*

An improved yellow-seeded composite, ‘Diara’, has been developed. It matures in 75–80 days and gives 12 per cent more yield (25–30 q/ha). It is fast becoming popular in the riverine areas of north Bihar. The composite ‘J 1’ (‘Arr 2’) gave 16 per cent more yield. ‘VL 16’ (a medium-early-maturing composite) has shown good promise in the hills of Uttar Pradesh, and ‘VL 42’ (a double-cross hybrid) has been found highly suitable for high-
altitude areas like Uttar Pradesh hills and Himachal Pradesh. 'Ganga 5', 'EH 2420', 'EH 2380' and 'J 603' have shown wide adaptability in the North-Eastern Hill zone.

New Promising Hybrids and Composites

The following hybrids have given good performance under commercial cultivation:

<table>
<thead>
<tr>
<th>Yellow hybrids</th>
<th>'EH 200174', 'EH 2380', 'EH 400175', 'EH 2420', 'J 1-140 J' ('Puerto Rico Gr I-116' × 'Fla 3H94') and 'J 617' × 'Vijay 1250-1'</th>
</tr>
</thead>
<tbody>
<tr>
<td>White hybrids</td>
<td>'Tuxpeno 1B' × 'MS 1', 'VC 69' × '(CM 400 × CM 300)', 'EH 3016' and 'Almeyac 41' × '(CM 400 × CM 300)'</td>
</tr>
<tr>
<td>Yellow composites</td>
<td>'B 21', 'B 31', 'J 43', 'J 52', 'D 751' and 'VC 80'</td>
</tr>
</tbody>
</table>

Development of Hard-endosperm Opaque-2 Varieties

Our past studies indicated that the gains through selection for semi-normal grain types were inconsistent and gave rather low yield, whereas a high frequency of total modified kernels could be rapidly gained in a few cycles of selection. In the current year ear-to-row selection was made on the basis of family performance rather than on the basis of individual progeny. In subsequent cycles, data on reciprocal sibs on family basis will be used in the selection of progenies. This selection procedure will help in unmasking the effect of endosperm dose and the predominant effect of environment to a limited extent.

Development of Maize Material for Winter Cultivation

Recent studies have shown that maize can be successfully grown in the winter season in eastern and southern frost-free states of India. The yields realized from winter cultivation have made maize popular in north Bihar, Tamil Nadu and Andhra Pradesh and it occupies over a quarter million hectares. Initial-evaluation trials on winter maize have shown the possibility of harvesting 8–10 tonnes with better management. Response to fertilizer application in winter was also better than in the rainy season. The promising hybrids and composites found are: 'EH 400175', 'EH 400475', 'EH 2310', 'Comp 108', 'VL 43' and 'VC 80' × 'Tuxpeno br2'. Moreover, a number of second-cycle inbred lines in top crosses gave up to 48 per cent more yield than the best control.
Evaluation of Elite Introductions

Among the introductions received and evaluated during the last year in the Introduction Nursery, the promising introductions were: ‘Jawahar’ × ‘Thai Composite DMR’ and the Indian material ‘Pop III’ × ‘Source 6’. A number of introductions like ‘Bogor II’, ‘M 236’, ‘HP 123’, ‘Suwan Source 5’ and composite ‘DMR 5’ showed resistance to brown-stripe, downy-mildew and stalk-rot under artificial inoculation. Under high natural incidence of common rust at Dharwar, ‘Hybrid 512’, ‘Katumavil B’, ‘Kanya Michoacan’ and ‘South African Composite’ showed resistant reaction. Combined resistance to turcicum leaf-blight, common rust and charcoal-rot was recorded in the winter season in ‘Composite 108’, ‘Ganga 4’, ‘VL 43’ and ‘Kisan’ × ‘Thai Comp 1 DMR’.

Multiple-disease-resistant Composites

The third cycle of selection for improving the level of disease resistance was operated in Erwinia-Pythium-resistant Composite (EPR). Full-sib progenies were evaluated for pythium stalk-rot, leaf- and sheath-blight, turcicum and maydis leaf-blight and sorghum downy-mildew. Based on yield and disease resistance, improved varieties have been developed.

Sources of Resistance to Pinkborer

Pink ragi-borer (Sesamia inferens) is one of the important pests which damage maize during winter season. Under artificial infestation, ‘Jawahar’ × ‘Thai Comp VC 80’ × ‘(Eto × Tuxp br2)’ and ‘Ganga 4’ have shown promise.

Intercultivation of Early-maturing Pulse and Oilseed Crops in Maize

Current studies have further supported the earlier observation that short-duration varieties of oilseeds (like groundnut, sesame, etc.) or pulse crops (greengram, soybean, etc.) can be successfully intercropped with maize without any loss to the maize crop. Intercropping of pulse crops increased the maize yield by 10–15 per cent and helped in the control of weeds.

BARLEY

Seven improved varieties (Table 1) were identified for pre-release mini-kit/adaptive trials by the All-India Barley Research Workers' Workshop during 1977. Among these, 'IDL 171', 'PL 03' and 'RD 103' are semi-dwarf, stiff-strawed, and the remaining ones are tall to medium-tall. 'Ratna', 'DL 36', 'DL 88' and 'RD 103', which have earlier been released/pre-released for various agro-ecological conditions, have shown wider adaptability to newer niches. For example, 'Ratna'—which was released for rainfed areas of Uttar Pradesh, Delhi, Bihar and West Bengal—has given 2.5 q/ha more yield than the standard wheat control in Maharashtra and Karnataka. 'DL 36', which has been recommended earlier for irrigated, timely sown conditions of the North-Eastern Plains Zone, showed adaptation under late-sown conditions of the zone, giving about 15 per cent more yield than the standard control. This variety, besides having high yield potential, possesses field tolerance to yellow-rust, covered-smut, spot-blotch and aphid.

Table 1. Promising barley varieties identified by the All-India Barley Research Workers' Workshop in 1977

<table>
<thead>
<tr>
<th>Zone</th>
<th>Agronomic condition</th>
<th>Variety</th>
<th>Zonal average yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-Western Plains Zone</td>
<td>Rainfed</td>
<td>'DL 157'</td>
<td>29.2</td>
</tr>
<tr>
<td></td>
<td>Irrigated, timely sown</td>
<td>'DL 120'</td>
<td>33.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'DL 171'</td>
<td>33.4</td>
</tr>
<tr>
<td>North-Eastern Plains Zone</td>
<td>Rainfed</td>
<td>'K 141'</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>Irrigated, timely sown</td>
<td>'P 103'</td>
<td>27.0 (Bihar only)</td>
</tr>
<tr>
<td></td>
<td>Irrigated, late sown</td>
<td>'DL 36'</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'DL 88'</td>
<td>20.9</td>
</tr>
<tr>
<td>Central Plains Zone</td>
<td>Rainfed</td>
<td>'DL 100'</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>'RD 137'</td>
<td>16.8</td>
</tr>
<tr>
<td>Peninsular Zone</td>
<td>Rainfed</td>
<td>'Ratna'</td>
<td>21.4</td>
</tr>
<tr>
<td>Maharashtra and Karnataka</td>
<td>Irrigated</td>
<td>'RD 103'</td>
<td>28.2</td>
</tr>
</tbody>
</table>

'DL 88', which was identified for release during the previous year, for irrigated, late-sown areas of the North-Western Plains Zone, gave 17 per cent more yield than the standard control under late-sown conditions of the North-Eastern Plains Zone. 'RD 103', recommended for cultivation in the irrigated areas of northern Rajasthan, showed adaptation to irrigated areas of
Karnataka. Among 3 newly developed strains, viz., ‘DL 120’, ‘DL 171’ and ‘P 103’, identified for cultivation under irrigated, timely sown conditions, the former two are recommended for the North-Western Plains Zone, and the last one for Bihar only. ‘DL 120’ gave, on an average, 3–8 q/ha more yield than ‘Jyoti’ (in Haryana) and ‘BG 25’ (in western Uttar Pradesh and Delhi). This variety also possesses better resistance to spot-blotch and covered-smut. ‘DL 171’ and ‘P 103’ responded well under moderately high soil-fertility conditions. ‘DL 171’ possesses wider adaptability than ‘Ranjit’ (released earlier) in this zone and is particularly suitable for yellow-rust-prone areas of Punjab, Jammu and Kashmir, Haryana, Delhi, western Uttar Pradesh and Rajasthan.

Among 4 new varieties, viz. ‘DL 157’, ‘DL 100’, ‘RD 137’ and ‘K 141’, identified for rainfed conditions. ‘DL 157’ gave 1 to 3 q/ha more yield than ‘DL 3’ and ‘RD 31’ in the rainfed areas of Haryana, Punjab, Rajasthan and western Uttar Pradesh. ‘DL 100’ and ‘RD 137’ gave, on an average, 1 q/ha more yield than the existing varieties in the Central Plains Zone comprising southern Rajasthan, southern Uttar Pradesh and northern Rajasthan. ‘DL 100’ has the additional attribute of field resistance to covered-smut and Helminthosporium. ‘K 141’ gave 32.3 q/ha more yield than ‘K 125’ (‘Azad’) in the North-Eastern Plains Zone (comprising eastern Uttar Pradesh, Bihar and West Bengal) and it possesses better field resistance to yellow-rust and covered-smut.


**SORGHUM**

Abrupt termination of rainfall by the first week of September in 1976, over large portions of sorghum tract, adversely influenced the late-maturing locals, but the high-yielding hybrids and varieties performed extremely well and compensated for the losses suffered by the late locals. In Maharashtra, the largest sorghum-growing state in the country, sorghum production increased 3-fold (2.958 million tonnes).
New High-yielding Hybrids and Varieties for Rainy Season

A new hybrid, 'CSH 6', was released for general cultivation during the rainy season (kharif) of 1977 by the Central Sub-committee on Release of Varieties. During 1972–76, it gave an average yield of 3,390 kg/ha, compared with 3,576 kg/ha of 'CSH 5' and 3,066 kg/ha of 'CSH 1'.

'CSH 6' performed well outside India in countries like Ethiopia, Upper Volta and several other African countries characterized by low and uncertain rainfall. It has a wide adaptation and could be a potential hybrid across continents where semi-arid and uncertain weather conditions prevail. It is recommended for cultivation in all rainy-season (kharif) sorghum tracts of the country as well as for the winter-season (rabi) and irrigated summer-season tracts.

Based on the work of the All-India Co-ordinated Sorghum Improvement Project (AICSIP), Tamil Nadu released '00-21', a tall mutant from 'CSV 5', and Karnataka released 'SB 1066' for general cultivation in their states.

New High-yielding Hybrids for Winter Season

The first rabi hybrids 'CSH 7R' and 'CSH 8R' were released by the Central Variety Release Committee during 1977. The performance of these hybrids is summarized in Table 2. These are recommended for cultivation in the Deccan rabi tract in Maharashtra, Karnataka and Andhra Pradesh. These hybrids performed very well, particularly under advanced dates of sowing.

Table 2. Mean grain yield of sorghum hybrids during winter seasons 1973–74 to 1975–76 in Deccan Plateau

<table>
<thead>
<tr>
<th>Entry</th>
<th>Average yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maharashtra</td>
</tr>
<tr>
<td>'CSH 7R'</td>
<td>2,446</td>
</tr>
<tr>
<td>'CSH 8R'</td>
<td>3,077</td>
</tr>
<tr>
<td>'CSH 1'</td>
<td>2,799</td>
</tr>
<tr>
<td>Local</td>
<td>2,300</td>
</tr>
</tbody>
</table>
Production Technology

A comprehensive production technology for rabi crop has been developed. The essential principles of this technology are:

(i) use of ‘CSH 7R’ and ‘CSH 8R’, (ii) advancing the dates of sowing, (iii) all basal fertilization, (iv) full seed rates, and (v) carbofuran seed treatment. Extensive implementation of this package may result in a breakthrough in the production of winter-season sorghum (rabi jowar).

PEARLMILLET

Development of Disease-free Hybrids

Unlike the previous hybrids, the new hybrids ‘BJ 104’ and ‘BK 560-230’ maintained a high degree of resistance to downy-mildew, giving a yield of 16 q/ha (which is comparable to that of ‘HB 3’ and ‘HB 73’). The yield data from the minikit demonstrations are given in Table 3. Another hybrid ‘BD 111’, has a potential excelling that of all the released hybrids. It gave a yield of 18.8 q/ha compared with 16.0 q/ha of the best hybrid, ‘BJ 104’. Newer hybrids with diverse female and male backgrounds are in the offing, viz. ‘PHB 50’, ‘ICH 105’, ‘ICM 763’ and ‘COH 2’, with a grain yield of more than 18 q/ha under rain-fed conditions, coupled with resistance to downy-mildew.

Table 3. Grain yield of new pearlmillet hybrids in minikit demonstrations

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Average yield (q/ha)</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘BJ 104’</td>
<td>15.9</td>
<td>31.9</td>
</tr>
<tr>
<td>‘BK 560-230’</td>
<td>16.7</td>
<td>48.7</td>
</tr>
<tr>
<td>‘HB 7’</td>
<td>14.2</td>
<td>25.7</td>
</tr>
<tr>
<td>Local</td>
<td>11.3</td>
<td></td>
</tr>
</tbody>
</table>

Diversification of Cytoplasmic Sources

Intensive efforts to develop early, short-statured and disease-resistant cytoplasmic male-sterile lines have resulted in the isolation of ‘PB 201 A1’, ‘Pb 202 A1’, ‘Pb 301 A2’ and ‘PB 401 A3’. They are earlier and shorter (100–130 cm) with longer ears 14–22 cm).
Direct Seeding vs Transplanting

The grain yield of pearl millet, either direct-seeded or transplanted, declined with the delay in planting, especially when direct-seeded. The grain yield in late direct sowing was 4.8 q/ha compared with 16.3 q/ha under transplanting. Therefore it appears that transplanting would be beneficial to offset rapid yield decline if sowings are delayed.

Weed Control

To keep the field weed-free, particularly during the first 4 weeks after germination, hand-weeding was the best wherever feasible. Weedicides could also be effectively used to check weed population. Pre-emergence application of propazine (0.5 kg ai/ha) gave 23.5 q/ha grain and repeated weedings gave 25.4 q/ha. At Jodhpur, pre-emergence application of atrazine (1 kg ai/ha) reduced weed population considerably and the yields of the hybrid ‘BJ 104’ tripled from 4.9 to 15 q/ha.

Plant-protection Measures

Chemical control of downy-mildew.—At the University of Mysore, seed treatment with a systemic fungicide CGA-1-82-50W @ 2 g/kg of seed not only checked but effectively arrested the spread and carry-over of downy-mildew in the soil. Extensive testing on a large scale is, however, necessary.

Downy-mildew control through cultural practices.—Early sowing with the onset of monsoon recorded low incidence of downy-mildew. Transplanting (compared with direct seeding) considerably reduced the occurrence of downy-mildew, particularly under late-sown conditions. Rogueing of disease-infected plants at pre-tillering stage (within 17 days of planting) considerably checked the incidence of downy-mildew because of less secondary spread. In addition to thinning and transplanting, rogueing not only helped reduce infection, but also enhanced the grain yield by 18 per cent.

Chemical control of white grub.—Farmyard manure and BHC 10 per cent @ 60 and 40 kg/ha, besides minimizing damage at all stages, gave maximum yield of 770 kg/ha compared with 260 kg/ha in the control.

White-grub control through cultural practices.—Intercropping of pearl millet with leguminous crops, in addition to providing
nutrition to the main crop by enriching the soil, effectively reduced the white-grub damage. Intercropping of pearlmillet with clusterbean (*Cyanopsis tetragonoloba*) showed minimum white-grub infestation (1.9 to 3.3 per cent damage) compared with greengram (10.7 to 12.9 per cent) and groundnut (16.5 to 26.4 per cent). Mixed cropping with pigeonpea or cowpea also gave some protection to pearlmillet against white-grubs.

**FINGER MILLET**

Attempts were made to identify selections with a wide range of adaptability and test them in minikits. In the early group (90–100 days) 'HR 374' and 'PES 176' with a yield potential of 21 to 23 q/ha, in the mid-late group (110–120 days) 'BR 407' with a yield potential of 25 q/ha, and in the late group (more than 120 days) 'PR 202' with 25 q/ha of yield, were recommended for release during the all-India workshop held in 1977. 'HR 374' and 'PR 202' were included in Minikit demonstrations in the rainy season 1977. 'VL 101' and 'HR 374' showed wide adaptability in the North-Eastern Hill Zone.

**MINOR MILLETS**

Based on all-India performance, 'ISe 702' and 'Arjunia' in *Setaria*, 'Ips 147-1', 'JNK 374' and 'Keharpur' in *Paspalum*, 'IPm 410' and 'IPm 1006' in *Panicum miliare*, and 'MS 4872' and 'PV 1685' in *Panicum miliaceum* were identified as promising cultures and were recommended for minikit demonstrations during the rainy season 1978.

An *Echinochloa* variety, 'Madira' ('VL 8'), evolved by the Vivekananda Parvatiya Krishi Anusandhan Shala, was recommended by the All-India Millet Workshop in 1977. It is early maturing, semi-tall and fertilizer responsive.

**POTATO**

Out of the 3 Indian hybrids selected as field-resistant genotypes against late-blight disease of potato in the International testing ground at Mexico, 'India 1035' and 'India 1038' have proved resistant also to brown-rot. This is the first identified source of resistance to known-rot (*Pseudomonas solanacearum*) in *Solanum tuberosum* varieties.
Under the All-India Co-ordinated Potato Improvement Project, the hybrids selected in the varietal assessment trials showed wide adaptability and high yield potential. The hybrids 'JE 303', 'JE 808', 'JE 4841', 'JF 4870' and 'F 6787' were early-maturing cultures, and 'D 3888', 'E 3797', 'JE 842' and 'E 4486' held out promise as main-season cultures.

'E 4451' was found the best variety at early as well as at maturity harvest (243 q/ha and 264 q/ha), followed by 'C 3721' (216.5 q/ha), at the Rajendra Agricultural University, Patna.

Intercropping of potato, wheat and onion proved profitable at Kanpur, Patna, Chhindwara and Rajgurunagar. At Kalyani and Rajgurunagar, sugarcane was found best suited for the purpose. Rice–potato–sesamum was found best at Bhubaneswar.

In the studies on the comparative efficiency of carriers of phosphorus in acid soils, the treatment with Suphala (15 : 15 : 15) @ 100 kg P₂O₅/ha gave the highest yield (221.3 q/ha), followed by single superphosphate @ 100 kg P₂O₅/ha + rock phosphate 100 kg P₂O₅/ha (204.6 q/ha), whereas the control plot gave the lowest yield (133.3 q/ha) in Bihar.

In a study on micronutrient effect on potato, presoaking of tubers in FeSO₄ for 12 hr @ 0.05% gave the maximum yield (346.8 q/ha), whereas the control (unsoaked) gave the lowest yield (224.4 q/ha) in Bihar.

It is now possible to forecast 2–3 weeks ahead the appearance of late-blight disease of potato in the Simla hills by using the following parameters:

(i) Late-blight would appear during the next 3 weeks whenever the total rainfall for 7 consecutive days exceeds 30 mm.

(ii) Late-blight would appear within a week after daily mean temperature of 22°C or below and a relative humidity of above 80 per cent or above without break for at least 2 days (48 hr).

Dithane M-45 and Difolatan 80 WP provided control both for late- and early-blight, resulting in improved yields. Both these fungicides effectively controlled the seed-piece decay. Incidence of black-scurf was effectively reduced by treatment of tubers with Agallool (0.5 per cent) alone or in combination with PCNB at 30 kg/ha.
The cut potato tubers treated with Dithane M-45 @ 0.5 per cent solution before sowing gave the best germination, reducing decay of tubers and increasing the yield in Bihar.

Treatment of seed potato with Agallol (0.5 per cent) for 10 min along with soil treatment with Brassicol 75 per cent WP (35 kg/ha) was most effective in controlling common scab (Streptomyces scabies) at Bhubaneswar.

Effective residues of phorate, Disulfotan and cytrolane granules @ 1.5 kg ai/ha persisted on the crop for about 55 to 65 days. Besides soil application of aldrin and heptachlor dusts, cutworms could also be controlled by application of chlorpyrifos or carbaryl @ 275 g and 1.0 kg ai/ha respectively. For the control of leaf-feeders (Epilachna beetles and lepidopterous caterpillars), foliar spray with carbaryl or endosulfan @ 1.0 kg and 400 g ai/ha, respectively, was found effective. Potato tuber moth could be controlled by foliar spraying with carbaryl @ 2 kg ai/ha.

Processing of potatoes could bring down the residues of all the insecticides below tolerance level, except of heptachlor and heptachlor epoxide. Carbaryl and chlorfenvinphos when applied @ 1.25 kg and 4.0 kg ai/ha, respectively, either at planting or at earthing time, proved safe from residual effect.

‘Kufri Chandramukhi’ could be raised very successfully in usar soil at Daleep Nagar farm, Kanpur. The average yield was 300 q/ha, with the gross income Rs 24,000/ha. The cost of cultivation was Rs 12,129.24/ha and the total profit (net income) Rs 11,870.76/ha. This is the first record when potato crop could be raised in usar soil by the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur.

PULSES

New Promising Varieties

In Bengal-gram, in addition to ‘H 208’ and ‘G 130’ for Northern Plains and ‘Annegiri’ and ‘JG 62’ for the central and peninsular zones, ‘BG 203’ and ‘K 468’ were released by the Workshop in 1977 for northern plains. Lentil varieties ‘Pant L-209’ and ‘Pant L-406’ were found superior to ‘L 9-12’ and released for the North-Western Zone. In pea, 2 early varieties, ‘EC 33866’ and ‘L 116’, have been recommended for specific situations. Some new extra-early genotypes of pigeonpea (arhar) including ‘Pant A-3’, ‘DL 74-1’, ‘DL 4-64’, ‘HU 1’, ‘JA 3’ and
'BDN 1', were identified. 'T 21' and 'BS 1' showed wide adaptability in the North-Eastern Hill Zone. Under Bihar conditions, in addition to 'Mukta', 'Dholi 1258' was found promising. Among bold-seeded varieties, 'Hy 3A' and 'Hy 3C' were recommended for Karnataka and 'Hyd 1', 'Hyd 2' and 'Hyd 4' were approved for release in Andhra Pradesh.

In greengram, a recently developed variety 'ML 5' gave good yield, though it is relatively late in maturity. It also showed considerable tolerance to yellow-mosaic virus. Among medium maturity group, 'S 8' and 'K 851' were promising during the rainy season. Two yellow-mosaic-resistant selections have done well in the coastal region of Orissa. In blackgram, the high-yielding, medium-late types are 'U 19', 'Pant U 26', 'UG 15' and 'UG 157'. The Central Subcommittee on Release of Varieties recommended the release of cowpea variety 'C 152' ('Pusa 152') for Andhra Pradesh, Karnataka and Kerala. The recently evolved cowpea varieties 'Copusa 1' and 'Copusa 3' were better than 'C 152' in seed quality and gave promising results. Among early maturing varieties of cowpea, 'PS 42' and 'P 3-1' showed good results.

Agronomy

Management of utera winter pulses.—The yield of late-planted lentil could be increased by using a higher than normal seed rate, narrow row spacing and application of 50 kg P$_2$O$_5$/ha. The yield of utera crops of lentil and Lathyrus sativus (khesari) could be substantially stepped up by a top-dressing of 20 kg N/ha immediately after the harvest of rice. At Kanpur, foliar spray of 30 kg P$_2$O$_5$ in 2 splits, one at the start of flowering and the other at pod-formation stages, gave lentil yield of 22 q/ha compared with 11 q/ha in the control, under utera conditions. Lentil sown after the harvest of paddy gave very poor yields (less than 4 q/ha) in spite of inoculation and application of other inputs.

Management of rainfed pulses.—Inoculated Bengal-gram under rainfed conditions gave better yield by the application of 20 kg N/ha and 50 kg P$_2$O$_5$/ha. Use of high seed rate of 100 kg/ha under rainfed conditions also considerably increased the yield.

Nitrogen contribution of legumes to cereal crops.—Legume-cereal rotation led to a saving of 21–30 kg N/ha in the fertilizer-nitrogen need of wheat, where it followed blackgram, compared with wheat sown after kharif cereals. Similarly, at Pantnagar all crops of winter legumes gave significantly higher yields of maize
compared with maize yield after wheat fertilized with 80 kg N/ha. However, the trend was not clear in the rice preceded by legume crops.

**Disease and Pest Control**

Pigeonpea (*arhar*) varieties 'C 11', 'NP (WR) 15' and '20-1' showed good wilt resistance at Delhi, Dholi and Jabalpur, whereas 'C 11' was free from wilt at Hyderabad. Screening against sterility mosaic showed that the ICRISAT lines '3783', '5444', '6997', '7035', '7119' and 'Pant B 76' were resistant under artificial inoculation conditions at Pantnagar. Against yellow-mosaic virus the greengram variety '24-2' and the germplasm lines '15225' and '15227' showed high degree of resistance, and the blackgram varieties 'UAH 2', 'UPU 3', '1-4-3-2', 'Pant U 19' and 'Pant U 26' were resistant at Pantnagar and Delhi. Fairly high degree of resistance was observed in the greengram line '29-13-2' and the blackgram line '6203-1' against powdery-mildew. Greengram line 'ML 162' was free from *Cercospora*.

Among winter-season pulses, gram varieties 'JG 1' and 'Hima' were resistant to collar-rot and 'Pant G 114' to root-rot. In pea only 1 line, '185', was found promising against powdery-mildew for 2 seasons. Lentil 'PL 81' and 'JL 461' were resistant to wilt and rust diseases.

Seed treatment with systemic insecticides, viz. carbofuran, phorate and disulphoton, was effective in controlling the pest complex in greengram and blackgram at Delhi. This would reduce the cost of insecticides as the granular formulations of these insecticides, though very effective, are expensive.

**Cooking Quality of Pigeonpea**

At the CFTRI, Mysore, the pigeonpea varieties that recorded minimum cooking time were: '4-84', 'BDN 1', 'Hyd 5', 'Hyd 3C' and 'DL 24-1'. Seed size had perhaps no relation with cooking time. The percentage of dispersed solids was more in these varieties.

**SOYBEAN**

Suitable varieties have been recommended for each of agroclimatic zones:

<table>
<thead>
<tr>
<th>Agroclimatic Zone</th>
<th>Recommended Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Hill Zone</td>
<td>'Bragg', 'Lee', 'UPSM 19'</td>
</tr>
<tr>
<td>Northern Plains</td>
<td>'Bragg', 'Ankur', 'UPSM 19', 'Alankar' ('PK 71-21')</td>
</tr>
<tr>
<td>Central Zone</td>
<td>'Bragg', 'Ankur', 'JS 2'</td>
</tr>
<tr>
<td>Southern Zone</td>
<td>'Improved Pelicon', 'Davis', 'Hardee'</td>
</tr>
</tbody>
</table>
Sources of resistance to yellow mosaic, rust, bacterial and *Macrophomina* diseases have been identified and suitable hybrid populations incorporating these resistant sources have been produced. Several selections from these are being evaluated that combine disease resistance with good agronomic characteristics. Genetic sources of good seed quality and better viability have been identified and these are being used in the breeding programme.

Mixed cropping of soybean with *mandua* [*Eleucine coracana* (L.) Gaertn.] in the hills and with maize and cotton in the plains has been successfully demonstrated. Effective *Rhizobium* strains have been identified, evaluated and commercial production of the cultures has been undertaken.

Methods of home-level consumption and commercial utilization of soybean have been developed. Products like soya-beverage, soyanuts, soya-sweets, soya-based weaning foods and soya-curd were found widely accepted. Studies on precooked soyadal and soya-cheese are in progress. Technical know-how for commercial production of soyamilk and a number of 'extruder-cooked' products has been generated. Several commercial products have already become very popular.

**OILSEEDS**

**Groundnut**

In view of its wider adaptability, a spreading variety ‘M 13’ selected by the Punjab Agricultural University has been released for cultivation in all major groundnut-cultivating areas in the country. Varieties ‘GAUG 1’ and ‘GAUG 10’ from Junagarh (Gujarat), ‘Jyoti’ from the JNKVV, Jabalpur (Madhya Pradesh), ‘Dh 2-20’ and ‘Dh 2-30’ from Dharwar (Karnataka), ‘AH 114’ from Kanpur (Uttar Pradesh) and ‘Latur No. 33’ from Parbhani (Marathwada) have been released for cultivation in the respective states.

A semi-spreading variety ‘TMV 10’ showed promise of good adaptability not only in Tamil Nadu but also in Andhra Pradesh and Maharashtra. ‘JL 24’, developed at the Agricultural Research Station, Jalgaon (Maharashtra), while maturing in just 87 days, gave a better yield than the recommended variety ‘SB 112’. Semi-spreading ‘RS 138’, developed from a Brazilian culture at Durgapura, has been recommended for pre-release multiplication in Rajasthan.
Through an extensive germplasm-testing programme, a number of genotypes with better plant type for higher yield and resistance to biological stresses have been identified and used extensively in hybridization programme to develop varieties with a combination of desirable quantitative and qualitative characteristics.

High population density is imperative to get better yield. The pre-requisite for maintaining an optimum plant density is the use of quality seed with better germination and fungicidal treatment of seed before sowing to protect against soil-borne diseases. Application of phosphatic fertilizers based on soil-test results, such micro-nutrients as zinc, boron and molybdenum wherever required and lime treatment of the light soils prone to acidity have been recommended to improve productivity of the crop.

Application of Thimet @ 1 kg ai/ha to the soil controlled the white-grub. Metasystox @ 450 ml/ha was found effective against aphids and jassids and carbaryl 0.2 per cent spray against leaf-miner. Two sprayings of Dithane M-45 @ 0.2 per cent on the 45th and 65th day of sowing controlled the tikka leaf-spot disease.

'TMV 2', 'TMV 6', 'TMV 7', 'TMV 10', 'IARI 48', 'AH 2105' and 'T 64' cultures showed high degree of tolerance to tikka (Cercospora) leaf-spot disease.

Rapeseed and Mustard

Raya variety 'Prakash' gave high yield in Haryana, 'RLM 198' in Punjab and 'Varuna' in Uttar Pradesh. 'K 88' yellow sarson has been recommended for cultivation in the central and western Uttar Pradesh.

Aphid-tolerant varieties like 'YS 74-1' and 'YS 74-2' of yellow sarson and raya type 'Dinanagar' were extensively used in hybridization programme to develop varieties tolerant to aphids which cause severe crop losses.

Timely sowing of rai in the first week of October has been emphasized to obtain better yields. Application of the usual doses of nitrogen and phosphatic fertilizers based on the soil-test results is important. But the application of sulphur or sulphur-containing fertilizers like ammonium sulphate and single superphosphate were found more important to this crop in sulphur-deficient soils. One to 2 irrigations improved the productivity of the crop.
Spray of 1.5 litres of Endosulfan or 1 litre of methyl demeton or 1 litre of Dimethoate or 250 ml of phosphamidon dissolved in 1,000 litres of water per hectare proved a good prophylactic measure against aphids. For mustard sawfly, painted-bug and flea-beetles, application of BHC 10 per cent dust @ 12-15 kg/ha or spray with 600 g of BHC 50 WP (0.1 per cent) ai dissolved in 300 litres of water per hectare, proved advantageous.

Control of \textit{Alternaria} blight in rai and \textit{sarson} was achieved with 3 to 4 sprays of difolatan @ 0.2 per cent or TPTH (Duta) @ 0.2 per cent after 60 days of sowing at 15-day interval. Severe incidence of downy-mildew and white-rust diseases could be checked by sowing the crop in the first week of October. Two yellow \textit{sarson} dwarf mutant types, resistant to \textit{Alternaria} blight, were utilized in resistance-breeding programme.

\textbf{Safflower}

Three varieties of safflower, viz. ‘Manjira’, ‘Tara’ and ‘T 65’, were released in Andhra Pradesh, Maharashtra and Uttar Pradesh respectively. Very high oil-yielding (up to 50 per cent) types ‘JL 1’ ‘JL 2’ and ‘JL 3’, have been isolated at Jalgaon. Intensive efforts are being made to develop varieties to suit irrigated, saline/alkali line conditions as well as those resistant to rust disease.

Time of sowing varies from region to region, but it is found important for higher yields. Nipping the safflower buds has resulted in increased yields through the resultant increase in flower and fruit-bearing branches.

Sorghum-safflower mixed cropping at a row spacing of 135 cm between 2 rows of safflower and a double row of sorghum in the intervening row space gave highest economic returns at Jalgaon. Safflower-Bengal gram in 1:5 proportion gave better returns at Coimbatore, whereas safflower alone fared better at Annegiri (Karnataka).

Endosulfan 0.05 per cent, monocrotophos 0.05 per cent, phosalene 0.05 per cent or dimethoate controlled the aphide, whereas Dithane M-45 and copper oxychloride controlled the \textit{Alternaria} blight and rust.

\textbf{C.istor}

Better yields from the high-yielding varieties and hybrids could be obtained by sowing them immediately after the onset of monsoon at a spacing of 60 cm \times{} 30 cm and a fertilizer rate of 40 kg N/ha (half as basal dose and the remaining half just before flowering).
Biological control of castor semilooper by *Telenomus proditor* and *Trichogramma* spp. was found effective in the Maha­boobnagar district of Andhra Pradesh.

**Linseed**

'Jawahar 7' linseed released by the JNKVV, Jabalpur, has been recommended for large-scale demonstration trials in *uteric* type of cultivation. A bold-seeded variety 'Ut I' has been released in Rajasthan. This matures in 120 days, and is also moderate­ly resistant to rust and wilt diseases.

Budfly infestation was minimum in the plots treated with Nuvacron. For the control of rust, as the hills act as foci for the occurrence of rust in plains, it was found necessary to destroy linseed straw and other plant residues which are likely to harbour rust telia in the hills. Growing of rust-resistant varieties in hills was also recommended.

**Sunflower**

An early-maturing variety 'Mordon' (75–80 days) has been identified. 'Latur' (selectios 'AS 37') has been released for cultivation in Vidarbha region of Maharashtra, and 3 jassid­resistant lines, 5 highly self-fertile lines, 2 *Sclerotinia sclerotiorum*-resistant lines and a number of rust-resistant lines have been isolated and used in breeding programmes.

The initial-evaluation trial of a set of Romanian hybrids obtained through Indo-Romanian technical collaboration has been continued for the third time. Some of these hybrids have indicated a good promise of high yield, high seed-filling capacity and wider adaptability. Simultaneously, efforts have been made to develop hybrids indigenously and a first initial-evaluation trial has been conducted with the locally developed hybrids. Though the hybrids in general have shown better performance than the open-pollinated varieties, the results are yet inconclusive.

As sunflower is a cross-pollinated crop, seed setting in it very much depends upon the level of bee population available in the vicinity at the time of flowering. In many areas of the country, inadequacy of bee population was observed, with the result that the seed setting was reduced. It has been found that with a characteristic hand-rubbing of the flower, seed-setting could be increased by 20–25 per cent.
Under rainfed conditions, soaking of seed for 24 hr in water before sowing was found to ensure better germination, better crop stand and consequently better yields. Intercropping of sunflower with cowpea or groundnut resulted in better economic returns. Application of TIBA to the head at the time of flowering increased the seed yield by increasing the number of filled seeds and consequently the seed weight.

Dithane M-45 was very effective in controlling rust disease. In view of the outcrossing habit of the crop, it is very difficult to maintain seed quality unless the seed crop is handled very meticulously in accordance with the established scientific seed-production procedures and rigorous seed-testing methods.

To ensure the continuous flow of quality seed for general cultivation, a 4-tier sunflower-seed production programme has been implemented during the year and 30 tonnes of elite seed has been produced.

COTTON

A short-staple Gossypium arboreum variety, 'LD 133' (for the Punjab), and 4 medium-staple G. hirsutum varieties, 'H 655 C' (Haryana), 'F 414' (a selection from 'Bikaneri Nerma' for Punjab), 'CP 15/2' ('Suman' for south India) and 'JK 97' (for Karnataka) were released.

Emphasis has been shifted to the development of medium-staple varieties and hybrids possessing characters of high yield, high ginning, pest and disease resistance and suitable for rainfed cultivation. Medium-staple hybrids, involving the male-sterile line 'Gregg', are under development. Of these, 'CPH 2' and 'CPH 4' have undergone extensive trials and are expected to be released shortly. 'CPH 6' and 'CPH 7' have also proved promising.

A new promising variety, 'Culture 1412' (2-way cross between bacterial-blight-resistant 'Reba B 50', the early and photoinsensitive Russian 'S 1998' and 'MCU 51412') has a short maturation period of 125 days with medium-staple, photoinsensitiveness and tolerance to bacterial blight and it gives a good yield of 20 q/ha in rice fallows. The variety is being tried in Tamil Nadu, Andhra Pradesh and West Bengal. During the year, crosses were effected between this variety and a jassid-resistant donor and further selections endowed with jassid resistance have been obtained.

'JK Hybrid 1', which is under advanced testing in Madhya Pradesh, gave 50 to 60 per cent more yield than 'Hybrid 4' and
it has better fibre qualities, capable of spinning 40s to 44s counts. In addition, it has high tolerance to jassids and bacterial blight, and has a compact plant habit. This hybrid appears very promising for rainfed areas.

Studies at Coimbatore on interspecific hybridization between *G. arboreum* and *G. herbaceum* cotton have revealed that the use of *G. herbaceum* varieties from Gujarat like ‘Sujay’ (which have a very long duration) results in *F₁* s also having a long duration, whereas a Dharwar *G. herbaceum* variety like ‘Jayadhar’ (which has a duration of 6½ months) gives rise to shorter-duration *F₁* s. The use of shorter-duration hybrids in rainfed areas, while efficiently utilizing soil moisture, also enables a winter season (*rabi*) crop to follow in the rotation. Moreover, interspecific incompatibility (which results in the presence of motes in the lint, seen in interspecific hybrids involving allotetraploids) is not seen to the same extent in the interspecific hybrids involving diploid species. This is possible due to the achievement of greater balance of genes in the *F₁* s and closer genetic relationship between local (*desi*) species.

In the North Zone, cycocel controlled excessive vegetative growth and increased the fruiting under the prevailing long-day conditions. However, this chemical is not useful to the same extent in the South where the control of vegetative growth is not a serious problem and fruiting is more efficient on account of the prevalent temperature and photoperiod conditions. Succinic acid increased the yields, both as seed treatment as well as soil application, though the mode of its action has not been understood. Treatment with anti-abscissants like naphthalene acetic acid (NAA) helped in retaining bolls, particularly during cloudy or moist weather. NAA, however, was not found efficient in combination with other chemicals and when the quality of the water was poor.

Magnesium was found deficient in the Deccan-canal soils, showing that the micronutrients have been exhausted in the soils where high-yielding varieties have been grown.

In a study on the relation between heterosis and photosynthetic rate, it was found that in the *F₁* hybrids possessing a high degree of heterosis, the photosynthetic rates in sympodial leaves as well as in the stems were higher than in those with a lower degree of heterosis. Removal of bracts had far-reaching effects on the quality of fibre and this differed from variety to variety.
Photosynthetic efficiency in *Gossypium* was found related to the thickness of leaves; varieties possessing thinner leaves were capable of higher $^{14}C$ fixation rates at light intensity of 1,500 f.c. The rate of boll growth, however, was not associated with the leaf or bract areas or with their photosynthetic efficiency. There was difference in the rate of translocation of photosynthates from the leaves to the pericarp. There were varietal differences in the production of neutral and acidic auxins. Varieties with a greater rate of growth of bolls also produced larger quantities of auxins.

To check the spread of pink bollworm in the South Zone, the measures found effective are: (i) growing shorter-duration varieties like ‘Bikaneri Nerma’, ‘F 414’ and ‘LH 299’, and (ii) discouraging the practice of growing more than one crop in a year in the same area and by shortening the planting season. Summer crops have been discouraged in the winter Cambodia tract and winter crops in the summer cotton tract. Farmers are being advised to restrict the sowing season to August and September.

Through integrated pest-control programmes operating in Punjab and Tamil Nadu, it was found possible to reduce the number of insecticidal sprays from 15-20 to 7-10 to get the same amount of pest control.

*Verticillium*-resistant types in the *G. barbadense* and *G. hirsutum* lines under development were selected both under wilt-infested-plot conditions as also through artificial inoculation in the greenhouse. A ‘Cool Bed’ technique was developed with which the screening work could be carried out throughout the year and which also enabled the screening of large populations. Among new accessions, ‘Tashkent 1’, ‘Tashkent 2’, ‘Albacala’ and ‘Bikaneri Nerma’ showed a good degree of tolerance. Some new varieties resistant to bacterial blight were obtained, viz. ‘HG IPS 775’. Further crosses made at the Central Institute for Cotton Research, Regional Station, Coimbatore, involving ‘1412’, and certain ‘EF’ and ‘PSH’ derivatives were also selected for resistance to bacterial blight.

Varieties with resistance or tolerance to *Rhizoctonia* root-rot, viz., ‘CRH 71’, ‘R 1614’, ‘R 44-B’ and ‘R 294-2-6’, were obtained. New line of work included development of lines resistant to *Myrothecium* and *Alternaria* blights.

**New Technique for the Determination of Fibre Fineness**

The working principle of the Digital Fibrograph (Model 230 A) was utilized for quick determination of Optical Fineness.
Coefficient (OFC) from which fairly accurate estimates of gravimetric fineness of cotton sample could be made. This new method, which suggests a fibre fineness index as \( (\text{OFC})^2 = \frac{W}{A \times L} \),

where \( A \), the amount counter reading at 100 per cent; \( W \), weight of the test boards, and \( L \), 2.5 per cent span length, is free from the drawbacks of Micronaire fineness measures and gives a closer approximation to the gravimetric values.

**Determination of Yarn Hairiness by Digital Fibrograph**

Yarn hairiness could also be evaluated quickly with Digital Fibrograph, based on the difference in the amount counter reading at 100 per cent on suspending the unsinged and singed yarn. It exhibited highly significant correlation with the conventional optical method (projection microscope).

**Lea Strength Corrections for Nominal Counts**

A new scientific procedure for determining lea strength corrections for nominal counts has been evolved, and has been approved by the ISI.

**Effect of Cellulase Enzyme on the Morphology and Fine Structure of Wheat Straw Pulp**

In earlier studies at CTRL on enzymic hydrolysis of cotton it was observed that though crystallinity increased as a result of cellulase action, the crystallite dimensions remained largely unaffected. However, in wheat straw pulp (WSP) cellulose the sharp increase in the crystallinity index from 59 per cent in the original state to 75 per cent at the end of 6 hr of enzymic hydrolysis is accompanied by considerable reduction in crystallite dimension (from 57 A to 39 A) in the direction 1 to 002 plane, without any change in the crystallite length and crystallite orientation. To bring about change in the crystalline size to the same degree by chemical means, it is necessary to resort to drastic treatment with acids and swelling agents, which also disrupts the crystalline orientation. Present studies revealed the presence of discrete hydrocellulose-like particles (normally observed after drastic acid hydrolysis) of WSP cellulose at the end of 6-hr cellulase treatment, which was unique.
Optical Anisotropy and Cellulose-dissolution Technique

Preliminary studies had revealed that crosslinks formed by the reactive dyes are weak and the conventional layer-expansion technique so useful in the evaluation of easycare-finished cotton was not applicable due to some inherent drawbacks in it like ‘polymer explosion’. By the use of CTRL cellulose-dissolution technique it could be revealed how certain reactive dyes do induce cross-linking and how the amount of dye in the fibre and conditions of application influence the crosslinking process.

Utilization of Cotton Stalks

A new process was developed to prepare particle boards from cotton-plant stalk by making stalks into chips, coating them with appropriate quantities of binding materials and pressing under suitable temperature and pressure. These boards so prepared and tested for density, tensile strength, modulus of rupture and water absorption etc. were found to conform with the ISI specifications for such boards.

Blending of Cotton with other Fibres

With jute staple the yarn produced by blending cottons like ‘L 147’ and ‘Suyodhar’ with jute staple was inferior to pure cotton in strength and regularity, but was comparable to cotton fabrics in breaking strength and elongation.

With wool noils.—The optimum twist multiplier in cotton-wool blending was 5 for cotton as well as blend containing 50 per cent wool noil. For the blends with 25 and 33 per cent wool noil, the tenacity increased with the increase in twist up to 6 twist multiplier. Considerable fall in tenacity with increase in the proportion of wool was observed in the blended yarn spun using microspinning technique.

With ramie fibres and polyester.—Ramie fibres could be successfully blended with cotton and polyester. Neppiness in chemically treated ramie cotton blends was high.

Experiments conducted on spinning from blends of cotton with jute staple, jute caddies, wool noils and ramie fibres have shown that there is an optimum level to which the natural fibres could be blended and the resultant yarn could be successfully converted into fabrics for various uses.
Response of Indian Cotton to Crosslinking Treatments

Some pre-swelling treatments in caustic soda, followed by crosslinking have been attempted on 8 varieties of Indian cotton, viz. ‘Gujarat 67’, ‘Hybrid 4’, ‘MCU 1’, ‘Deviraj’, ‘A 218’, ‘66BH 5/91’, ‘Digvijay’ and ‘Sanjay’, spun to 2/30s. The mercerized samples were crosslinked under 2 conditions, viz. (i) mercerized, washed, dried at room temperature and crosslinked with 80 per cent DMDHEU, and (ii) mercerized, washed and immediately crosslinked in wet state.

Analysis of tenacity and elongation data after crosslinking revealed that higher retention of tenacity was achieved, in general, in the case of samples mercerized and crosslinked in wet state compared with those in dry state. Values of crease-recovery angle (CRA) of the samples mercerized and crosslinked in dry state were high, ranging from 297° to 279°, while that of wet crosslinked varieties varied from 293° to 229°. By crosslinking in wet state after mercerization it was possible to obtain good combination of high retention of mechanical properties and high degree of the CRA.

JUTE

The Central Variety Release Committee has released ‘JRO 524’, which is high yielding, resistant to premature flowering and least susceptible to yellow mite. The fibre is of better quality and easily extractable. Identification of a premature flowering resistance gene Sudan Green has led to the evolution of varieties like ‘JRO 524’, ‘JRO 878’ and ‘JRO 7835’. These varieties have enabled the sowing of crop as early as mid-March instead of middle of April, the usual sowing time of jute.

An X-ray-induced Corchorus capsularis male-sterile line combined with other undesirable growth characteristics could not be utilized in the hybrid seed-production programme. Hence the hybrids involving this male-sterile line and the other unrelated genetic stocks have been further X-rayed. As a result, in the X generation a few male-sterile variants combined with normal growth characteristics have been isolated which are being further improved, so that they could be advantageously utilized in hybrid jute-seed-production programme. Another male-sterile line has been isolated from a C. olitorius stock and further studies to utilize this male-sterile line in breeding programmes are in progress.
In fertilizer trials under low-fertility conditions \((N_{40} P_{20} K_{40})\), ‘JRC 978’ and ‘JRC 212’ did well at Nowgong, ‘JRC 3121’ and ‘JRC 212’ at Katihar, and ‘JRC 7447’ at Kendrapara; whereas under high-fertility conditions \((N_{60} P_{30} K_{60})\), ‘JRC 6382’ and ‘JRC 7447’ did well at Nowgong, ‘JRC 3121’ and ‘JRC 7447’ at Katihar and ‘JRC 4444’ at Kendrapara.

A distinct yield advantage of 7–8 q/ha could be obtained between the early harvesting (125 days) and late harvesting (150 days) of *C. capsularis* jute. However, for early as well as for late harvesting situations the following varieties were found suitable: for Kendrapara ‘JRC 212’ for early harvesting and ‘JRC 3187’ for late harvesting, for Katihar ‘JRC 212’ for early harvesting and ‘JRC 31335’ for late harvesting, and for Nowgong ‘JRC 212’ for early harvesting. There was no striking difference in yield in the late-harvested crop at Nowgong.

Similar yield differences were found between early- and late-harvested *C. olitorius* crop at Baharaich (Uttar Pradesh). ‘JRO 7835’ and ‘JRO 3690’ were the best for early harvesting (120–127 days), whereas ‘JRO 3690’ and ‘JRO 524’ were found better for late harvesting (152–163 days).

The compost of water-hyacinth proved beneficial to soil productivity and crop yield. Foliar application of potash has been found possible in jute. Potash (5 kg) in the form of muriate of potash (KCl) by foliar spray (equivalent to 1.5 per cent KCl) increased the yields over the crop treated with 40 kg of potash/ha applied to soil. Jute plant tolerated K concentration up to 10 kg/ha (3 per cent KCl) without any damage. This finding offers scope for economizing on potash application, and advantageous potash manuring of the crop during floods and drought. The optimum fertilizer dose for *C. capsularis* crop (‘JRC 212’) in lower Assam like Gopalapara and Kamrup was \(N_{40} P_{40} K_{40}\), for *C. olitorius* crop (‘JRO 632’) was \(N_{30} P_{30} K_{30}\), whereas at Katihar for *C. olitorius* crop (‘JRO 632’) \(N_{60}\) alone was best. Among jute-based cropping patterns, those found satisfactory under rainfed conditions were: jute–rice–lentil and jute–rice; whereas under irrigated conditions were jute–rice–wheat, jute–rice–potato, jute–rice–rice and jute–rice–mustard.

Stem-weevil in *C. capsularis* jute could be controlled by the application of carbofuran at 1 kg ai/ha as well as Endosulfan @ 0.075 per cent. Endosulfan 0.04 per cent could control yellow mites. Dipel (a commercial strain of *Bacillus thuringiensis*) @ 1.2 kg/ha in 600 litres of water controlled jute semilooper pest.
Spraying of Bavistin \((C_9H_{12}N_3O_2)\) at 0.08 to 0.1 per cent concentration provided protection against Hooghly wilt disease in *C. olitorius*. Seed treatment with Bavistin controlled the incidence of root-rot disease.

‘JRO 514’ has been identified as the least susceptible variety to root-knot nematodes.

Fluchloralin (N-propyl-N-(2-chloroethyl)-2, 6-dinitro-\(-n\)-trifluoro methylaniline) is found to be a selective weedicide in jute farming.

**Technology**

It was found that the fibre development rate was more rapid in white jute than in tossa jute.

At least 3 chromophoric groups in lignin residues of jute have been identified as responsible for yellowing after bleaching.

Polypropylene staple fibre has been blended with jute to produce fine and strong yarn for decorative and furnishing fabrics. Samples of novel textile were produced by blending jute and ramie with polyester and other man-made fibres on cotton system. Non-woven fabrics prepared from jute- and cotton-mill wastes were successfully screen-printed and coextruded with low-density polyethylene. Methods were developed for chemically treating degummed ramie to improve its processability in cotton system in blends with other fibres.

A technique was evolved for processing pineapple-leaf fibre on jute machinery.

Jute stick has been used with 50 per cent rice-straw in mill trials to make pulp-boards at reduced cost. Processed root-cuttings of jute gave paper and boards of very high strength.

Further refinement has been made in the development of charcoal of high carbon content (up to 90 per cent) from jute stick.

**TOBACCO**

Two improved chewing tobacco varieties, ‘Gandak Bahar’ (‘HP 6-20’) and ‘Sona’ (‘HP 63-3’) evolved at the Tobacco Research Station, Pusa, have been released for cultivation in Bihar. Two Hookah tobacco varieties, ‘DD 437’ and ‘HD 65-40’, evolved at the Tobacco Research Station, Dinhatta, have been recommended for release in West Bengal. A Natu variety ‘DG 3’ has been
recommended for the Natu tobacco-growing areas of Andhra Pradesh. Among powdery-mildew-resistant varieties of flue-cured Virginia tobacco at Shimoga (Karnataka), the culture '2338' gave maximum yield. 'CTRI Special' was better than 'HR 70-57' for bright leaf yield at Rajahmundry. In Burley tobacco, 'Ky 58' and 'Burley 1' showed promise at Dharwar (Karnataka).

Varietal screening revealed 2 genotypes resistant to stemborer and 1 free from leaf-curl (virus) disease, but none resistant or tolerant to *Cercospora* leaf-spot disease. Culture '1071' was free from black-shank.

Application of nitrogen from organic source (cake) to flue-cured Virginia tobacco was beneficial under light soil conditions of Gujarat. Green-manuring with ginglyl coupled with application of 40, 50 and 50 kg/ha of N, P₂O₅ and K₂O, respectively, gave better yield of Natu tobacco at Guntur. Application of 180 kg N/ha and planting the crop in the second week of October at a spacing of 75 cm x 45 cm gave better yields of cigar-wrapper tobacco at Dinhatta. In a trial with slow-release nitrogenous fertilizers on chewing tobacco at Pusa, Suphala gave highest yield of cured leaf. Mustard cake+urea (50 : 50 N) gave maximum spangle score. Tobacco crop following sannhamp gave the highest cured leaf as well as first-grade leaf yield of chewing tobacco at Pusa. Anhydrous ammonia together with green-manuring could be used as a fertilizer in bidi tobacco. Green-manuring+ammonium sulphate gave better yield of bidi tobacco (3,555 kg/ha) than Agro compost+ammonium sulphate (3,418 kg/ha). Application of 60, 40 and 20 kg/ha of N, P and K 20 days before transplanting of bidi tobacco gave better yields than the normal practice. Liming @ 1,000 kg/ha gave good yield of cigar-filler tobacco at Dinhatta. Application of basic slag was useful in the production of cigar-wrapper tobacco in the acid soils of West Bengal.

Crop rotations like maize-rice-tobacco (cigar-wrapper) and jute-rice-tobacco (cigar-wrapper) were found more remunerative. Use of antitranspirants and hormones helped in the establishment of a uniform crop. Among them, the spraying or dipping the leaf portion of seedlings, in 2 or 5 per cent Vapour gard, spraying of auxin H-61 @ 200 ppm twice and spraying of NAA @ 120 or 60 ppm have helped in reducing the percentage of gaps and establish an uniform crop. Quality of the leaf with the use of these chemicals was not in any way affected. Under central Gujarat
conditions, irrigation at 10-day interval after first priming gave maximum yield of green leaf as well as cured leaf of flue-cured Virginia tobacco.

Rabbing of nursery site was beneficial to control weeds. At Anand, AC 92533 @ 263 mg ai/plant reduced the suckers up to 95 per cent. Chlorophyriphos, trichlorofon and monocrotophos were found most effective in the control of tobacco caterpillar. Neem-kernel suspension material from plant origin was found good antifeedent to tobacco caterpillars in the tobacco nurseries. Demonstration trials with this material during 1977–78 nursery season have proved very successful and farmers appeared to be happy with this method of control. In an attempt to introduce biological control of the tobacco caterpillar, *Telenomus remus* parasites have been released in the tobacco nursery areas of Rajahmundry. This approach has now been extended to Guntur and Prakasam districts of Andhra Pradesh.

Aldicarb and Fensulfothion in different doses and in spot or row application significantly controlled the root-knot nematodes in flue-cured Virginia tobacco. Some crops have been identified as trap crops for *Orobanche*, viz. Cowpea, Deccan hemp, blackgram, greengram, pigeonpea, niger, linseed and lucerne.

Spraying of a chemical ripening-agent, CEPA, improved the bright-grade outturn and reduced the cost of priming and curing.

The quality indices of Natu tobacco have been evolved and total N, soluble N and nicotine were found to have a positive relationship with quality. Therefore these constituents can be helpful parameters in the determination of the quality of Natu tobacco.

The quality indices for chewing tobacco were also worked out. The top grade of chewing tobacco will be rich in total N, protein N, nicotine, PEE and K, and low in Ca and silica. White encrustation on fermented chewing tobacco was found a good index for quality leaf. The white encrustation contained silica, Ca, Mg, \( P_2O_5 \), sulphate, carbonate, chloride, and the malic and citric acids.

Studies on some organophosphorous residues showed degradation up to 70–80 per cent during flue-curing.

A procedure to recover solanesol from tobacco waste with 70 per cent purity has been developed at the Central Tobacco Research Institute, Rajahmundry.
'Green-threshed' tobacco-curing technique led to saving in the cost of curing.

Paddy-husk briquettes were found very effective and cheaper substitute for coal or firewood or even loose paddy husk. The paddy-husk briquettes were more economical than the paddy husk, since the transportation cost of the latter was more than that of the former.

Low-profile barn of 60 cm × 40 cm × 33.5 cm designed and constructed at the Tobacco Research Station, Hunsur (Karnataka), was found very economical, as it consumed only 4.48 kg of wood for obtaining 1.0 kg cured leaf compared with 5.75 kg, 8.21 kg and 10.00 kg wood consumed in the other 3 types of barns at present in use in Karnataka.

SUGARCANE

Significant progress has been achieved in creating genetic variability for evolving commercial sugarcane varieties in different agro-climatic zones. Thirteen kilograms of hybrid fluff was supplied to 15 state research stations to raise about 2.7 million seedlings. This was possible through the National Hybridization Garden Programme started recently at the Sugarcane Breeding Institute, Coimbatore. Uttar Pradesh, which covers largest area under sugarcane, received 3 kg of fluff to raise about 0.6 million seedlings. In addition, 0.3 million seedlings were air-lifted from Coimbatore to reduce the mortality in seedlings when transplanted to the field. Air-lifting of seedlings by about the end of June (when the monsoon breaks in in the north India) significantly increased the rate of seedling survival.

Short-duration varieties 'Co 7704', 'Co 7712', 'CoA 7601' and 'CoC 67-1' were released. 'Co 7712' at 8 months gave 18 per cent sucrose in juice and 90 per cent purity. 'CoA 7601' also performed similarly at 9 months. These varieties may very well fit into the cropping systems in north India along with wheat and rice.

Out of 17 'Co'-varieties released from the Sugarcane Breeding Institute, Coimbatore, for testing at the state centres, 'Co 7704' and 'Co 7712' are early maturing with high sugar content, fitting in 9-month crushing season, whereas 'Co 7717' (released from Karnal) possesses better quality and tolerance to top-borer and red-rot disease. It is particularly suitable to replace the ruling and declining variety 'Co 1148' in north India.
In Andhra Pradesh and Tamil Nadu it has not been the practice to grow a short-term commercial sugarcane crop except as a seed crop. But isolation of ‘CoA 7601’ at the Sugarcane Research Station, Anakapalle, from the fluff obtained from the Sugarcane Breeding Institute, Coimbatore, has enabled raising of a short-duration sugarcane crop with practically no loss in quantitative and qualitative attributes. Though early maturing, it is not inferior in yield to ‘Co 419’ and ‘Co 997’. ‘CoA 7601’ planted in February (yield 110.49 tonnes) and June (82.55 tonnes) as also the ratoon crop (93.47 tonnes) gave good yield in 8 to 8½ months.

The yield of the February-planted crop was not influenced by the change in inter-row spacing. Though the April-planted crop did respond to varied spacing, 60 cm inter-row spacing was found advantageous. The cultivation of early maturing high-sugared variety ‘Coj 64’ in Punjab has resulted in unprecedented sugar recovery of 10.0 per cent during November–December in sugar factories where this variety was grown. Studies on irrigation efficiency employing 3 methods of irrigation, viz. skip-furrow, flat and furrow, showed that skip-furrow method gave the same yield with reduced amount of irrigation water at 18.75 ha-cm at 50 per cent available soil moisture compared with 30.00 ha-cm under flat system of irrigation. This led to 61 per cent economy in irrigation water compared with the conventional flat method of irrigation.

In the space-planting technique, the April–May space-transplanted crop showed reduced tillering and consequent decline in the number of millable canes. Varietal variation was found in respect of tillering phase in this planting technique. This emphasizes the need and scope for varietal selection specifically for late planting and innovative agricultural practices.

Field tests in Tamil Nadu confirmed the finding that sucrose content increases significantly up to 10 per cent over the control by ripening the cane by polaris. Sodium metasilicate also gave encouraging results.

For the control of top-and stalk-borers, 2 sprayings of monocrotophos @ 0.75 kg ai/ha in September–October and soil application of carbofuran @ 0.2 per cent ai/ha against the second brood and 0.5-1.00 kg ai/ha against the third brood, followed by detrashing of the lower dry leaves during September—October and removed of late shoots have been found useful.
Spraying of sugarcane crop for the control of pests or spraying chemical-ripeners is a tedious and laborious job, especially in the absence of an appropriate spraying device in a tall crop like sugarcane. To overcome this difficulty, the Indian Institute of Sugarcane Research, Lucknow, has designed and fabricated a spray-beam in combination with 2 feet sprayers, which has a swath width of 10.4 m and takes only 75 min to cover 1-ha crop, involving only 4 men in the spraying operation.

The design of the earlier model of the hot-air unit to treat the seed-cane has been modified now to convert it into a moist hot-air-treatment unit. This unit has improved the operational efficiency by reducing the treatment duration from 8 hr to 4 hr. The humidification of the chamber prevented the loss of moisture from seed-cane also.

SUGARBEET

It was found possible to obtain a yield of 60 tonnes/ha with 15 per cent sugar content. Variety 'Ramonskaya' with indigenous seed was recommended for cultivation in Sriganganagar area, and 'Maribo Macropy', 'Kawegigopoly', 'Mezzanopoly A', 'Tri-bal', 'HnR-Poly' and 'Hh Moniton 212' were found promising for different locations. Inadequacy of the germplasm and the inherent difficulties to obtain it (since sugarbeet breeding by and large is in the hands of private companies in the sugarbeet-growing countries and they are reluctant to part with the basic material) have posed a limitation for the progress of sugarbeet-breeding researches in the country. However, attempts are being made to procure it through bilateral agreements and protocol arrangements. Nevertheless, efforts are being made to elevate the productive potential of the available material through population-improvement methods and the resultant propagations (‘Pant S 1’, ‘Pant S 2’, ‘Pant S 10’, ‘Pant Composite 1’ and ‘Pant Composite 6’) have shown encouraging performance. Kalpa centre of the Himachal Pradesh University (Agricultural Complex) under the All-India Co-ordinated Project for the Improvement of Sugarbeet is continuing to produce nucleus and foundation seed of the recommended variety 'Ramonskaya' and the National Seed Corporation is producing the commercial seed for distribution to farmers.

Cultures '68 MSH-128', 'Anglo-Maribopoly', 'Pant Composite 1', 'Hh Monotri' and '68 MSH-155' showed a good degree
of tolerance to *Sclerotium* root-rot, whereas 'Pant Composite 1', 'Poliram' and 'Maribopoly V' proved tolerant to *Cercospora* leaf-spot disease.

Sugarbeet could be successfully cultivated in saline-alkaline soils. Application of 120 kg N/ha proved optimum for higher root yields. The crop seemed highly responsive to micronutrient deficiency.

Effective chemical control measures have been recommended to control *Cercospora* leaf-spot, which generally occurs towards the harvesting phase of the crop. However, *Sclerotium* rot could be controlled by a suitable crop rotation and also by the use of Brassicicol drenching @ 15 kg/ha.

Feeding of beet tops and beet pulp to milching cattle was found to increase milk yields.

**PLANTATION CROPS**

**Coconut**

The Central Plantation Crops Research Institute, Kasaragod, has located 8 'superpalms' that give an annual yield of 270-478 nuts compared with the national average of 35 nuts. These superpalms have a high rate of leaf and spadix production (1 in 15-20 days compared with 1 in 30 days in the normal plants) and generally have one or more female flowers in each rachilla. Tremendous potential exists for increasing yields if it can be established that the high-yielding ability is due to their superior genetic make-up and they are propagated vegetatively. Work on vegetative propagation has also been initiated.

A spacing of 6.6 m in the triangular method (245 plants/ha) was found most remunerative for laterite soils under rainfed conditions at the Pilicode centre of the Kerala Agricultural University. Intercropping with 600 cocoa plants in a hectare of coconut orchard gave an additional income of Rs 10,000.

Work at the Konkan Krishi Vidyapeeth, Dapoli, showed that there is a linear response to application of N and a dose of 0.75 kg N/palm gave the maximum yield of 84 nuts/year.

**Cashewnut**

Five cashew hybrids, yielding 15 kg high-quality nuts per tree in the sixth year of orchard life, have been evolved at the
Cashew Research Station, Vengurla (Maharashtra). These are being clonally multiplied.

Budding on 3–4-months-old seedlings in the nursery under controlled conditions and transplanting them in the field by the onset of the south-west monsoon proved a good practice for large-scale adoption.

At the Kerala Agricultural University selection 'BLA 139-1' gave a good yield of 30.7 kg nuts on 5-year average. Keeping bees increased fruit set.

Cardamom

For the control of nematodes, Aldicarb 10 kg ai/ha proved successful. For the control of Azhukal disease, Difolatan, Dithane C-90 or M-45, Cocide and Milto, at a concentration of 0.3 per cent, have been found successful at the Kerala Agricultural University.

Pepper

In a test on resistance to the root-knot nematode (*Meloidogyne incognita*), the standard *Garuga pinnata* has been found resistant, whereas variety 'Valiapakkanakadan' the least susceptible, at the Central Plantation Crops Research Institute. At the Kerala Agricultural University, 'Narayakodi' and 'Padappan' were found less susceptible to it.

Ginger and Turmeric

Turmeric clonal selections '2A' and '15B' have recorded high yields of 33–38 tonnes/ha at Kasaragod (Kerala), Goa and Pottangi (Orissa). The average yield is 18 tonnes/ha. Selections '20A', '24D' and '21A' gave 14 per cent curcumin content.

The germplasm collection has been further strengthened to over 600 types of ginger and 400 types of turmeric during the recent survey conducted in different parts of the country. These are being screened for their yield and quality characteristics.

VEGETABLES

The Central Variety Release Committee released the following varieties: in garden pea an extremely early (55–60 days) variety 'Arkel' from the IARI, and 'GC 141' (mid-season) and 'GC 195' (early) from Gwalior; in brinjal 'Pusa Kranti' (IARI) and 'H 4' (HAU); in tomato a nematode-resistant variety 'S1 120' (IARI).
'HS 101' (HAU) and 'S 12' (PAU); in cauliflower 'Pusa Depali' for October maturity, 'Pusa Synthetic' for mid-December maturity and 'Pusa Snowball 1' and 'Pusa Snowball 2' among temperate types of late-maturity group (IARI); in onion 'S1 131', a white onion variety suitable for dehydration (IARI); in chilli 'G 4' and 'G 5' (Lam, Guntur); in muskmelon 'Pusa Madhuras' and 'Pusa Sharbati' (IARI), 'Hara Madhu' (PAU) and 'Durgapura Madhu' (Durgapura, Jaipur); and in watermelon 'Sugar Baby' (IARI) and 'Durgapura Meetha' (Durgapura, Jaipur). Besides, a bittergourd hybrid 'Pusa Domausmi' X 'S 144' has been developed at the IARI which has outyielded the commercially recommended variety 'Pusa Domausmi' by 84 per cent. The Rajendra Agricultural University, Patna, has developed a promising brinjal hybrid 'Muktakeshi' X 'Banaras Giant'. 'TP 3', a superior-quality variety of garden-pea, has been developed at the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. At Hissar, brinjal variety 'Br 112', onion 'Hissar 2', chilli 'Hissar 7' and carrot 'Hissar Selection' have been developed for the Haryana region. Some promising strains of bean (Dolichos lablab), viz. 'HD 1', 'HD 5' and 'HD 18', have been developed at the HAU, Hissar. One spontaneous early mutant of bean. 'Typicus', with dwarf bushy habit was identified at the TNAU. The Rajendra Agricultural University, Patna, has identified 4 promising strains of parwal (Trichosanthes dioica), viz. 'Hilli', 'Safeda', 'Nemia and 'Doodali'.

At the IARI, brinjal selections resistant to Phomopsis blight have been made. 'Pusa Purple Cluster' brinjal has been found resistant to bacterial wilt. Promising lines have been identified in cabbage and cauliflower for resistance to blackrot disease and in garden-pea for resistance to wilt. Eleven selections resistant to Septoria leaf-spot and rust have been made in cowpea at the IIHR, Bangalore. They are superior to 'Pusa Dophasli'.

At the IIHR, Bangalore, storage rot of onion was checked by steeping the bulbs for 30 min in captan (0.1 per cent), Aureofungin and thiram (0.1 per cent). Steeping of tomato seedlings in streptomycin sulphate/penicillin/oxytetracycline-HCl arrested the bacterial wilt. Demosan and thiram as seed-dressers, Benomy1, Bavistin and Calixin as root-dip and captan and Dithane M-45 as soil-drench were effective in the control of foot-rot disease (Sclerotium rolfsii) of chilli. At the TARI, seed-dressing of cauliflower with 0.2 per cent Thiride gave a better germination, stand and healthier nursery.
Lasso, a weedicide @ 2 kg ai/ha, followed by 1 hand-weeding 5–6 weeks after sowing controlled the weeds in okra. In cabbage a spacing of 60 cm × 40 cm was suitable for late cauliflower variety 'Snowball'. In brinjal 'Pusa Purple Long' at a spacing of 75 cm × 45 cm and optimum fertilizer dose of 150 kg N/ha, and 100 kg P₂O₅/ha proved beneficial at the IIHR, Bangalore.

**Floriculture**

Among the floricultural crops, the new varieties released are: 37 new varieties of rose, 14 of hibiscus, 9 of croton and 4 of bougainvillea. The rose variety 'Mohini' aroused international interest in view of its novel and unusual chocolate-brown colour; 'Super Star', 'Happiness' and 'Queen Elizabeth' were found suitable for export of cut flowers. Besides these, varieties of gladiolus have been recommended for growing for cut flowers. 'Ratna Butterfly' proved a good multiplier of corms in plains and a promising variety for export of cut flowers. In orchids, 30 native species were identified as highly ornamental and recommended for multiplication. One orchid variety of *Dendrobium phalaenopsis*, viz. 'Madam Pompadour', with beautiful flower and long stalk, performed well under Bangalore conditions. Among seasonal flowers, a virus-resistant variety of *Zinnia* and an F₁ hybrid of holyhock have been released.

The agro-techniques for growing roses and gladiolus for export and their packaging have been standardized. A pot mixture for growing orchids has also been standardized. In tuberose, a spacing of 20 cm × 10 cm gave highest yield of flowers (5.83 q/ha). Early and higher yield was obtained from bulbs weighing 11–16 g. For jasmine oil, *Jasminum grandiflorum* proved the best, and agro-technique for obtaining highest yield of flowers has been standardized. In carnation lower plant density (30 plants/m²) was found suitable for production of quality blooms and higher seed yield.

Calixin (0.05 per cent) effectively controlled powdery-mildew of rose. Bavistin (0.1 per cent) and Daconil (0.2 per cent) were very effective against *Septoria* leaf-spot of chrysanthemum. Bavistin (0.1 per cent) and Difolatan (0.2 per cent) controlled *Cercospora* leaf-spot of jasmine. 'Damping-off in aster caused by *Rhizoctonia solani* could be effectively checked by soil-drenching with Benomyl (0.1 per cent), Bavistin (0.05 per cent) and NF-44 (0.2 per cent). Corm-rot of gladiolus, caused by *Fusarium oxysporum* f. sp. *gladioli*, was controlled by Bavistin (0.05 per cent) as well as by hot-water treatment for 5 to 10 min at 50°C.
Rural Agro-Industrial Complexes

The ICAR sanctioned a scheme for setting up of an Agro-Industrial Complex each in Karnataka and Bihar under Indo-Bulgarian Project from 1 July 1976 for 3 years. The main concept of this scheme is to follow the ideal of integration of production, processing and marketing, but the objective behind the whole programme is to prepare the background for taking up work on a large industrial complex. During the first phase of the programme the promising Bulgarian and Indian varieties of vegetables will be tested for processing and higher production.

Testing of Bulgarian Vegetable Varieties
(Progress in the Operational Research Project)

For yield and processing quality, 8 varieties of tomato, 3 of pickling cucumber, 6 of capsicum, 1 of chilli, 2 of Frenchbean, 1 each of watermelon, muskmelon and pea, 5 of onion and 2 of squash were tested at the IIHR, Bangalore. The performance of tomato varieties was fluctuating. In pickling cucumber, the Bulgarian variety ‘Pliska’ gave the highest yield, and ‘Delicates’ showed the best fruit quality. In French-bean, Bulgarian variety ‘Nikus’ was superior in pod quality though the local variety gave highest yield. Capsicum varieties from Bulgaria, viz. ‘Zlaten Medal’, ‘Djala Kapija’ and ‘Sofia Kapija’, compared well in yield with the Indian recommended varieties ‘California Wonder’ and ‘Chinese Giant’, but the fruit colour and shape of the former lacked consumer appeal. In yield the Bulgarian chilli variety ‘Plodiviski Ljut’ compared well with the local variety ‘Jwala’. In garden-pea Bulgarian variety ‘Uspech’ compared well with ‘Bonneville’ in yield and quality. In watermelon, muskmelon and squash, Indian varieties performed better.

FRUITS

Mango

The mango varieties ‘Mehmooda Vikarabad’, ‘Chousa’ and ‘Maju’ were found to be good for preservation as pure pulp, and ‘Kurnuli Mulgoa’ (a cultivar with excellent flavour) was ideal for blending its flavour in pulp at Sangareddy. ‘Sukul’ proved best for juice preparation at Basti.

Banana

‘Monsmari’ (a cultivar of ‘Dwarf Cavendish’) gave high production with big fruits and high sugar content at the Kerala Agricultural University, Mannuthy.
A new variety, 'H 135', was bred by the Tamil Nadu Agricultural University, Coimbatore. For controlling bunchy top, application of granular insecticides like Thimet (15 kg/ha) or Dysis-ton (40 kg/ha) gave best control of aphid population, under Kerala conditions.

**Citrus**

Kinnow mandarin performed better under Punjab, Himachal Pradesh and Maharashtra conditions.

A mild strain of tristeza virus disease in sour lime was isolated at the University of Agricultural Sciences, Hebbal, Bangalore, which can counteract the severe strain of tristeza.

Rangpur lime and Rangpur lime (Kodur) have been found to be best rootstocks for Sathgudi and Mosambi scions under Tirupati (Andhra Pradesh) and Maharashtra conditions respectively.

Application of 4 kg ai/ha of DBCP was the best for controlling population of citrus nematode (*Tylenchulus semipenetrans*) in sour lime plantations of Tamil Nadu. Dikron at 2.5 kg/ha successfully controlled the weeds in Mosambi orchards under Shirirampur conditions. The Citrus Research Station, Tirupati, supplied 25,000 virus-free Sathgudi buds to fruit-growers. A virus-free citrus germplasm bank has also been established at the Punjab Agricultural University.

**Grapes**

In grapes, 2 outstanding hybrids, viz. 'B 11-3' ('Anab-e-Shahi' × 'Queen of the Vineyard') and 'C 36-16' ('Black Champa' × 'Thompson Seedless') have been developed at the IIHR, Bangalore. The varieties 'Robinson', 'Torrey', 'Fregno' and 'Albriton' are performing well at Mahabaleshwar.

Anthracnose disease of grapes was controlled by 0.20 per cent Difolatan sprays, whereas powdery-mildew by M & B 21914 (0.05 per cent) or Bavistin (0.05 per cent) or Microsul (0.2 per cent) sprays at Hyderabad.

**Pineapple**

A good number of spineless hybrids have been produced at Bangalore. At the Indian Institute of Horticultural Research and the Assam Agricultural University, application of 200 ppm NAA, 2 months after flowering, increased the fruit weight of 'Kew' pineapple significantly.
At the Kerala Agricultural University a population of 43,036 plants/ha compared with conventional planting of 15,000 plants/ha gave best yield of ‘Kew’ pineapple. Besides, leaf cuttings with 1–3 leaves, prepared from the crowns of ‘Kew’, dipped in a solution of Dithane Z-78 (0.02 per cent), were able to root up to 90 per cent.

Pomegranate

Cracking and splitting of pomegranate fruits is caused by calcium and boron deficiency, according to a report from the Udaipur University.

Ber

Powdery-mildew of ber was controlled by 3 sprays of Karathane L.C. (0.15 per cent) or Morocide (0.01 per cent) at 15-day interval at the Udaipur University. At the Haryana Agricultural University, Hissar, an income of Rs 19,600/ha could be obtained by following proper management practices.

Temperate Fruits

In Himachal Pradesh 4 promising hybrids of apple were developed incorporating ‘Ambri’ character in them. Peach cultivar ‘Flordasun’ ripened by the end of April and gave a good yield in Punjab. Besides, removal of 20–30 per cent of previous season linear growth in peach during the third week of February was found superior at Chaubattiá. A major breakthrough has been achieved in vegetative propagation of walnut, persimmon and pecan.

MEDICINAL AND AROMATIC PLANTS

Mutation breeding attempted in lemongrass at the Kerala Agricultural University, by using gamma-rays, has resulted in isolation of a good number of vigorous plants. These are being tested for grass yield and oil content to isolate high-yielding types.

‘Nilamboor’ variety of vetiver gave the maximum oil yield with quality. Planting of vetiver in May and June gave high root yield and planting in June–July gave high oil yield.

The Indian Institute of Horticultural Research has reported the following findings:
Faster Multiplication of Dioscorea

Clonal propagation is a quicker method than tuber planting for multiplication of sapogenin-bearing Dioscorea sp. Studies conducted during 1976–77 have shown that under intermittent mist, single-leaf stem-cuttings taken from 1- or 2-month-old greenhouse-grown Dioscorea floribunda vines treated with 1 ppm, 2, 4-D and 0.1 ppm benlate or benlate alone would give 90–100 per cent rooted plantlets. The mother plants raised from tuber pieces under greenhouse conditions produced 20–30 single-leaf stem-cuttings at monthly intervals. The plants obtained through this method produced about 10 leaves within 2 months and the stem-cuttings gave 90–100 per cent rooted plantlets under experimental conditions.

Increasing Diosgenin Content in Dioscorea

Incubation of freshly harvested and homogenized tuber samples of D. floribunda for 24 hr at 37°C increased the diosgenin content by 16.4 per cent. The use of 500 ppm squalene increased the diosgenin yield by 30.9 per cent.

LAC

The salient achievements in lac research at the Indian Lac Research Institute, Namkum, Ranchi, during the year are given below.

Lac Cultivation

One monoecious variety of putri (Croton oblongifolius) and another of baryari (Desmodium pulchellum) have been identified as promising kusmi lac hosts, to augment production of the superior-quality lac.

For rendering the lac insects amenable to laboratory experiments, attempts were made to rear them in the laboratory on chemically defined diets made up of amino acids, vitamins, sugars and mineral salts, using agar-agar as a substrate for their colonization. The newly emerged lac larvae survived for 61 days in the katki 1977 season, but they compared poorly in their growth and development with those grown under the natural conditions.

Studies on the relative and seasonal abundance of the inimical and beneficial parasites of lac insects have now provided the basic information needed to develop an effective pest-management technology.
Further tests with the marker genes and evidence from the X-
irradiation studies have provided additional evidence of a unique
chromosome behaviour in the Indian lac insect, *Kerria lacca*
(Kerr). The male *K. lacca* is somatically a diploid, but it breeds
as a true haploid, transmitting only the maternal genome through
the sperm due to heterochromatization and elimination of the
paternal chromosome set in the male germline. The *K. lacca*
genes are thus autosomal in expression, but are sex-linked in
transmission. This information now forms the basis of the current
programme of breeding lac insects for quality and high producti-

The recent discovery of a white mutant was hailed as a signifi-
cant development in lac research in view of the long-standing;
industrial demand for a dye-free lac resin, which is presently met
by bleaching involving considerable expenditure and loss of some
desirable properties. The mutant, however, subsequently proved
to be too weak to serve as an insect of commerce. Nevertheless,
studies of the available colour forms (crimson, yellow and white)
have suggested possibility of blocking exclusively the resin dye
through mutation breeding, and such mutants (by virtue of retain-
ing the body colour) may be expected to do away with the bio-
logical weaknesses of the totally dye-free white mutant to help pro-
duce the much-needed white lac. Work along these lines is now
in progress and has already led to the detection of yet another ex-
tremely light resin colour variant now being studied at the insti-
tute.

Studies on the losses caused by enemy insects of lac have re-
vealed that such losses are rather unusually high, about 50 per cent
in the yield of sticklac on *kusum* in *aghani* crop and about 90 per
cent on *Moghania macrophylla* in *katki* crop.

*Agronomy and Plant Genetics*

*Introduction of rain trees for lac cultivation.*—The rain tree, a
potential host of lac in India, grows very slowly, taking 15–20
years to reach the proper lac-inoculation stage. The plants treated
with NPK fertilizers, at planting in June, in September and in the
following March and June, and irrigated weekly in summer
months, showed significant increases in both plant height and
shoot length.
Macrocyclic molecules from aleuritic acid.—Isoambrettolide, a compound used in perfumery, has been synthesized from aleuritic acid by a new and simple route in contrast to old procedures which consist of multi-step sequence of reactions.

Ion-exchange resin from shellac.—Ion-exchange resin developed from shellac on examination at the Central Marine Chemicals Research Institute, Bhavnagar (Gujarat), was found to have certain drawbacks such as colour throw, poor rate of exchange and attrition resistance, which have been overcome during the period under report. The colour throw was completely eliminated by washing the resin with sodium carbonate solution (4 per cent) and by extracting with spirit in a soxhlet. The rate of exchange and attrition resistance were improved by proper packing and backwashing the column when the rate was found comparable to other synthetic resin-based ion-exchange resin.

Modification of lac with glycols and dicarboxylic acids.—For preparing a high-molecular-weight urethane from shellac with improved properties such as high adhesion, flexibility and chemical resistance, it has been modified with ethylene glycol and dicarboxylic acids such as adipic, phthalic, terephthalic and maleic in different proportions. Of all these acids, adipic appeared to be the best, giving a polyester having lowest acid value. From the chemical constants, the polyester thus obtained appeared suitable for further reaction with an isocyanate to get a urethane whose preparation is under way.

Lac-based insulating varnish.—A lac-based insulating varnish was evolved by reacting shellac and double-boiled linseed oil in presence of incorporating agents, which gives a breakdown voltage of 3 KV/mil, indicating that it can be used as a high-grade insulating varnish.

Effect of plasticizers on the electrical properties of shellac.—Marked improvement in the breakdown strength of shellac varnish (air-drying) has been obtained by the addition of the plasticizer, tricresyl phosphate. The breakdown strength (BDS) of shellac with 15 per cent tricresyl phosphate was twice that of the plain shellac, and it is accompanied by considerable improvement in the flexibility as well.

Technology

Manufacture of shellac and dewaxed lac in aqueous medium.—The present method of dewaxing lac in aqueous medium is
lengthy and time consuming. The aqueous extract of lac in soda solution when immediately cooled to 10° to 15°C and filtered with some filtering aid, gave perfectly dewaxed lac and resulted in a saving of 24 hr.

Utilization of waste mica.—Insulating boards were prepared with waste mica, using shellac or modified shellac as bond. The waste mica in powder form was used as such, otherwise it was calcined (at 900°C for 1 hr) and powdered. The mica powder was made into a paste by mixing with an alcoholic solution of shellac or shellac modified with urea and formaldehyde. The paste was dried, powdered and hot-pressed in a hydraulic press for making insulating boards. The impact strength of these boards was low but they had high electrical insulation. The boards were quite tough and could stand drilling, sawing, punching and other such operations of the machine workshop.

Rubber-shellac combination.—Shellac and modified lacs were incorporated into a blend of 50 parts of natural rubber and 50 parts of styrene-butadiene rubber with carbon-black filler. The shellac and modified lac (Zn-salt of lac) increased all the mechanical properties with both the fillers, especially with zinc-salt of lac.

Extension

Co-polymerization of shellac with vinyl monomers.—Graft co-polymerization of shellac with acrylamide in dioxane at room temperature, by using a new technique (ceric-ion technique) gave maximum grafts, i.e. 80 per cent compared with 20 per cent with methyl methacrylate.

Extension training and exhibition.—Six candidates were given training and the institute participated in the Farmers' Fair held at the College of Agriculture, Rajendra Agricultural University, Ranchi, in September 1977.

PLANT PROTECTION

Though the results of research in plant protection are included with other details of specific crops, information on certain broad areas of plant-protection activities not covered elsewhere is highlighted here.

Biological Control of Pests

In 1977 the ICAR launched an All-India Co-ordinated Research Project on the Biological Control of Crop Pests. There are
12 co-operating centres covering various agro-ecological regions and major pests of field crops, vegetables, fruits and plantation crops. In a mini-workshop, the scientists of the co-operating centres discussed and sorted out the specific priorities of research. These include destructive pests of rice, cotton, sugarcane, tobacco, coconut, cashew, coffee, mango, apple, potato, vegetables and also 2 aquatic weeds, viz. water hyacinth and water fern. The specific pests which have immediate potentials of biological control are brown planthopper of rice, pyrilla and borers of sugarcane, beetles of coconut, san-jose scale of apple and leaf-eating caterpillar of tobacco and several forms of cutworms affecting other crops. The programme, thus marks the beginning of a systematic approach to pest management at national level without endangering the ecosystem with indiscriminate use of pesticides.

**Nematode Pest Control**

The implementation of an All-India Co-ordinated Research Project on Nematode Pests of crops by the ICAR during the year fulfils a major gap in plant-protection researches. Scientists from 12 co-operating centres met and identified the priority areas of research on destructive nematode pests of field crops, vegetables, fruits and plantation crops. Research on integrated control of major nematode pests, involving host resistance, cultural practices and need-based use of pesticides, has been projected in this programme.

**Rodent-pest Management**

A Co-ordinated Research Programme on Rodents was launched by the ICAR during the year at 4 centres. The areas of research identified by experts are restricted to: (i) behavioural studies in various agro-climatic zones, (ii) bait shyness, and (iii) sex attractants. The agro-ecological areas covered are the desert areas, north Indian plains, the south Indian plateau in Karnataka and the plantation crops areas in Kerala. An important component of this programme is the social engineering aspect where rodent-pest management will be undertaken in a sizeable area over a cluster of villages at each of the centres.

In addition, the training programmes of apex-level trainees in rodent-pest management were organized at 8 centres in the country under the National Rodent Pest Management Programme started jointly by the Indian Council of Agricultural Research, Agricultural Universities, Central Directorate of Plant Protection and the State Governments.
White-grub

The white-grubs constitute a number of forms which are polyphagous and which are feared to become a limiting factor in intensive cropping. The ICAR is supporting multi-localational research on these pests and has formulated an all-India co-ordinated project for consideration in the Sixth Five-Year Plan.

Disease and Pest Surveillance

The ICAR continued to organize the research-based wheat-rust surveillance at national level. This programme is essentially meant to provide information on the foci of infection of the 3 rusts of wheat and their spread to other areas. The data have provided valuable help in adjusting the varietal pattern on a geographical basis to minimize the intensity of the rust diseases.

Similarly, under the All-India Co-ordinated Rice Project, a production-oriented survey was organized to monitor the performance of high-yielding varieties in respect of major diseases and pests.

2. SOIL AND WATER MANAGEMENT, AGRONOMY AND AGRICULTURAL ENGINEERING

SOIL SURVEY

The National Bureau of Soil Survey and Land Use Planning completed the survey and mapping of about 63,00,000 hectares in the states of Punjab, Maharashtra, Gujarat, Karnataka, Kerala and North-Eastern Region. Field correlation and laboratory characterisation of important soil series were done and their appropriate use as per their capability suggested.

Coconut plantation of Karnataka.—The keeping quality of nuts grown in the soils of Tumkur and Hassan was found to be far superior to those of the nuts produced in Bangalore. Attempts were made to correlate the keeping quality of nuts with that of important soil characteristics. Observations were made on the parent material of soil, colour, texture, pH, cation-exchange capacity, water-holding capacity, moisture equivalent, available potash, mineralogy of sand fraction and local management practices. Further studies on correlating soil properties with the quality are in progress.

Orange plantations in Nagpur region of Maharashtra.—The oranges grown on Panjra soil series were superior to those grown on Linga soil series in respect of fruit quality, yield, growth condition and longevity. The studies were undertaken to correlate the soil properties of both the soil series with that of quality of oranges.
Soils of Panjra series classified as 'fine', Montmorillonitic, Hyperthermic family of Typic, Chromusterts, are deep to very deep, dark to very dark brown, clay to gravelly clay loams. The sub-soil is mixed with coarse to medium undurated, lime nodules and gravels in varying proportions. The roots penetrate through depth vertically. The sub-soil has better aggregation leading to higher permeability and aeration.

Soils of Linga series is classified as fine, Montmorillonitic, Hyperthermic family of Udic Chromusterts, and are deep to very deep, dark grayish brown, poorly drained, clayey having high co-efficient of expansion and contraction. The sub-soil is compact and hard when dried and thus restricts vertical root penetration as well as development of fine roots.

The close view of typical soil profiles from these two series are given below:

![PANJRA SERIES](image1)

![LINGA SERIES](image2)

Fig. 2. Orange-growing soils
Under similar levels of management, marked differences were observed with respect to yield, quality and size of fruits grown on Linga and Panjra series.

<table>
<thead>
<tr>
<th>Yield</th>
<th>Fruit number (per hectare)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panjra</td>
<td>2,75,000 to 3,12,500</td>
</tr>
<tr>
<td>Linga</td>
<td>1,50,000 to 2,25,000</td>
</tr>
</tbody>
</table>

**Land-use planning.**—A detailed soil survey of a village, viz., Chausli, situated at an altitude of about 1,700 metres selected by Vivekananda Parvatiya Anusandhan Shala, Almora, to start operational research project, was completed. Land use depending on depth of soil, slope and erosion status was suggested for proper planning of land use as per capability classes.

A detailed soil survey for land-use planning on a farm of about 300 hectares near Mathura was completed for establishment of a National Goat Research Centre by the Council. Depending on land capability, suitable soil groups were suggested both for irrigated as well as under un-irrigated conditions along with appropriate soil and water management measures. Land, unsuitable for cultivation, was recommended for limited open grazing for goats.

**Survey of barrak watershed, north-eastern region.**—At the request of the North Eastern Council, Shillong, Soil Survey of Barrak Watershed comprising a total area of about 12,500 km² falling in the States of Nagaland, Manipur, Assam and Mizoram was completed. A pre-feasibility study report containing photointerpretation map, geomorphological map and soil map was also prepared. A map indicating problems that are unique to the region particularly with respect to jhooming (current as well as old), erosion by way of land slips etc., and potential areas for agriculture, plantation crops, orchards and vegetable was prepared. Appropriate management practices with cropping patterns suited to different soils and slopes are specified in the report.

**Integrated rural development plan.**—For the preparation of rural integrated plans of Chandrapur and Wardha districts in Maharashtra, Cannanore in Kerala and Tumkur in Karnataka, the soil surveys were completed and the maps giving information on present land use and suggested land use were prepared. In Wardha district, emphasis is more on agriculture, whereas in Cannanore district, plantation crops and paddy are suggested.
Soil Conservation

The Central Soil and Water Conservation Research and Training Institute, Dehra Dun, and its centres at Chandigarh, Kota, Vasad, Agra, Ootacamund and Bellary dealt with problems of conservation of soil and water as natural resources and their management for higher production under various land uses.

Loss of soil and plant nutrients under different land uses.—At Vasad Centre, studies were carried out regarding run-off soil loss and nutrient losses under different land uses. It was observed that the plot under grass cover of Dichanthium annulatum did not permit any run-off and any soil loss and hence nutrient losses, whereas cultivated fallow gave the maximum run-off, soil and nutrient losses. Amongst the cropping systems tried, growing of green manure tobacco which is the main crop of the region on ridges, was highly beneficial compared to flat planting in terms of soil and moisture conservation and increased yield of the crop from 12.8 q/ha to 14.3 q/ha of tobacco-cured leaf.

The experiments were also carried out on building up the fertility of the surface soils. In the process of ravine reclamation a lot of soil work is done and the subsoil is brought on the surface. Normally a subsoil is poor in organic matter and other plant nutrients as compared to surface soil. In a study (an average of 1975-1977) on subsoil exposed by reclamation of ravine lands, annual application of 30 tonnes of farmyard manure/ha in addition to green manure increased the yield of wheat from 11.7 to 30.2 q/ha (i.e. 158 per cent increase over control) and tobacco from 17.1 to 28.1 q/ha (i.e. 64 per cent increase over control).

At Chandigarh Centre, studies were carried out to find out the effect of closure with afforestation and gully control measures on run-off and peak discharge in two small watersheds in Siwalik hills which were treated with soil conservation measures. The results indicated that there was a reduction in run-off and no effect on peak discharge as a result of simple closure over a period of time and there was further decrease in run-off to the tune of 48.4 per cent and peak discharge to the tune of 62.9 per cent as an effect of closure and afforestation with gully control measures, as compared to closure alone.

Cropping pattern (pulses).—At Kota Centre, redgram (arhar variety ‘Local Kota’) grown in 60 cm apart lines, gave a grain yield of 18-20 q/ha. Introducing one line of blackgram (‘T9’) or greengram (‘PS-16’) in between redgram lines gave additional
yield of 5-6 q/ha (Table 1). This also reduced weed problem for redgram. This mixed cropping of redgram with compatible pulse crops like blackgram and greengram would increase pulse crop yields per unit area.

Table 1. Yield of grain (kg/ha) under different mixed cropping treatments (1976-77) Kota

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Main crop (arhar)</th>
<th>Inter-crop (moong/urd/jowar)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arhar (60 cm)</td>
<td>1,875</td>
<td>—</td>
<td>1,875</td>
</tr>
<tr>
<td>Arhar (90 cm)</td>
<td>1,701</td>
<td>—</td>
<td>1,701</td>
</tr>
<tr>
<td>Arhar (120 cm)</td>
<td>1,569</td>
<td>—</td>
<td>1,569</td>
</tr>
<tr>
<td>Arhar (60 cm) : moong (1:1)</td>
<td>1,917</td>
<td>509</td>
<td>2,426</td>
</tr>
<tr>
<td>Arhar (90 cm) : moong (1:2)</td>
<td>1,535</td>
<td>605</td>
<td>2,140</td>
</tr>
<tr>
<td>Arhar (120 cm) : moong (1:3)</td>
<td>1,167</td>
<td>570</td>
<td>1,737</td>
</tr>
<tr>
<td>Arhar (60 cm) : urd (1:1)</td>
<td>2,014</td>
<td>578</td>
<td>2,592</td>
</tr>
<tr>
<td>Arhar (90 cm) : urd (1:2)</td>
<td>1,493</td>
<td>721</td>
<td>2,214</td>
</tr>
<tr>
<td>Arhar (120 cm) : urd (1:3)</td>
<td>1,347</td>
<td>726</td>
<td>2,073</td>
</tr>
<tr>
<td>Arhar (60 cm) : jowar (1:1)</td>
<td>1,271</td>
<td>1,493</td>
<td>2,764*</td>
</tr>
<tr>
<td>Arhar (90 cm) : jowar (1:2)</td>
<td>1,042</td>
<td>1,132</td>
<td>2,174*</td>
</tr>
<tr>
<td>Arhar (120 cm) : jowar (1:3)</td>
<td>833</td>
<td>1,486</td>
<td>2,319*</td>
</tr>
</tbody>
</table>

*In addition to grain yields, arhar + jowar treatment gave 167, 178 and 181 q/ha of stover respectively having an economic value varying from Rs. 1,600 to Rs. 1,800/ha @ Rs. 10/q.

Water management.—The experiment was carried out at Kota Centre on skip-row irrigation for gram. It was successfully proved that by skipping irrigation in some gram rows, it is possible to attain yields comparable to regular irrigation (every row irrigated) and thus cover larger areas with the same quantity of irrigation water and obtain higher yields. An average yield of 23.3 q/ha of gram was obtained by skip-row irrigation as compared with 18.4 q/ha with no irrigation and 24.5 q/ha with normal irrigation in every row.

Cropping systems.—At Bellary, it has now been possible to have more than one crop in normal single cropped area in semi-dry region. In view of the availability of water from Tungabhadra
canal, the studies were carried out for introduction of crops and crop sequences. It was found that maize-wheat, maize-Bengal gram, maize-safflower, bajra-safflower, bajra-wheat crop combinations were very promising. Maize and bajra yielded on an average 3,976 and 3,528 kg of grain/ha respectively. The crops of safflower, wheat and Bengal gram which succeeded maize had an average yield potential of 20-24 q/ha. The safflower and wheat crops which succeeded bajra had a yield potential of about 19 q/ha.

Training.—Professional training in Soil and Water Conservation continued to be imparted under regular courses of 22-weeks duration. Gazetted officers, deputed by different State Departments, were trained at Dehra Dun Institute (U.P.), while the non-gazetted graduate assistants were trained at the training centres at Kota (Rajasthan), Ootacamund (Tamil Nadu) and the collaborating training centres at Hazaribagh DVC (Bihar). A total of 62 gazetted officers (at Dehra Dun) and 126 non-gazetted (38 at Ootacamund, 41 at Kota, and 47 at Hazaribagh) assistant trainees received the professional training in Soil and Water Conservation for managing the action programme in the States in 1977.

Operational research project.—Operational Research Project in the catchment of Sukhna Lake, Chandigarh, has been in operation for the last 2 years. The Sukhna Lake of Chandigarh was constructed at a cost of Rs. one crore. 66 per cent of its storage capacity was lost within a period of 15 years which works out to be a net sediment rate of 150 tonnes/ha/year.

The project area selected is probably the worst area in the whole of Sukhna catchment having an area of 16 km². The area was devoid of any vegetative cover worth the name. The average slope of the sub-watersheds feeding the main stream was 30 to 40 per cent. The slope of the main channel itself was 6 per cent. The erosion potential of the sub-watersheds was estimated to be from 1,000 to 2,000 tonnes/ha/year.

With the package of practices viz., staggered contour trenches, Brushwood dam, check dams, grade stabilizers, debris basin and planting Acacia catechu, Dalbergia sissoo, Eucalyptus, and Lukshiopsis hinata (bhabhar grass) adopted in the watershed of 6 ha. 0.17 tonnes of sediment per ha could be achieved from an area which was releasing 900 tonnes/ha of sediment before the treatment.
SOIL SALINITY RESEARCH AND RECLAMATION TECHNOLOGY

The studies on the reclamation of sodic or alkali soils, which occupy an area of about 2.5 million hectares, have been in progress at the Soil Salinity Research Institute, Karnal and at two of the research centres (Kanpur, Indore) of the Integrated Project for Research on Water Management and Soil Salinity. The salient results achieved during the year are as under:

*Exchangeable sodium and water movement in soils.*—Experiments conducted under field conditions to study the effect of exchangeable sodium on the drying pattern of a differentially gypsum treated sodic soil under the different evaporative demands (average potential evaporation of 2.5 and 12.5 mm/day). Table 2 presents the cumulative water loss under the treatments control (ESP 38) and the one that received 30 tons/ha (ESP 4) during summer (PE=12.5 mm/day) and winter (PE=2.5 mm/day).

Table 2. Cumulative water loss under G₀ and G₃₀ with varying evaporative demand

<table>
<thead>
<tr>
<th>PE (mm/day)</th>
<th>ESP of surface (0—15 cm)</th>
<th>Cumulative water use (mm)</th>
<th>Duration (days)</th>
<th>Zone of evaporation (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5</td>
<td>38 (no gypsum)</td>
<td>37·6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>4 (gypsum 30 tonnes/ha)</td>
<td>41·8</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
<td>2.5</td>
<td>38 (no gypsum)</td>
<td>44·6</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4 (gypsum 30 tonnes/ha)</td>
<td>41·8</td>
<td>27</td>
<td>38</td>
</tr>
</tbody>
</table>

PE—Potential evaporation

The data indicated that during summer under high evaporative demand, the surface layers under high ESP dried up rapidly and the lower layers did not contribute much to replenish the loss from water transmission properties under low ESP, the zone of evaporation deepened, indicating contribution from the lower layers. In winter under low evaporation demand the losses were gradual delaying the formation of surface dry layer, thereby deepening the zone of evaporation. Under low ESP during winter as well, there was a greater contribution of the lower layers towards the evaporative losses.

6—1080AR&Edu/77
Studies on performance of closed level and graded border in alkali soils.—For efficient irrigation of wheat crop in alkali soils, graded borders with 0.70 cutoff ratio gave the highest application and distribution efficiencies of 78% and 82% respectively. The corresponding crop-yield and water-use efficiencies are 41.5 q/ha and 150 kg/ha/cm. The variation of water-use efficiency for graded and level borders are shown in Fig. 3.

![Graph showing the relationship between cutoff ratio and application efficiency for graded and level borders.](image)

Fig. 3. Relationship between cutoff ratio and application efficiency

Effect of missing application of P or both P and K in rice or wheat or in both crops on their yields in semi-reclaimed sodic soils.—Studies were started from kharif 1974 on the effect of phosphorus and potassium on the yield of rice and wheat in sequence. No reduction in grain yield was observed in either of the two crops till rabi 1977 by missing the use of P or both P and K as revealed by the data given in the Table 3.
Table 3. Grain yield of rice and wheat in respective seasons during 1974—77

<table>
<thead>
<tr>
<th>Nutrients added (kg/ha)</th>
<th>Rice crop</th>
<th>Wheat crop</th>
<th>Rice crop</th>
<th>Wheat crop</th>
<th>Rice crop</th>
<th>Wheat crop</th>
<th>Paddy Soil available-P (Olsen’s P in ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₀ P₀ K₀</td>
<td>38.1</td>
<td>8.4</td>
<td>32.9</td>
<td>12.0</td>
<td>141.1</td>
<td>13.9</td>
<td>36.9</td>
</tr>
<tr>
<td>N₀ P₀ K₀</td>
<td>36.4</td>
<td>41.1</td>
<td>59.8</td>
<td>38.6</td>
<td>31.5</td>
<td>48.8</td>
<td>78.1</td>
</tr>
<tr>
<td>N₁₀₀ P₅₀ K₅₀</td>
<td>65.6</td>
<td>37.1</td>
<td>61.6</td>
<td>37.1</td>
<td>83.4</td>
<td>45.7</td>
<td>81.5</td>
</tr>
<tr>
<td>N₁₀₀ P₅₀</td>
<td>66.3</td>
<td>41.4</td>
<td>57.7</td>
<td>37.5</td>
<td>77.9</td>
<td>45.6</td>
<td>80.6</td>
</tr>
<tr>
<td>N₁₀₀</td>
<td>71.7</td>
<td>39.0</td>
<td>57.9</td>
<td>38.2</td>
<td>85.0</td>
<td>48.0</td>
<td>79.8</td>
</tr>
<tr>
<td>N₁₀₀ P₅₀ K₅₀</td>
<td>70.8</td>
<td>40.5</td>
<td>57.9</td>
<td>37.1</td>
<td>80.5</td>
<td>47.2</td>
<td>80.6</td>
</tr>
<tr>
<td>N₁₀₀ P₅₀ K₅₀</td>
<td>64.5</td>
<td>40.2</td>
<td>57.8</td>
<td>36.6</td>
<td>80.4</td>
<td>44.9</td>
<td>79.0</td>
</tr>
<tr>
<td>N₁₀₀</td>
<td>68.5</td>
<td>41.4</td>
<td>57.8</td>
<td>36.6</td>
<td>80.4</td>
<td>44.9</td>
<td>81.9</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>9.6</td>
<td>8.2</td>
<td>9.8</td>
<td>3.3</td>
<td>13.3</td>
<td>5.9</td>
<td>6.8</td>
</tr>
</tbody>
</table>
Tolerance of sunflower to exchangeable sodium.—Effect of varying exchangeable sodium percentage (ESP 4 to 63) levels obtained as a result of differential gypsum application to highly sodic soils was studied on the yield of sunflower grown in summer. Data in Fig. 4 show that nearly 50% reduction in yield occurred at an ESP of about 35. It may be pointed out that in the same soil while wheat yield underwent 50% reduction at an ESP of about 45, the paddy yield was nearly unaffected up to an ESP of 60.

Fig. 4. Sunflower yield at varying exchangeable sodium percentage levels.
Forage grasses for alkali soils.—Several forage grasses were evaluated for their performance on alkali soils. It was found that these problem soils could be utilized for growing locally adapted salt-tolerant forage grasses such as Diplachne fusca and cultivated grasses like blue panic (Panicum antidotale), para grass (Brachiaria mutica) and rhodes grass (Chloris gayana).

Effect of nitrogen levels on the yield of Diplachne fusca.—Effect of 5 levels of nitrogen on the yield of Diplachne fusca was application of any amendment. Total forage yield from six cuttings (Table 4) during 1977 show that this is a highly promising grass for being grown in sodic soils. Yield increased significantly up to 30 kg N application per hectare.

Table 4. Green forage yield of grass (Diplachne fusca) from sodic soil during 1977

<table>
<thead>
<tr>
<th>N level</th>
<th>Green forage yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>255.8</td>
</tr>
<tr>
<td>10</td>
<td>284.0</td>
</tr>
<tr>
<td>20</td>
<td>350.3</td>
</tr>
<tr>
<td>30</td>
<td>465.1</td>
</tr>
<tr>
<td>40</td>
<td>466.6</td>
</tr>
<tr>
<td>C. D. at 5%</td>
<td>55</td>
</tr>
</tbody>
</table>

Reclamation and utilization of salt-affected soils.—Studies on reclamation of sodic soils at Kanpur and Indore centres revealed that even after 6 years of initiation of reclamation, the differences in both rice and wheat yield were discernible under different levels of amendments application. Gypsum application @ 80% of gypsum requirement (0-15 cm soil depth) appeared to be optimum for rice-wheat rotation. The comparative study of gypsum and pyrites on equivalent dose basis revealed that at Kanpur the pyrites were inferior to gypsum but at Indore both the amendments were at par (Table 5). The addition of organic mulches enhanced the efficacy of amendments in reclamation of sodic soils both at Kanpur and Indore.
Table 5. Comparative efficiency of gypsum and pyrites in wheat and rice production (q/ha) on salt-affected soils

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Indore (Deep black clay soil)</th>
<th>Kanpur (Alluvial sandy loam soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice</td>
<td>Wheat</td>
</tr>
<tr>
<td>Control</td>
<td>24.56</td>
<td>16.37</td>
</tr>
<tr>
<td>Gypsum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>@40%  GR</td>
<td>30.66</td>
<td>20.81</td>
</tr>
<tr>
<td>@60%  GR</td>
<td>31.91</td>
<td>22.75</td>
</tr>
<tr>
<td>Pyrites (15% S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>@40%  GR</td>
<td>31.08</td>
<td>21.64</td>
</tr>
<tr>
<td>@60%  GR</td>
<td>32.19</td>
<td>24.58</td>
</tr>
<tr>
<td>Pyrites (30% S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>@40%  GR</td>
<td></td>
<td>44.00</td>
</tr>
<tr>
<td>@60%  GR</td>
<td></td>
<td>48.78</td>
</tr>
<tr>
<td>C. D. at 5%</td>
<td>5.60</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Experiments conducted at Naini Deo University of Agriculture and Technology, Faizabad (UP), showed that under the conditions of alkali soils at Kumargang Farm Paddy variety 'IR-28' yielded about 50 q/ha and this variety was found to be more suitable under such soil conditions.

Among wheat varieties tested in the alkali soils 'HD-1553' performed better. Whereas among barley varieties, 'Ratna' was found to be superior.

Water Management

Research on water management has been in progress under three All-India Co-ordinated Research Projects, viz. (i) Integrated project for research on water management and soil salinity; (ii) water management in high rainfall areas and temperate hill zones, and (iii) Use of saline water in agriculture. The salient achievements are as under:

Effect of canal irrigation on water-table.—The studies have been in progress at HAU, Hissar to observe the rise of water-table due to introduction of irrigation. The observations recorded during the last 10 years have revealed that the water-table has risen from 16.66 m to 7.25 m and it works out to be an average of annual rise of 94.0 cm. The rise of water-table over the years is depicted in Fig. 5. The speed with which the water-table is rising in the
Fig. 5. Rise in water table at Hissar
productive lands is quite alarming, because the underground water in Haryana State is not of good quality and as the water-table rises, it may lead to the development of salinity. In view of this, necessary drainage etc. needs attention for arresting the further rise of water-table.

**Border strip.**—Considering the crop yields, water use and various irrigation efficiencies, the following dimensions of borders were found optimum for irrigation of wheat at different centres. The results are presented in Table 6.

*Table 6. Optimum size of border strips for efficient irrigation*

<table>
<thead>
<tr>
<th>Centre</th>
<th>Soil type</th>
<th>Stream size (fps)</th>
<th>Optimum dimension of borders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Length (m)</td>
<td>Width (m)</td>
</tr>
<tr>
<td>Jobner</td>
<td>Sandy</td>
<td>2.8</td>
<td>20</td>
</tr>
<tr>
<td>Hissar</td>
<td>Sandy loam</td>
<td>15.0</td>
<td>70</td>
</tr>
<tr>
<td>Madhapura</td>
<td>Sandy loam</td>
<td>10.0</td>
<td>40</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>Sandy clay loam</td>
<td>6.0</td>
<td>45</td>
</tr>
<tr>
<td>Jabalpur</td>
<td>Clay loam</td>
<td>4.2</td>
<td>70</td>
</tr>
<tr>
<td>Rahuri</td>
<td>Clay</td>
<td>4.0</td>
<td>100</td>
</tr>
<tr>
<td>Kota</td>
<td>Clay</td>
<td>19.5</td>
<td>150</td>
</tr>
</tbody>
</table>

**Water use and irrigation scheduling in different crops.**—In greengram (*moong*) ensuring one irrigation at pod filling stage under Hissar conditions produced a good yield of gram (Table 7). The data also point out that irrigation application at flowering stage should be avoided as this encourages vegetative growth which is detriment to grain yield. On heavy clay soils of Central India, gram requires two irrigations scheduled at IW/CPE ratio of 0.4 with 8 cm depth of irrigation for optimum yield.

*Table 7. Effect of irrigation schedules on the grain yield of gram variety ‘G-130’ at Hissar*

<table>
<thead>
<tr>
<th>Irrigation at</th>
<th>No. of irrigations</th>
<th>Depth of grain (cm)</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branching</td>
<td>2</td>
<td>8</td>
<td>23.4</td>
</tr>
<tr>
<td>Flowering</td>
<td>1</td>
<td>8</td>
<td>22.5</td>
</tr>
</tbody>
</table>
In lentil the experiments conducted at CSSRI, Karnal, showed that the soils which had good moisture storage capacity, the crop sown after a heavy pre-sowing irrigation produced 22 q/ha of grain yield with just one irrigation applied at IW/CPE ratio of 0.3 with 6 cm depth of water, whereas the yield of lentil was 20 q/ha when no irrigation was applied.

For greengram and cowpea, at Hissar, with three irrigations at 7 cm depth each applied at IW/CPE ratio of 0.4, about 11 q/ha of moong yield was obtained during summer season. Similar was the water need for cowpea crop in summer season.

In mustard, on deep sandy loam soils at Jobner, mustard variety ‘Varuna’ yielded 19.1 q/ha with three irrigations applied at 0.40 IW/CPE ratio with 5 cm depth. The water-use efficiency was 127 kg/ha/cm for this moisture regime.

In safflower on sandy loam soils at IARI, New Delhi, an yield of 19.7 q/ha was obtained with only two irrigations applied at rosette and flowering stages.

In sunflower at Madurai, the crop when irrigated at IW/CPE ratio of 0.75 with 6 cm depth, produced seed yield equal to IW/CPE ratio of 0.9 and economised 6 cm of irrigation water. At Rahuri, on heavy clay soils irrigation to sunflower may be delayed up to IW/CPE ratio of 0.45 with 6 cm depth without any adverse effect on seed yield. For late sown sunflower under Hissar conditions, one irrigation at flowering stage produced about 14 q/ha of seed yield. Additional irrigation at seed formation stage was found to be unnecessary.

The rice crop has become an important crop in the non-traditional rice-growing areas of the northern States of Punjab, Haryana and Western U.P. At Ludhiana, on well-drained sandy-loam soil, irrigation of rice after one day of drainage produced as much grain yield as the existing practice of continuous submergence and saved about 50 cm (25%) of irrigation water (Table 8).
Table 8. Effect of various moisture regimes on grain yield and irrigation requirement of rice at Ludhiana

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grain yield (q/ha)</th>
<th>Irrigation requirement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continuous ponding</td>
<td>58.3</td>
<td>204</td>
</tr>
<tr>
<td>2. 1 day drainage*</td>
<td>57.5</td>
<td>151</td>
</tr>
<tr>
<td>3. 3 days drainage</td>
<td>49.6</td>
<td>114</td>
</tr>
<tr>
<td>4. 5 days drainage</td>
<td>46.7</td>
<td>96</td>
</tr>
<tr>
<td>5. 7 days drainage</td>
<td>48.2</td>
<td>82</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>8.2</td>
<td>8</td>
</tr>
</tbody>
</table>

*Period between infiltration of ponded water and subsequent irrigation.

Wheat studies on irrigation scheduling on the basis of IW/CPE approach (IW—quantity of irrigation water and CPE—cumulative pan evaporation from U.S. Wheather Bureau Class A Pan) were also carried out at Jabalpur, Indore and Kharagpur centres and the results confirmed the earlier finding that on heavy black clay soil, irrigation at IW/CPE ratio of 1.05 with 6 cm depth is necessary for higher grain yield. On deep soils with good moisture storage capacity, as at Ludhiana and Karnal, application of heavy presowing irrigation of 10 to 14 cm depth (depending on the previous crop and soil type, to recharge the soil profile up to a depth of about 200 cm) was found useful (Table 9). This practice reduced the need for post-sowing irrigations considerably. These results are helpful in such canal command areas where water availability, particularly in the later part of rabi season, is rather limited.

Table 9. Effect of initial depth of wetting and different post-sowing irrigation schedules on grain-yield of wheat (q/ha) at Karnal

<table>
<thead>
<tr>
<th>Irrigation of 6 cm depth at</th>
<th>Depth of pre-sowing irrigation</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 cm</td>
<td>11 cm</td>
</tr>
<tr>
<td>IW/CPE 0.9</td>
<td>52.1(6)</td>
<td>50.9(6)</td>
</tr>
<tr>
<td>*CRI : B : F</td>
<td>42.5(3)</td>
<td>47.1(3)</td>
</tr>
<tr>
<td>*CRI : F</td>
<td>38.7(2)</td>
<td>39.4(2)</td>
</tr>
<tr>
<td>Mean</td>
<td>45.4</td>
<td>47.2</td>
</tr>
</tbody>
</table>

*Irrigation at CRI stage was missed due to occurrence of rainfall. Figures in bracket are number of irrigations including pre-sowing.
Water management in high rainfall areas and temperate hill zones.—In rice studies were conducted at Dehra Dun, Kalimpong, Palampur and Shillong to determine the best water regime for paddy under irrigated conditions. Temperate areas like Palampur where the temperature of continuously flowing irrigation water is low, pose the additional problem of low temperature in the root zone, inhibiting paddy yield. Studies at all locations indicated the ponding of water to a depth of 5 to 10 cm in the paddy fields, ensure maximum yield (Table 10).

Table 10. Water management practices vs yield of paddy

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Palampur (China-988) Local (‘VL-8’) ‘Ratna’ (‘P-33’)</th>
<th>Kalimpong (Kal. i) (‘Khono-rulu’)</th>
<th>Shillong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed</td>
<td>34.3 15.5 36.9 36.9 36.9 34.9</td>
<td>45.9 45.9 50.8 58.6 28.7</td>
<td></td>
</tr>
<tr>
<td>Continuous saturation</td>
<td>43.5 20.4 43.1 47.2 45.6 45.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous submergence</td>
<td>44.8 21.9 41.9 47.1 50.8 58.6 28.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5—10 cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On wheat studies were conducted at Palampur during rabi 1976 with six moisture levels and three phosphorus levels to find out the relation between soil moisture and P levels in respect of consumptive use of water and P availability (Table 11).

Table 11. Grain yield of wheat ‘S-308’ (q/ha) (Palampur 1976-77)

<table>
<thead>
<tr>
<th>Moisture level</th>
<th>P₂G₃ (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfed</td>
<td>2.7 9.8 11.5</td>
</tr>
<tr>
<td>IW/CPE=0.60</td>
<td>5.6 17.0 19.6</td>
</tr>
<tr>
<td>IW/CPE=0.75</td>
<td>6.2 22.7 24.9</td>
</tr>
<tr>
<td>IW/CPE=0.90</td>
<td>6.8 23.0 23.4</td>
</tr>
<tr>
<td>Irrigation at 65% available moisture</td>
<td>9.8 34.4 36.7</td>
</tr>
<tr>
<td>Irrigation at CRI=jointing=flowering+milktage</td>
<td>9.1 26.5 27.3</td>
</tr>
</tbody>
</table>

Grain yield of wheat increased significantly both with increasing levels of moisture and phosphorus. The relationship between moisture and P levels was found to be very high since highest yield of wheat was obtained at highest level of moisture and highest level of phosphorus.
Use of saline water in agriculture.—The effect of different qualities of irrigation waters on crop growth and soil properties was examined at a number of centres. The EC of the irrigation waters which could be used successfully for growing different crops of various locations are as under:

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Soil texture</th>
<th>EC of water (mmhos/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agra</td>
<td>Wheat</td>
<td>Sandy loam</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Mustard</td>
<td>Do.</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>Do.</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Pearl-millet</td>
<td>Do.</td>
<td>8</td>
</tr>
<tr>
<td>Bapatla</td>
<td>Rice</td>
<td>Clay soil</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Sunflower</td>
<td>Sandy soil</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Ragi</td>
<td>Do.</td>
<td>6</td>
</tr>
<tr>
<td>Dharwar</td>
<td>Wheat</td>
<td>Medium black clay soil</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>Do.</td>
<td>4</td>
</tr>
</tbody>
</table>

Different varieties of cereal and oilseed crops were tested for their tolerance to saline-water irrigation. The promising varieties at different centres are as under:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Laha</td>
<td>‘T 59’, ‘Appress mutant’</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>‘SF 5’</td>
<td></td>
</tr>
<tr>
<td>Bapatla</td>
<td>Groundnut</td>
<td>‘TMV 2’</td>
</tr>
<tr>
<td>Ragi</td>
<td>‘PR 202’</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>‘RP 4-14’, ‘SR26-B’, ‘SR 1-2-1’</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sunflower</td>
<td>‘Bulgarian Inbred,’ ‘Ramson Record’, ‘EC 101494’</td>
</tr>
</tbody>
</table>

Experiments were conducted with pearl-millet, wheat and cowpea at Agra Centre and rice, ragi and sunflower at Bapatla Centre to examine the various combinations of good (canal) and poor (well-tubewell) quality water that could be used for irrigation without much adverse effect on crop growth and soil properties. In general, irrigation with highly saline water alone was harmful.
to crop growth but if one irrigation with saline water was supplemented with two canal water irrigations, the crop yield was much higher and comparable to the yields obtained with the use of canal water alone.

Soil Management

**Micronutrients—Delineation of micronutrient-responsive areas.**—Six thousand eight hundred twenty-six soil and 2,773 plant samples were analysed for available micronutrient contents. Moderate to severe deficiency of zinc was observed at Ludhiana, Kapurthala, Ferozepur, Gurdaspur, Sangrur, Bhatinda, Faridkot and Patiala districts of Punjab; Bhind and Jabalpur districts of Madhya Pradesh; Nellore, Nalgonda, Mehboobnagar and Anantapur district of Andhra Pradesh; Meerut, Banda, Hamirpur and Jalaun districts of Uttar Pradesh.

Moderate to severe deficiency of copper was observed at Madurai district of Tamil Nadu.

Moderate to severe deficiency of iron was observed in North Gujarat, Ludhiana district of Punjab; Coimbatore district of Tamil Nadu; Bihd and Bulandshahr districts of Uttar Pradesh.

**Response of crops to zinc application.**—240 field experiments were conducted on wheat, paddy, maize and bajra. The average response ranged from 1.9 to 12.6 q/ha in wheat and 3.4 to 6.1 q/ha in paddy. The results are presented below:

<table>
<thead>
<tr>
<th>Crop</th>
<th>State</th>
<th>No. of experiments</th>
<th>Increase over control grain yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Range</td>
</tr>
<tr>
<td>Wheat</td>
<td>Gujarat</td>
<td>5</td>
<td>7·9—21·6</td>
</tr>
<tr>
<td>Wheat</td>
<td>Madhya Pradesh</td>
<td>12</td>
<td>1·0—8·5</td>
</tr>
<tr>
<td>Wheat</td>
<td>Bihar</td>
<td>14</td>
<td>2·3—5·5</td>
</tr>
<tr>
<td>Wheat</td>
<td>Tamil Nadu</td>
<td>2</td>
<td>6·4—12·4</td>
</tr>
<tr>
<td>Wheat</td>
<td>Haryana</td>
<td>57</td>
<td>0·3—9·2</td>
</tr>
<tr>
<td>Wheat</td>
<td>Punjab</td>
<td>15</td>
<td>0·9—31·2</td>
</tr>
<tr>
<td>Paddy-millet</td>
<td>Haryana</td>
<td>37</td>
<td>0·4—3·5</td>
</tr>
<tr>
<td>Paddy</td>
<td>Bihar</td>
<td>17</td>
<td>3·7—10·6</td>
</tr>
<tr>
<td>Paddy</td>
<td>Andhra Pradesh</td>
<td>62</td>
<td>0·2—19·0</td>
</tr>
<tr>
<td>Maize</td>
<td>Punjab</td>
<td>19</td>
<td>0·2—18·0</td>
</tr>
</tbody>
</table>
Rate of depletion of micronutrients.—Work done at Anand and Ranchi centres showed that under intensive cropping with total annual dry matter production of 5.56 to 38.54 tons/ha the depletion of S, Fe, Mn, B, Zn, Cu and Mo ranged from 12.6 to 26.7, 2.01 to 10.72 kg/ha, 281 to 7.292 g/ha, 151 to 944 g/ha, 98 to 659 g/ha, 96 to 285 g/ha and 7.9 to 51.8 g/ha, respectively.

These data suggested that soils with moderate to low reserve of sulphur and micronutrients may become deficient in these nutrients within a few years under condition of intensive cropping and use of high doses of fertilizers.

Efficiency of organic manure as a source of zinc.—Work done at Ludhiana showed that poultry manure applied @ 5 tons/ha, zinc @ 11.2 kg/ha, FYM @ 12 tons/ha, piggery manure @ 2.5 tons/ha gave 7.2, 3.6, 2.4 and 1.9 q/ha higher grain yield than control respectively.

Susceptibility of varieties of zinc deficiency.—On the basis of appearance of deficiency symptoms, their severity, depression in growth and dry matter production under conditions of zinc deficiency the following order of susceptibility were observed at different centres:

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Degree of susceptibility to zinc deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ludhiana</td>
<td>Raya</td>
<td>'GLE 1' &gt; 'RLM 218' &gt; 'RS 3' &gt; 'RLM 202' &gt; 'RLM 234' &gt; 'RL 187' &gt; 'RLM 198'</td>
</tr>
<tr>
<td>Hissar</td>
<td>Raya</td>
<td>'RH 297' &gt; 'RL 18' &gt; 'TH 59' &gt; 'RM 30' &gt; 'Rai B/85' &gt; 'Laha 101'</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>Rice</td>
<td>'Ratna' &gt; 'RP 193-1' &gt; 'Mashuri' &gt; 'MTU 8002' &gt; 'CI612-S'</td>
</tr>
<tr>
<td>Ranchi</td>
<td>Potato</td>
<td>'Kufri Chamatkar' &gt; 'Kufri Alankar' &gt; 'Kufri Chandramukhi' &gt; 'Kufri Jyoti'</td>
</tr>
<tr>
<td>Delhi</td>
<td>Wheat</td>
<td>'HD 2009' &gt; 'NP 824'</td>
</tr>
<tr>
<td></td>
<td>Soyabean</td>
<td>'Lee' &gt; 'Brag'</td>
</tr>
</tbody>
</table>

Improvement of physical condition of soil.—The field experiments conducted at Kharagpur on lateritic sandy-loam soil showed that the loss of water and nutrients from paddy fields by deep percolation could be reduced by making four passes of a 800 kg roller on the surface of the soil when at proctor moisture. The bulk density of the (10-20 cm) and (20-30 cm) layers was increased by 0.09 g/cm³. The grain yield of paddy (‘IR-8’) crop
was increased by 30% over the control yield of 33.4 q/ha and wheat (‘Sonalika’) crop yield was increased by 9% over the control yield of 45.8 q/ha.

A similar experiment conducted at Jaipur on Durgapura non-calcic brown-sandy soil showed that the loss of water and nutrients by deep percolation through this soil could be reduced by making 20 passes of 150 kg roller on the surface of the soil, one day after irrigation or rainfall during summer season and two days after irrigation or rainfall during winter season. The bulk density of the surface 20 cm layer was increased by 0.09 to 0.15 g/cm³ and infiltration rate was reduced by 20% from 19.4 cm/hr. The grain yield of bajra (‘BJ-104’) was increased by 30% over the control yield of 12.2 q/ha (rainfed) and wheat (‘Kalyansona’) crop yield was increased by 20% over the control yield of 33.8 q/ha.

The field experiments conducted at Jabalpur on black-clay soil revealed that an adequate air-water balance could be maintained in the root zone for the growth of upland crops during rainy season, by planting the crops on ridges or raised beds having 1.2% slope. In the upper 20 cm of ridges having 1.2% slope the non-capillary pore space (greater than 0.009 mm diameter) was found to be increased by 25% over 26.9%, bulk density reduced by 0.10 g/cm³ from 1.16 g/cm³, and the amount of moisture retained decreased by about 20%. The grain yield was increased by 20% over the control yield of 19.3 q/ha for soyabean, by 40% over the control yield of 26.3 q/ha for maize and by 4-folds over the control yield of 11.5 q/ha for jowar.

Microbiological decomposition of organic matter.—In an experiment to test the efficiency of Aspergillus sp., Penicillium sp., Trichurus spiralis and Pestalotiopsis vericolour on decomposition of farmwastes, Pestalotiopsis vericolour was found to be most efficient. It reduced C/N ratio from 36.8 to 21.1 as compared to control (uninoculated 29.7) during 3 months composting period.

The decomposition varied with organism and material used. Penicillium sp. decomposed leaf falls at a faster rate whereas T. viride and Penicillium sp. were effective on water hyacinth.
Enrichment of compost.—Enrichment of compost with Azotobacter and P solubilising organisms supplemented with rock phosphate was attempted. Though the Azotobacter population recorded a small increase in the composting mass under inoculation series, the increase was not maintained for long period. Application of rock phosphate and FYM stimulated Azotobacter population and inoculation with Aspergillus awamori further increased the population of Azotobacter showing the effect of available P.

The total nitrogen content of farm-wastes and city-waste compost and soil increased by 6.5, 10.3 and 15.0% (Bangalore) and of FYM by 10 to 20% (Hissar). Application of rock phosphate @ 10 kg P₂O₅/tion compost had a positive effect on nitrogen fixation. Available P was increased due to A. awamori and maximum solubilization was obtained when both Azotobacter and A. awamori were inoculated.

Biological nitrogen fixation.—Leguminous plants are well known for their capacity of fixing free atmospheric nitrogen due to the presence of symbiotic bacteria belonging to the genus Rhizobium in the root nodules. Although precise information is not available, due to the complexities involved on how much available nitrogen is left behind per hectare by different pulse crops, rough estimates have been made in different parts of the world through agronomic experiments using the yield increases in the succeeding crop as index of increased soil fertility. Thus, it has been estimated that different legumes add the equivalent of as much as 50-250 kg N/ha to the soils in which they are grown. The following summarises briefly the major facts on different aspects of biological nitrogen fixation.

Nitrogen gains by legumes and residual nitrogen left behind in the soil through Rhizobium application.—In grain legumes, part of the fixed nitrogen goes into the tops and grains at the pod-filling stage and the remainder is released to the soil. On the other hand, in green manuring, most of the fixed nitrogen of a legume is turned back into the soil. Losses excreted due to the leaching, erosion, denitrification and volatilization have not been measured under field conditions in India but data are available to show that the extent of nitrogen excreted by grain legumes grown with and without Rhizobium inoculation differs considerably (Table 12).
Table 12. Nitrogen added to soil by pulse crops (IARI experiments)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nitrogen excreted (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without Rhizobium inoculation</td>
</tr>
<tr>
<td>Blackgram</td>
<td>8</td>
</tr>
<tr>
<td>Cowpea</td>
<td>9</td>
</tr>
<tr>
<td>Pea</td>
<td>12</td>
</tr>
<tr>
<td>Gram</td>
<td>36</td>
</tr>
</tbody>
</table>

Legumes in crop rotations.—Recent work at IARI on the contribution of legumes to soil fertility and productivity has very clearly shown that the inclusion of a legume in a crop sequence not only supplied the nitrogen but it also made more phosphorus available to the next crop, and also that phosphated legumes help in mobilisation of soil nitrogen. Thus, it has been observed experimentally that growing fodder cowpea before a crop of sorghum and wheat provided the equivalent of 38.5 and 35.1 kg of commercial nitrogen, respectively, in terms of grain production. Grain cowpea, however, provided the equivalent of relatively less amounts, that is 22.8 and 11.9 kg commercial nitrogen/ha respectively. Thus, it would appear that a forage legume variety would provide more nitrogen carryover than a grain legume variety of the same species.

Under irrigated condition, maize yields were increased by an equivalent of 40 kg N/ha provided as carry-over residual fertility by a fodder berseem crop grown in rabi. However, grain pea crop did not leave any residual fertility.

Under rainfed conditions, kharif legumes like mung, cowpea, urid and groundnut and in the following kharif season, bajra were grown at three levels of fertility to assess the carry-over fertility from legumes. Results of one season showed that groundnut and cowpea left in the soil residual nitrogen equivalent to about 40 kg N/ha.

Arhar—wheat rotation was found to be more profitable in economic terms, investment and availability of fertilizer and mutual crop benefit than maize—wheat rotation. In a cereal—pulse—oilseed—millet cropping sequence under limited water and fertilizer availability, the sequences maize (cobs), peas (green pods), mung, and urid—barley—mung gave returns of the order of Rs. 7,241/- and Rs. 5,586/- per hectare per year, respectively.
**Legumes in intercropping systems.**—Experiments conducted at IARI, New Delhi, showed that significantly higher grain yields were obtained from maize when intercropped with legumes, than that obtained with maize as the sole crop. Maize yields were relatively higher than when it was intercropped with mung (15.14 q/ha) or soyabean (16.6 q/ha), the nitrogen contribution to maize from groundnut and mung being equivalent to about 40 kg N/ha and 25 kg N/ha, respectively. When sorghum was planted in paired rows (30 cm between the rows in the pair) and a space of 90 cm was left between the paired rows for growing intercrops of mung, urid, cowpea (grain), cowpea (fodder) or groundnut, sorghum recorded higher grain yield than when it was grown as pure crop; the increase in the sorghum grain yield under companion cropping was 4 to 10 q/ha more from soils stand of sorghum (33.4 q/ha).

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

**Yield potential of crops in different soil tests.**—Experiments have been in progress to test the genetic yield potential of crops when required amount of fertilizer are applied as per the soil-test data of different types of soils (Table 13). It may be seen from these results that the ‘Sonalika’ variety of wheat on red soils of Nalhati (W. Bengal) and ‘C-1307’ variety of sugarcane on medium black soils at Sehore (M.P.) have yield of 5.7 tonnes/ha and 148 tonnes/ha respectively even in the non-traditional areas when adequate amounts of soil nutrients are applied.

**Nutrient requirements for targeted yield of crops.**—Nutrient requirement of different crops were determined to arrive at precise fertilizer recommendations for specific yield targets. The data are presented below:
<table>
<thead>
<tr>
<th>Centre</th>
<th>Soil type</th>
<th>Crop and variety</th>
<th>Nutrient requirement in kg/q of grain yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Jabalpur</td>
<td>Medium black</td>
<td>Maize (‘Chandan Makka’)</td>
<td>1.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gram (‘JG-221’)</td>
<td>3.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wheat (‘Patel I’)</td>
<td>2.29</td>
</tr>
<tr>
<td>Ludhiana</td>
<td>Grey brown</td>
<td>Wheat (‘WL711’)</td>
<td>2.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>barley (‘DL-70’)</td>
<td>1.63</td>
</tr>
<tr>
<td>Coimbatore</td>
<td>Black</td>
<td>Rice (‘Bhavani’)</td>
<td>1.46</td>
</tr>
<tr>
<td>Ranaghat (W.B.)</td>
<td>Gangetic alluvium</td>
<td>Rice (‘Jaya’)</td>
<td>2.08</td>
</tr>
</tbody>
</table>

Table 13. Yield potential of crops in different soil types

<table>
<thead>
<tr>
<th>Centre</th>
<th>Soil type</th>
<th>Crop and variety</th>
<th>Max. yield obtained (q/ha)</th>
<th>Treatment level for maximum yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Jabalpur</td>
<td>Medium black</td>
<td>Maize ‘Chandan Makka’,</td>
<td>64</td>
<td>200</td>
</tr>
<tr>
<td>Sehore (MP)</td>
<td>Do.</td>
<td>Sugarcane ‘CO-1307’</td>
<td>1.82</td>
<td>490</td>
</tr>
<tr>
<td>Jabalpur</td>
<td>Do.</td>
<td>Gram ‘JG-221’</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Jabalpur</td>
<td>Do.</td>
<td>Wheat ‘Patel I’</td>
<td>43</td>
<td>120</td>
</tr>
<tr>
<td>Gurdaspur</td>
<td>Chestnut</td>
<td>Rice ‘IR-8’</td>
<td>75</td>
<td>200</td>
</tr>
<tr>
<td>Ludhiana</td>
<td>Grey brown</td>
<td>Wheat ‘WL-711’</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Ludhiana</td>
<td>Do.</td>
<td>Barley ‘DL-70’</td>
<td>61</td>
<td>100</td>
</tr>
<tr>
<td>Nalhati (W.B.)</td>
<td>Red soil</td>
<td>Rice ‘Ratna’</td>
<td>48</td>
<td>80</td>
</tr>
<tr>
<td>Nalhati (W.B.)</td>
<td>Do.</td>
<td>Wheat ‘Somalia’</td>
<td>57</td>
<td>200</td>
</tr>
<tr>
<td>Burdwan (W.B.)</td>
<td>Alluvial</td>
<td>Rice ‘Pusa 2-21’</td>
<td>70</td>
<td>100</td>
</tr>
</tbody>
</table>
In simple followup trials, the concept of yield targetting was successfully demonstrated on medium black soils in cultivators' fields at Jabalpur on gram and soyabean. With soyabean 'JS-2' as against an yield target of 25 q/ha the yield obtained was 28.4 q/ha. With gram, the yield obtained was 28.3 q/ha as against an yield target of 30 q/ha.

Extensive followup trials on farmers' field with wheat at Ludhiana also indicated that yield levels targetted below 40 q/ha could invariably be achieved within an area of ±5% following fertilizer applications for this purpose based on soil testing.

Response to 'P' in acid soils.—Studies in acid red-loam soils of Ranchi areas indicated that the yield of wheat increased from 14.5 to 24 q/ha with application of P_2O_5. The efficiency of fertilizer 'P' in such soils was directly related to the method of application of phosphorus. The application methods were in order of drilled below seed > band placement > mixed with seed > split application > broadcast. The quantity of P_2O_5 required for maximum yield was 67 kg/ha when it was drilled below seed, whereas it was 143 kg/ha when the fertilizer was applied by broadcast method.

**DRY-FARMING RESEARCH AND TECHNOLOGY**

Nearly three-fourths of the country is entirely dependent on rains for cropping which introduces an element of instability in Indian agriculture. Moreover, because of the widening gap between the farmers of assured irrigation and those of unirrigated areas, the council took up an All-India Co-ordinated Research for Dryland Agriculture in October 1970. During the year under report the Project had been in operation at 23 centres with the Co-ordinating Unit at Hyderabad. The salient achievement during the year are as under:

*High annual production obtained on rainfed lands.*—In crop sequence trials at various research centres, the following sequences were found highly productive:

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop sequence</th>
<th>Yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Kharif</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Dehradun</td>
<td>Maize-wheat</td>
<td>44·1</td>
</tr>
<tr>
<td></td>
<td>Rice-wheat</td>
<td>44·2</td>
</tr>
<tr>
<td>Hoshiarpur</td>
<td>Maize-gram</td>
<td>20·3</td>
</tr>
</tbody>
</table>
Rabi oilseeds found more remunerative in Hissar region.—
On the basis of results obtained during the last six years at the
Hissar Centre the superiority of rabi oilseed crops over gram
appears to have been established both as regards stability
of production and as the more profitable crops. The results are
as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram</td>
<td>4.6</td>
<td>3.5</td>
<td>2.3</td>
<td>8.8</td>
<td>31.0</td>
<td>31.0</td>
<td>13.5</td>
</tr>
<tr>
<td>Mustard</td>
<td>7.4</td>
<td>7.2</td>
<td>5.5</td>
<td>10.6</td>
<td>30.0</td>
<td>21.6</td>
<td>13.7</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>5.6</td>
<td>—</td>
<td>2.7</td>
<td>8.7</td>
<td>20.0</td>
<td>17.9</td>
<td>11.0</td>
</tr>
<tr>
<td>Taramira</td>
<td>12.8</td>
<td>8.1</td>
<td>10.8</td>
<td>11.7</td>
<td>9.3</td>
<td>14.1</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Increase in yield by the use of harvested water.—In most
regions there is considerable runoff. This could be stored and
used as one supplemental irrigation to the non-rainy season crop
if not required to save a rainy season crop during a drought.

The runoff water stored was recycled to be used as supple-
mental irrigation to wheat crop at Dehradun. The results con-
sistently showed the usefulness of the recycling of runoff water
(Table 14).
Table 14. Yield of wheat ‘RR 21’, (kg/ha) as influenced by supplemental irrigation—Dehradun

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1974-75</th>
<th>1975-76</th>
<th>1976-77</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3776</td>
<td>1249</td>
<td>1110</td>
<td>2045</td>
</tr>
<tr>
<td>One pre-sowing irrigation (5 cm)</td>
<td>4540</td>
<td>2088</td>
<td>2981</td>
<td>3203</td>
</tr>
<tr>
<td>One irrigation at crown-root-initiation stage (5 cm)</td>
<td>4671</td>
<td>1999</td>
<td>3039</td>
<td>3236</td>
</tr>
<tr>
<td>One pre-sowing irrigation and one irrigation at crown-root-initiation stage (10 cm)</td>
<td>4660</td>
<td>2955</td>
<td>4078</td>
<td>3896</td>
</tr>
<tr>
<td>S. Em(∥)</td>
<td>146</td>
<td>250</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>439</td>
<td>721</td>
<td>369</td>
<td></td>
</tr>
<tr>
<td>Rainfall in crop season (mm)</td>
<td>258</td>
<td>121</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

The experiments were also conducted at Hoshiarpur, Varanasi and Agra (Table 15): Table 15. Yield of different crops under different practices

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Practice</th>
<th>Yield (q/ha)</th>
<th>C.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoshiarpur</td>
<td>Wheat</td>
<td>No irrigation</td>
<td>3.8</td>
<td>3.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>one irrigation</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>Varanasi</td>
<td>Barley</td>
<td>No irrigation</td>
<td>24.0</td>
<td>5.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>one irrigation</td>
<td>35.2</td>
<td></td>
</tr>
<tr>
<td>Agra</td>
<td>Barley</td>
<td>No irrigation</td>
<td>21.9</td>
<td>4.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One irrigation</td>
<td>27.7</td>
<td></td>
</tr>
</tbody>
</table>

Use of surface mulches for enhancing crop yields.—At Dehradun and Anand, organic surface mulches (husk or some other farm-waste) substantially increased the yield of wheat and bidi tobacco.

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop</th>
<th>Practice</th>
<th>Yield (q/ha)</th>
<th>C.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehradun</td>
<td>Wheat</td>
<td>No mulch</td>
<td>10.6</td>
<td>1.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mulch applied</td>
<td>19.1</td>
<td></td>
</tr>
<tr>
<td>Anand</td>
<td>Bidi Tobacco</td>
<td>No mulch</td>
<td>11.8</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mulch applied</td>
<td>16.9</td>
<td></td>
</tr>
</tbody>
</table>

Improved sorghum production in Hyderabad district.—In cooperation with the District Administration of Hyderabad area, an area of 5,200 ha of phosphorus-deficient black soils was selected. On this area the sorghum crop was raised with improved
dryland practices which included use of seeds of improved variety ('CSH-5'), and application of 25 kg N and 50 kg P₂O₅ per hectare, adequate plant population was maintained with proper weeding. The yield data obtained from 100 farmers are presented below:

<table>
<thead>
<tr>
<th>Block</th>
<th>No. of participating farmers</th>
<th>Range of yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Local practice</td>
</tr>
<tr>
<td>Chevella</td>
<td>100</td>
<td>10.0 to 13.0</td>
</tr>
</tbody>
</table>

**Production potential—yield of crops under traditional vs improved practices.**—Centres demonstrated the impact of improved practices by growing crops in large plots using the improved and the common farm practices in the area (Table 16).

**Table 16. Comparative yield (q/ha) of crops under traditional and improved practices of production**

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crop yield q/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Traditional practices</td>
</tr>
<tr>
<td>Hoshiarpur</td>
<td>Wheat 23.00</td>
</tr>
<tr>
<td></td>
<td>Rcy 5.9</td>
</tr>
<tr>
<td></td>
<td>Maize 18.2</td>
</tr>
<tr>
<td>Agra</td>
<td>Pearl-millet 10.2</td>
</tr>
<tr>
<td></td>
<td>Mustard 3.4</td>
</tr>
<tr>
<td></td>
<td>Barley 7.0</td>
</tr>
<tr>
<td>Sholapur</td>
<td>Pearl-millet 6.7</td>
</tr>
<tr>
<td></td>
<td>Sorghum 5.0</td>
</tr>
<tr>
<td>Rajkot</td>
<td>Sorghum 3.3</td>
</tr>
<tr>
<td></td>
<td>Groundnut 0.8</td>
</tr>
<tr>
<td>Dehradun</td>
<td>Maize 11.3</td>
</tr>
<tr>
<td></td>
<td>Wheat 10.3</td>
</tr>
<tr>
<td>Anand</td>
<td>Cotton 2.8</td>
</tr>
<tr>
<td>Kovilpatti</td>
<td>Sorghum 1.0</td>
</tr>
<tr>
<td></td>
<td>Cotton 1.3</td>
</tr>
<tr>
<td></td>
<td>Pearl-millet 4.9</td>
</tr>
</tbody>
</table>

**Integrated management in rainfed pearl-millet.**—An integrated management approach in rainfed pearl-millet revealed that application of 40 kg N/ha along with weedicide (1 kg/ha a.i. of atrazine applied pre-emergence) raised grain yield by 200-300 per cent. However, use of fertilizers proved a waste in the absence of weedicide. Among various intercrops for dryland
pearl-millet, *mung* (*Phaseolus aureus*) planted in between two paired rows of *bajra* gave additional pulse yield of 4-6 q/ha without competing with the main crop.

**Integrated approach to dryland crop system.—** Achievement of untapped production per unit of rainfall in drought-prone areas lies with the integrated management in crop system. Studies conducted at CAZRI during 1977 revealed that cultivation of *bajra* by conventional method (i.e. local variety, regular row-planting, no manuring, no weeding) gave a yield of 317 kg/ha. Against this, integration of improved variety of *bajra* 'BJ 104', triple-row planting (30 cm between rows and 180 cm between pairs of triple row), optimum manuring (15 tonnes FYM+30 kg N/ha), and one hand-weeding into the new technology of water harvesting increased the yield to 2,761 kg/ha.

**Planning for high productivity at less water-use.—** The CAZRI has developed a comprehensive system for the farms projects and river basin water planning. The system quantitatively estimates the capacity of soil profile to contribute water to the crop, the cumulative maximum evapo-transpiration by combining these two aspects predicts the number, date and depth of irrigation and with the successive deletion of the least efficient irrigation units, maximizes the yield with the available water supply. To illustrate, the irrigation requirement for maximum wheat yield (5,430 kg/ha) under Jodhpur conditions is 84 cm. Against this, 76% reduction in water reduced the yield only by 32%. Thus, the optimally planned irrigation maximizes the production per unit of limited water supply.

**ARID ZONE RESEARCH AND DESERT TECHNOLOGY**

The Indian arid zone includes 0.32 million km$^2$ of hot desert and 0.07 million km$^2$ of cold desert, which accounts for 12 per cent of the total geographical area of the country. It is inhabited by about 19 million people and 23 million livestock. The salient results of research in different disciplines are given below.

**Improvement of Crops**

A local variety No. 2 of *bajra* was improved through recurrent mass selection which gave consistent better performance than the recommended variety 'B.J. 104' for arid areas. The yield was 31.5 per cent higher than that of 'B.J. 104' (18 q/ha). Besides the variety was quite responsive to fertilizer application. Further improvement to cover disease-tolerance is under way.
**Setaria italica (kangni)**

Among the several high-yielding strains of *Setaria italica (kangni)* developed at Central Arid Zone Research Institute, the strain No. 1 yielded higher (19 q/ha) than *bajra* 'BJ 104' (18 q/ha) this year. The grain yield obtained from this strain was also as good as that of *bajra* even in bad years (with sub-normal rainfall, disease epidemic or drought). The strain escapes the drought on account of early maturity (50-55 days).

**Water Conservation and Run-off Farming**

Studies conducted at Central Arid Zone Research Institute, Jodhpur, revealed that bare soil catchment sloped 0.5% towards cropped area and surface sealed with thin layer of pond silt, yielded run-off 38 to 68 per cent of the total rainfall. In 1977, additional water supply from run-off increased *bajra* yield by 95 per cent (1,199 to 2,338 kg/ha) compared with flat surface control. Change of plant geometry of *bajra* from single to triple row arrangement and planting in localized high-moisture-band along with the catchment made efficient use of low-tension water. This resulted in the improvement of the production from 1,199 to 2,761 kg/ha in addition to 258 kg of grain obtained from cowpea crop which was planted in the low-moisture-band in the middle of large space between the pairs of triple rows.

**Goat**

*Versatility of goat as a desert animal.*—An extra-ordinary ability of the typical Rajasthan desert goat to withstand both acute and chronic water stress during summer was experimentally verified at the Central Arid Zone Research Institute, Jodhpur. Controlled experiments on water-use efficiency of this animal gave much higher rating than even the hardy Marwari sheep of this desert. When denied water for four days during summer, a Bärmer goat lost a meagre 6 per cent of its body weight whereas the Marwari sheep lost as much as 22 per cent. Even a restriction of 75 per cent water during peak summer does not cause any appreciable loss in body-weight or food-intake of these goats.

**Forage Production**

*Defoliation management for off-season forage production in desertic regions.*—Cutting height of forage grasses during growing season (July-September) plays an important role in their subsequent winter-spring growth (December-April). Studies conduc-
ted to observe this trend showed that in *Lasiurus sindicus* dry matter yields from winter-spring growth increased from 7.7 q/ha at 5 cm cutting height to 13.6 q/ha at 15 cm height. Similarly in *Cenchrus ciliaris* it increased from 2.0 q/ha (5 cm) to 4.1 q/ha (15 cm). Thus it is concluded that 15 cm cutting height would be a safe threshold during winter-spring when no other green grazing was available to the animals.

**Water Use**

*Efficient use of water for grasses.*—In experiments conducted at the Central Arid Zone Research Institute, the consumative use of water generally increased with increase in cutting intervals and nitrogen levels. The water-use efficiency was in terms of kg dry matter produced/ha/mm of water was the highest in *C. ciliaris* (15.35) followed by *C. setigerus* (11.98) and *L. sindicus* (11.75).

**New Fodders**

*Use of spineless cactus as a fodder reserve.*—Among the spineless cactus collections at CAZRI, Jodhpur, *Opuntia ficus-indica* was found to be the most promising and a three-year old cactus plant produced green forage to the tune of 30 t/ha. It is highly drought-resistant and can grow in areas of 150-200 mm rainfall on deep sandy soils planted at spacement of 5m². The green forage from this cactus contains 6.8% protein which borders the minimum protein level (7%) recommended for normal maintenance of animals.

The cactus-fodder could be fed alone for 6 to 10 weeks without any ill effect. Mixing it with dry feed, i.e. pala or Lung is recommended to avoid diarrhoea. Raising plantations of this cactus in the hot desert and drought-prone areas would serve as an insurance against erratic rainfall conditions leading to normal crop failures by way of providing reserve food and would also help to reduce the large-scale animal migration and casualty during famine.

*Fertilizer economy.*—Studies were carried out at Central Arid Zone Research Institute, Jodhpur, to quantify nitrogen addition by legumes like *mung*, *guar* and *moth* the effect of phosphate sources on this parameter. Thirteen varieties of *mung* were screened for their nitrogen fixation capacity.

It was observed that about 20 kg N/ha was made available to the succeeding barely crop.
M-10 and M-15 were more efficient in fixing nitrogen as compared with their parent R.S. 4, thereby indicating that gene mutations could be induced for the trait of nitrogen fixability. A positive relationship was found with root-cation-exchange capacity at flower initiation stage with the addition of nitrogen to soil. Application of 40 kg P₂O₅/ha was found to increase the N-fixing capacity of pulses.

Use of saline water in arid zone agriculture.—Comprehensive studies conducted at Central Arid Zone Research Institute, Jodhpur, showed that even highly saline waters, such as are common in arid zone, could be used in irrigation for raising wheat crop in a cyclic management. With water 3.7 to 7.5 cm/litre (5,000-10,000 micromhos EC), yields of 15-20 q/ha are possible. Salinity added to soil by these waters was amenable to leaching by prevailing rainfall and alkali hazard also did not show any extraordinary build-up.

Efficient use of water.—A comprehensive system to utilize available water for different crops was evolved with the help of computers. This technique was applied to wheat, mustard, sunflower and safflower competing for tubewell water, supply of 2,000 gallons/hr or 10.2/ha cm/week. By systematic planning of water-use, it was possible to provide irrigation to all these crops which could not have been possible without such planning. This resulted in increased area under each crop and subsequently increased production. Thus the total area under irrigation increased from 4.3 to 14.5 ha, and the productivity from 9,618 kg to 19,098 kg from the same finite water supply of 10.2/ha cm/week.

A case study on desertification.—The Central Arid Zone Research Institute, Jodhpur, has in collaboration with UNESCO and UNDP taken up a “case study on desertification” and “feasibility study on monitoring of Desert Process”. Luni Development Block in Jodhpur district was selected for the study. From the analysis of processes of desertification, the following points have emerged:

(i) Due to over-exploitation of land in natural resources, a process of desertification has become more pronounced.

(ii) Over-grazing by livestock and rodent menace, human pressure on trees and shrubs has adverse effect on the arid biome and impede the process of regeneration of shrubs and trees.
(iii) As a result of increased exploitation of underground water from 1968 to 1976 discharge potential of the wells has fallen.

(iv) The quality of water has also declined in most of the wells in Luni Block.

The case Study Report gives a number of recommendations, and outlines the technology evolved by the Institute for enhancing the productivity of arid lands and combating desertic conditions. The studies are being extended to the entire western Rajasthan.

Soil Conservation

Studies on wind erosion control—Sand-dune stabilisation.—Results of the experiments conducted at the Central Arid Zone Research Institute, Jodhpur, indicated that as high as 1.2 cm (180 tonnes/ha) erosion of sand during a fortnight from a bare sandy plain in Bikaner district was observed as compared to 0.04 cm (6 tonnes/ha) from grassland and 0.2 cm (30 tonnes/ha) from land covered with bajra stubble. At another location, it was observed that the movement of 12.5 cm (1,875 tonnes/ha) of sand from a bare sand-dune in 15 days time as against this, there was no erosion but deposition of 0.08 cm (12 tonnes/ha) of sand in stabilised dune, having a cover of grass and trees.

Application of quantitative geomorphology in basin hydrology.—In an experiment conducted at CAZRI, a valuable practical application of the quantitative geomorphology in the basin hydrology was demonstrated by establishing the mathematical relations of the mean annual run-off based on 70 years rainfall with the geomorphic characteristics of the drainage basins in sand-stone region of Jodhpur district. Mean annual run-off is directly related to drainage basin area and total stream length and this relationship is highly significant ($r=0.999$ and 0.958 respectively) at 1% level of probability. Mean annual runoff is inversely related to drainage density and first order stream frequency and these relationships are significant ($r=0.8098-0.607$ respectively) at 1% and 5% levels of probability, respectively.

Resistivity death-sounding technique.—While conducting resistivity survey of Central Research Farm of CAZRI, it was observed that dry sand, moist sand, loamy sand with adequate moisture had resistivity ranging between 100-200, 60-130 and 45-90 ohm metres and could be easily identified and demarcated up to a minimum depth of 1.25 metres. Sandy hummocks showed very high and distinct resistivity. That of kankar pan varied from 50 to
150 ohm metres when dry but when moist it fell to 80-100 ohm metres. Its occurrence could be recorded at a minimum depth of 2 to 10 metres below ground level. It was also observed that thin pan area was less mineralized as compared with thick pan zones. Apart from providing clues to ground water resources the resistivity survey appears as a powerful tool for quick appraisal of soil characteristics including depth and thickness of kankar pan in arid regions.

**Rodent and Pest Management**

*Metabolism and Eco-physiology of Rajasthan desert rodents.*—In an experiment at CAZRI, temperature regulation and Basal Metabolic Rate of 9 species of Rajasthan desert rodents, of different habits and habitats, and of *Rattus rattus* and *Mus musculus* were studied during winter. The desertic species, like the ruderal ones, maintain homoeo-thermy by a balanced interaction between BMR and thermal conductance. BMR of the desertic species were generally higher than expected values on body weight basis. *Mus booduga*, the smallest, and *Tatera indica*, the largest of the desertic species, respectively recorded (a) the highest and the lowest oxygen consumption rate (4.34 and 1.17 l/hr/kg), (b) the highest and the lowest conductance values (71.4 and 37.0 Kcal/°C/m²/day) and (c) the lowest and the highest equivalent thickness of covering as fur (1.008 and 1.94 cm). Most of the species examined do not appear to follow the Surface Area Law. Respiratory Quotients of all species were nearly 1.0 (0.070-0.99).

**Forestry**

*Natural regeneration of an exotic tree species.*—*Colophospermum mopane* (Caesalpinaceae) a medium-sized fodder tree species introduced at CAZRI in 1964 from South Rhodesia, has been the only tree species which has reproduced profusely through seed dispersal under arid conditions. On an average, natural regeneration of 142 seedlings per tree was recorded which spread over 30 metres on the leeward side of the mother tree. Leaves contain 14.6 per cent C.P. and 10.1 per cent D.C.P. The tree can withstand lopping and provides avenues for supplementary food for livestock in the arid regions.

*Candelilla wax.*—Candelilla wax, which has great industrial potential was isolated from *Euphorbia antisyphilitica* (a desert shrub of Mexican origin) at CAZRI, Jodhpur. In initial stage of testing, a production of 26.4 tonnes of plant material/ha. on dry weight basis was achieved. Using solvent extraction method, it
was found that candelilla wax form 2.5 per cent of plant on dry weight basis. Thus about 660 kg/ha of refined wax could be obtained which as reported in literature falls well within the limit of economic exploitation.

**AGRONOMY**

The All-India Co-ordinated Agronomic Research Project was executed at 44 model agronomic centres where about 680 complex experiments were conducted during the year to evolve suitable agronomic practices for various crops, cropping patterns and sequences in different agro-climatic regions of the country. In addition to this about 8,600 experiments were also conducted on cultivators' fields in 52 districts spread over different states. Some of the salient results from this project and from other institutes and universities are given below:

![Production potential under assured input conditions (average of 1974-1977)](image)

*Fig. 6. Production potential under assured input conditions (average of 1974-1977)*
Production Potential

Various crop sequences were tried at different centres to assess the production potential for foodgrain production under assured input conditions. Total foodgrain production of 10 tonnes or more per hectare per year was obtained at 11 centres (Fig. 6). The highest yield of 16.6 tonnes per hectare per year was obtained at Managalore with three-crop sequence of rice-rice-rice. This was followed by 14.8 tonnes per hectare per year at Bhavanisagar where also three-crop sequence of rice-rice-rice was used. Other crop sequences which yielded more than 10 tonnes per hectare per year were rice-wheat-rice at Varanasi, rice-wheat-rice at Kalyani, rice-rice-rice at Karamana, rice-maize-cowpea at Bhubaneswar, maize-wheat-greengram at Ludhiana, rice-wheat-greengram at Delhi, maize-wheat-greengram at Pura Farm, rice-wheat at Palampur and rice-wheat-jowar at Kurjat. The amount of fertilizers used for different crops in the sequences at different places are given in Table 1 and these were based on the recommendations at different places.

Some other crop rotations included cash and fodder crops along-with foodgrain crops. These rotations revealed that four-crop sequence with maize-potato-wheat-greengram tried at Ludhiana produced 9.6 tonnes per hectare of grains in a year besides 21.1 tonnes per hectare of potato. Similarly a sequence of rice-potato-wheat-cowpea fodder tried at Pura Farm gave on one hectare in one year, 8.2 tonnes of foodgrains, 15.8 tonnes of potato and 29 tonnes of green fodder of cowpeas.

Production under Resource Constraints

The studies conducted in 1976-77 revealed that at Bhubaneswar, Mangalore and Titabar the total yields of rice-rice rotation from plots fertilized with full dose for both crops 3/4th for the first and full for the second crop, and 3/4th for both crops, were similar indicating thereby that the fertilizer recommendation for the entire sequence of crops needs consideration from the point of fertilizer economy. At Karamana and Thanjavur, however, the reduction in fertilizer level for any of the crops in the sequence was not possible.

In rice-wheat rotation the fertilizer dose for rice crop only could be reduced by 25 per cent without affecting the total yield of two crops at Pantnagar, Kathulia Farm, and Chiplima centres.
In jowar-wheat rotation, however, it was not possible to economise on fertilizer use as both the crops required their full recommended dose for their normal yields.

**Production under Intensive Farming Systems on Small Holdings**

Intensive cropping with 2 to 3 crops on one hectare holding were studied and the data on yields are reported in Table 2. The cereals generally occupied 50 to 66 per cent of the total area at all the locations except at Maruteru where 100 per cent area was under rice. The major contribution in production was, therefore, from cereals at all the locations. The highest grain productions of 7.8, 7.1 and 6.3 tonnes/ha were recorded at Pantnagar, Varanasi, and Anantharajapet, respectively. The production of pulses was 1.6 to 0.8 tonnes/ha at Varanasi and Hissar. Oilseeds contributed only 0.9 tonne at Karaiyiruppu and 1.3 tonnes at Anantharajapet. Potato and vegetables had a major share in the production at Navsari, Akola, Pantnagar, Hissar and Palampur. Green fodder to the extent of 40 to 180 tonnes could be obtained on most of the farms except at Tanjavur, Pantnagar, Karaiyiruppu, Bhavanisagar, Anantharajapet and Maruteru where fodder crops were not included in the cropping system.

**Response to Major and Micronutrients**

The data on response of various crops to major nutrients from the experiments conducted on cultivators' fields are given in Table 3. The response of crops, in general, increased with the increase in the fertilizer input at all the places. It was revealed that the response to $N_{60}$ alone was either inferior or as good as the response to $N_{60}P_{30}$ in the case of rice, wheat, jowar, maize and bajra at most of the places. Similarly, the response to $N_{120}$ was also either inferior or as good as the response to $N_{60}P_{30}, N_{60}P_{60}$ and $N_{60}P_{30}K_{20}$ at most of the places. This, therefore, indicated that when balanced use of fertilizers is made the level of nitrogenous fertilizers could be reduced without reduction in the yield of crops. The data on kharif rice from Bilaspur, Mysore, Chingleput and Geralpur and rabi rice from Balasar and Nalgonda further indicated that the yields due to $N_{60}P_{30}$ and $30$ were even significantly more as compared with $N_{120}$ alone. The data also revealed that at higher level of fertilizer input, even the inclusion of K was beneficial to the crops.
Significant responses to the application of micronutrients were also recorded at a number of centres. At Andhra Pradesh Agricultural University, Hyderabad, higher yields of irrigated groundnut were reported with the application of Zinc sulphate @ 50 kg/ha in addition to the recommended fertilizer dose of the 10 kg N, 60 kg P₂O₅ and 45 kg K₂O per hectare. Beneficial effect of zinc application was also observed on rice at Nandyal, Anantarajapet, Kathulia, Kharagpur and Bulandshahr, on jowar at Indore and on maize at Pura and additional yields ranging between 3 and 10 q per hectare were obtained.

At Rajendra Agricultural University, Bihar, planting potato tubers, presoaked in FeSO₄ (0.50% solution) for 12 hours increased potato yield. At Indian Agricultural Research Institute, New Delhi, application of urea mixed with neem-cake in rice resulted in increased yield of rice and also of the subsequent crop of wheat.

Return-cost Ratio of Fertilizer on Cultivators' Fields

From the studies conducted on response to fertilizers by various crops in different regions the gross return and the return-cost ratio (Rs/Rs) have been worked out (Fig. 7). The return varied from place to place which may be attributed to the variation in soil and climatic conditions of a place. Responses are generally high on soils with low fertility levels. The returns per rupee invested on fertilizer, in general, was high with low level of fertilizer input and it reduced with the increased level of fertilizer input. The gross value of production was, however, higher with the higher level fertilizer input. At Bhagalpur, for kharif rice return of Rs 4.10 was realised per rupee invested on fertilizer at level of application of 60 kg N/ha and it reduced to Rs 2.66 when the level of application was increased to 120 N-60 P₂O₅-60 K₂O kg/ha. But in case of rabi rice the returns were better, in general, with medium to higher level of fertilizer input. In case of wheat at Alwar, the maximum production was, obtained with the application of 120-60-0 and 120-60-60 kg N-P₂O₅-K₂O per hectare. The return-cost ratio was almost uniform (Rs 2.12 to Rs 2.49) at all the levels of fertilizer application, which may be due to low crop response to added fertilizer indicating thereby high soil fertility status. In case of maize and jowar the return varied between Rs 1.42 and Rs 2.68 only per rupee invested on fertilizers.
Fig. 7. Returns from fertilizer application on cultivators' fields (1974-77)
*Varietal Response to Fertilizer Application on Cultivators' Fields*

Studies on the comparative responses of different varieties to the application of $N_{50}P_{40}K_{40}$ in *kharif* season showed that 'IR-20' rice variety gave higher response than 'Jayanti' at Bhagalpur and Saran. 'MR-301' rice variety gave higher response of 2.6 q/ha than 'MR-136' at Mysore, whereas 'Masuri' gave 4.7 q/ha more than 'Sakti' at Balasore. In *rabi* season, 'Ratna' gave higher response than 'CR-63-252' in Balasore (4.8 q/ha). Under rainfed conditions, 'Jaya' gave 4.0 q/ha more yield than 'PTB-26' at Malapuram.

The responses of wheat varieties to the application of $N_{50}P_{40}K_{40}$ did not show any difference in general in most of the districts. At Bulandshahr, however, the variety 'HD-2009' gave 5.0 q/ha more yield than 'HD-1553', whereas the variety 'HD-1982' gave higher response over 'HD-1553' by 5.0 q/ha at Midnapore. At Jind, variety 'Kalyansona' was better than 'C-306' by about 4.5 q/ha.

*Response to Organic Manures*

Studies on the nitrogen economy through organic manures revealed at Bhavanisagar that application of townyard manure at the rate of 12 tonnes per hectare was as effective as application of 60 kg of nitrogen along with 30 kg each of phosphorus ($P_{2}O_{5}$) and potassium ($K_{2}O$) per hectare. Beneficial effect of townyard manure was also recorded at Jabalpur in rice-wheat-green gram rotation where application of 12 tonnes per hectare of farmyard manure to rice gave an extra yield of 12.6 q/ha of rice and this was more than that obtained with the application of 60 kg nitrogen per hectare through chemical fertilizer. There was also some residual response to this by the subsequent wheat crop. Farmyard manure was, however, not as effective as chemical fertilizers when applied to rice at Thanjavur, Karanmana, Varanasi, Pune, Masodha and Rahuri.

*Long-range Effect of Continuous Use of Farmyard Manure, Phosphorus and Potassium*

In rice-rice sequence, 15 tonnes FYM/ha applied continuously both in *kharif* and *rabi* and applied once either in *kharif* or in *rabi* gave a total response of 27.2, 19.5 and 20.6 q/ha at
Mangalore. 6.4, 5.4 and 3.2 q/ha at Anantharajapet, and 11.8, 10.2 and 1.6 q/ha at Bhubaneswar. In rice-wheat sequence, the response was 13.9, 13.8 and 13.0 q/ha at Raipur, 13.2, 9.9 and 0.7 q/ha at Kharagpur, 12.3, 9.9 and 10.2 q/ha at Masodha, and 10.0, 9.8 and 9.1 q/ha at Varanasi. In jowar-wheat, it was 9.9, 9.1 and 5.8 q/ha at Sehore, and 37.4, 25.5 and 29.2 q/ha at Sirguppa. In maize-wheat, the response was 9.2, 7.8 and nil q/ha at Pantnagar, and 16.2, 20.0 and 20.2 q/ha at Ludhiana.

In rice-rice rotation, 60 kg P₂O₅ applied continuously during both the seasons, or applied once either in kharif or in rabi gave a total response, of 7.5, 6.1. 8.2 q/ha at Anantharajapet and 3.1, 4.1 and 12.1 q/ha at Maruteru respectively. In rice-wheat, the responses were, respectively, of 23.3, 20.3 and 20.9 q/ha at Raipur, 8.49, 8.3 and 6.3 q/ha at Kharagpur, 20.0, 24.0 and 24.2 q/ha at Masodha and 11.9, 9.8 and 11.3 q/ha at Varanasi. The response to phosphate in rabi was negative at Kharagpur. In jowar-wheat rotation, the responses were 12.9, 9.1 and 12.7 q/ha at Sehore. In maize-wheat, it was 15.4, 17.2 and 15.6 q/ha at Ludhiana.

Response to 30 kg K₂O/ha in rice-rice rotation applied continuously in kharif as well as in rabi or applied once either in kharif or in rabi was 3.2, 3.1 and 3.9 q/ha at Anantharajapet, 4.7, 4.8 and 0.8 q/ha at Maruteru and 7.6, 0.12 and 0.27 q/ha at Bhubaneswar. In rice-wheat, it was 11.9, 13.5 and 10.5 q/ha at Kharagpur, 1.8, 4.5 and 0.3 q/ha at Basudeopur and 5.1, 0.8 and 2.6 q/ha at Varanasi. In maize-wheat, the response was 2.1, 1.9 and 2.1 q/ha at Talabtilloo.

Weed Control

Studies made at the Andhra Pradesh Agricultural University, Hyderabad, on control of Typha angustata indicated that the application of Tafapon in combination with 2,4-D (both @37.5 kg/ha) was more effective followed by the combination of 2,4-D @ 25 kg/ha and Gramoxone @ 25 l/ha. Water hyacinth was most effectively controlled by the herbicide combination of 2,4-D @ 5 kg/ha + Gramoxone @ 4 l/ha followed by the combination of 2,4-D @ 4 kg/ha + Gramoxone @ 2 l/ha.
At the Haryana Agricultural University, Hissar, an application of 0.5 kg a.i./ha of atrazine in *bajra* at pre-emergence stage was found to be very effective in controlling weeds. Lasso at 0.5 l/ha gave better weed control in *bajra* as reported from the Co-ordinated Project.

At the Orissa University of Agriculture and Technology, Bhubaneswar, the post-emergence application of Propanil @ 2 kg a.i./ha, effectively controlled the grasses and sedges in upland rice. Studies under the Co-ordinated Project revealed that propanil, butachlor and benthio carb at 3 kg/ha could be used for controlling weeds in upland rice.

At the Punjabrao Krishi Vidyapeeth, Akola, the critical period for weed competition and inter-cultural operation in cotton was found to be between 3 and 6 weeks after sowing. The weeding done within this period increased the yield of cotton by about 1.7 q/ha.

**Agronomy for Dryland Farming**

*Moisture conservation.*—The studies conducted at the Indian Agricultural Research Institute, New Delhi, revealed several techniques for moisture conservation under rainfed farming. The practice of dust mulch and straw mulch increased the yield of sorghum by 4 to 7 q/ha over no mulch. Application of antitranspirants like atrazine (120 g/ha), Phenyl mercuric acetate (PMA) (1×10^-4M solution) and Kaolin (6% suspension) as foliar spray at the time of initial flowering, also increased the sorghum yield by 10 to 12 q/ha over control. Application of straw mulch in *moong* crop grown in *kharif* in *moong*-mustard rotation helped in conserving enough moisture in the surface soil layers and enabled better germination of succeeding mustard crop in *rabi* season. The use of mulch in mustard crop and Kaolin sprays further increased the yield over that of unmulched crop. In the case of wheat also, the application of Kaolin, CCC and PMA increased the yield of wheat by 23.5, 20.4 and 11.8 per cent, respectively over the control.

*Double cropping in drylands.*—Double cropping in dryland was found feasible and remunerative at a number of locations. At Talabtilloo, maize variety ‘GS-2’ followed by wheat variety
'HD-1981' and maize variety 'GS-2' followed by safflower variety 'A-300' and at Anantharajpet during *khurif*, sunflower variety 'EC-68415' and groundnut 'AH-1192' both followed by horsegram (local) in *rabi* were more remunerative than other cropping sequences tried.

*Table 1. Amount of fertilizers (kg/ha of N-P₂O₅-K₂O) used for different crops in production potential trials under assured input conditions*

<table>
<thead>
<tr>
<th>Centre</th>
<th>Crops and fertilizers used (kg/ha of N-P₂O₅-K₂O)</th>
<th>Khurif</th>
<th>Rabi</th>
<th>Summer</th>
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<tbody>
<tr>
<td>Mangalore</td>
<td>Rice 180-90-90</td>
<td>Rice</td>
<td>Rice</td>
<td>Rice</td>
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<tr>
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<td>Bhatanisagar</td>
<td>Rice 120-60-60</td>
<td>Rice 120-60-60</td>
<td>Rice 120-60-60</td>
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<td>Vrannasi.</td>
<td>Rice 150-60-60</td>
<td>Wheat 120-60-60</td>
<td>Rice 120-60-60</td>
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<td>Kalyani.</td>
<td>Rice 80-40-40</td>
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<td>Rice 100-50-50</td>
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<td>Karamana.</td>
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<td>Rice 90-45-45</td>
<td>Rice 90-45-45</td>
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<td>Maize 120-60-60</td>
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<td>Kharlag.</td>
<td>Rice 120-60-60</td>
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<td>Jowar 100-50-50</td>
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<td>Centre</td>
<td>Cereals</td>
<td>Pulses</td>
<td>Oilseeds</td>
<td>Cash crops</td>
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<td>$N_{30}P_{30}$</td>
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<td><strong>Rice (kharif)</strong></td>
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<td>Bhagalpur ('IR-20')</td>
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<td>Bilaspur ('Jaya')</td>
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<td>24.7</td>
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<tr>
<td>*Balasore ('Ratna')</td>
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<td>Bullandshahr ('KT-41')</td>
<td>Una ('Vijay')</td>
<td>Delhi ('Hyb. J-17')</td>
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<td>1.36</td>
<td>0.58</td>
<td>1.38</td>
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*Data relate to 1975—77 only
**Data relate to 1976-77 only
P and K may be read as $P_2O_5$ and $K_2O.$
AGRICULTURAL ENGINEERING

Research was concentrated during the year on farm machinery, energy requirements in crop production, wells, and post-harvest technology of cereals and pulses, through four co-ordinated plan schemes and about ten ad-hoc schemes.

**Farm Machinery**

Research, development, prototype production and evaluation were carried out on implements required for seed-bed preparation, sowing, harvesting, threshing and processing.

*Soil-working implements.*—For effective breaking of clods and preparing seed-bed, a pulverizing roller was developed at Ludhiana as an attachment to go behind a nine-tyne cultivator suitable for a 35-H.P. tractor. Its width is 2.07 metres and is made of mild steel bars. It was tested in medium to heavy soils along with disc harrows and cultivator. Its performance was considered to be satisfactory as one hectare could be covered in only 5.2 hours as against 8.5 hours with a disc harrow and the average clod size was also smaller.

Under the prototype scheme, to help tribal areas 50 sets of hand-tools, manufactured on German prototypes were completed and despatched to a number of centres as per the directions of the ICAR, by the centre at Coimbatore. The universities receiving these sets will train a few tribal people to operate the various hand-tools and also with their help evaluate the performance of the different types of hand-tools.

*Sowing and planting.*—The available seed-cum-fertilizer drills sow the seeds in line. They, cannot be used for planting the seeds at desired distances. Hence at Ludhiana, studies were taken up to evolve a machine which could drill seed and fertilizers and also at the same time be used as a planter. The advantage expected from this machine is its low cost of manufacture and also its suitability for a wide variety of crops. The development work was completed and field evaluation for sowing groundnut, maize, cotton, soyabean, peas, bhindi was taken up.

*Ganga seed-drill.*—(mounted on desi-plough). The implement was developed at Zonal Research Centre, Indian Agricultural Research Institute, New Delhi. The implement is used for sowing various seeds such as wheat, barley, peas, bajra, sorghum, maize etc. The fertilizer could also be applied simultaneously by the side and 2.5 mm below the seeds. Calibrated wooden
rollers are used for sowing seeds and metering the fertilizer. The machine is designed to sow crops under dryland farming conditions.

The weight of the machine without desi-plough is 15 kg. The draft requirement of the seed-drill is 35 to 50 kg and is operated with a pair of bullocks with one man. It covers about 0.5 hectare in 8 hours and the cost of operation is Rs 24/ha. The cost of seed-drill without desi-plough, is about Rs 225/-.

Seed-cum-fertilizer drill (bullock-drawn).—A bullock-drawn, seed-cum-fertilizer drill was developed at the Research Testing and Training Centre, Pune, under the Co-ordinated Scheme for Research and Development of Farm Implements and Machinery. It has three furrow openers for fertilizers for seed separately. The ranges of seed drilling rate varies from 10 kg/ha to 150 kg/ha, and fertilizer rate from 25 kg/ha to 350 kg/ha. Row to row spacing could be arranged at 22.5 cm, 30 cm and 45 cm. It requires one man with a pair of bullocks to operate and could be used for sowing wheat, jowar, gram etc. and drilling granular fertilizer. It covers an area of 1.00 to 1.5 hectares in 8 hours depending on the row spacing.

At Poona, for drilling of fertilizers as a second dose, a hoe-cum-fertilizer distributor was developed. It is useful for removing weeds in between two crop lines and also simultaneously apply the fertilizer in between the lines.

Potato Planter-cum-Intercultivator.—It is a tractor-operated automatic potato-planter. The machine is hitched behind a tractor on three-point linkage. The seed-potato in a graded size is filled in the hopper. On operating the machine in forward direction, it opens furrows (60 cm apart), places seeds at an interval of 25 cm and makes ridges. After sowing operation the machine is used for earthing the ridges operations. It has a capacity of about 3 ha/day.

A manually-operated top dresser for paddy was designed at Rajendranagar. It consists of a fertilizer-drilling mechanism, a float fixed with a furrow opener and a hopper for fertilizer. A ground wheel is provided for operating the drilling mechanism. It requires two labourers to operate one for pulling the implement and another for controlling and balancing the machine. This has to be tested under different field conditions.
Paddy-transplanter.—Research and development of a tractor-drawn paddy-transplanter at Ludhiana was reported in the previous report. Several operational deficiencies such as gaps in line, non-uniform picking, low-field efficiency etc. were reported. Laboratory studies were, therefore, conducted to eliminate the various defects observed.

Harvesting machinery.—At Ludhiana, for harvesting the cereal crops tractor-mounted reaper binder was developed. The Agriculture University in collaboration with a private company brought out a prototype which was tested at the University farm and also at farmers' fields in the districts of Ludhiana, Jullundur and Amritsar. Though the performance was encouraging, several minor defects were observed and attempts are being made to remedy these defects.

Harvesting of potato crop comprises two distinct operations, viz. (i) removal of haulm, (ii) digging up of the potatoes. For removing the haulm, a tractor-drawn haulm cutter was reported earlier. Several field trials were carried out with the above under field conditions when several defects were noticed which are being remedied.

For digging of the potatoes over the ground an oscillating device was developed which is undergoing field evaluations and modifications.

Thresher.—The design and development of a high capacity multi-crop thresher was reported earlier at Ludhiana. Several field trials were carried out with this machine for threshing wheat, paddy and maize. Outputs of 8, 12 and 30 q per hour respectively were recorded in the trials. Few operational problems such as vibrations, breakage of bearing bolts, choking of straws were noticed which are being looked into.

Power tiller.—At Coimbatore, research was reported on the development of a low-cost power-tiller and also development of a harvester as an attachment to the power tillers. Though the basic designs were completed, field evaluation for evaluating performance and durability have been undertaken and are in progress. The various defects observed are being eliminated.

Growth-chamber Studies on Growth Dynamics of Rice

Environment plays an important role in determining the growth development and yield of plants. It influences moisture, temperature, nutrient offtake, insect and disease resistance in
plants. To analyse the response to these factors, the Indian Institute of Technology, Kharagpur developed and studied a growth chamber under field conditions. These studies include the light distribution, energy, effect of time yield and studies on macro- and micronutrient offtake of rice plant. It was observed that inefficient utilisation of light energy in the plant canopy is a major factor which reduces yields. It was also observed that the most favourable temperature cycle for active tillering which is 21° to 36°C which in turn, gave high yield of rice. The temperature cycle below this reduces the yield appreciably. Soil is also subjected to more reducing conditions under submergence than under saturation. An increased concentration of phosphorus, iron and manganese was noted in plants under submerged conditions.

Energy Requirements for Intensive Agricultural Production

The scheme was continued at five centres—Ludhiana, Pantnagar, Kharagpur, Jabalpur and Coimbatore. Energy data was collected for a large number of crops, rotations and operations, on experimental plots and also through surveys of over a score of sample farms at each Centre. Results obtained more or less confirmed the previous year's findings and are presented below.

1. Irrigation is the major energy consuming operation for almost all crops. About 40 to 60 per cent of the total energy is required for lifting water depending upon the soil type, crops and crop rotation.

2. The second major energy consuming operation is the seedbed preparation operation on heavy soils. On light soils harvesting threshing operation came second in energy consumption.

3. Upland paddy crop required maximum energy as compared with any other crop.

4. The animate power source have been observed to be costlier. Though energy derived from it was low yet the cost incurred was high.

5. The utilization of tractor power in almost all cases of mechanized farms included in the field survey samples of the 5 centres was observed to be below 60 per cent. For individual ownership of tractor and machinery even the tractor sizes of 20 and 30 H.P. are too big for optimal operations.
6. The operational cost on mechanized farms may be reduced substantially by:

(a) better matching of equipment;
(b) replacement of rotavator with disc-harrow for seed-bed preparation;
(c) rationalising the number and sequence of operation for seed-bed preparation, and
(d) minimising unproductive use of tractor, particularly for transport.

7. The operational capabilities on the bullock farms was increased by 30 to 40 per cent through substitution of indigenous implements by improved implements like disc-harrow, seed-cum-fertilizer drill, etc. Such an improvement might lead to more timely operations, more intensive crop husbandry and higher intensities of cultivation. Also, the total energy cost was reduced through the substitution of indigenous implements by improved implements.

8. In intensive system of farming even the bullock-operated farms depend to an extent of 70 to 80 per cent on the diesel engines, electrical motors and hired tractor power for their energy needs. The bullocks supply only 15 to 20 per cent of the total energy needs.

9. The studies showed that with 200 per cent cropping intensities, a pair of bullock could cover only about 2 hectares using indigenous implements. The range of this limit was found to vary from 10 to 20 hectares for 35 H.P. tractor and 3 to 5 hectares for 8 j.p. power tiller.

10. For paddy and wheat cultivation, the use of power tiller was found to be less energy consuming and economical than bullocks or tractor but the difference was marginal. While for maize cultivation the situation is uncertain.

11. For seed-bed preparation, rotavator was found to be economical and less energy consuming than other implements on heavy soils.

12. Under the village survey conducted in Ludhiana district, it was found that in paddy growing areas, farmers having bullocks does not cultivate different crops e.g. wheat, paddy, etc.) without the help of tractor.
Open Wells and Tube-wells

The Co-ordinated Project on 'Optimum Utilization of Ground-water through Wells and Pumps' has been functioning at five main centres, namely Ludhiana, Pantnagar, Baroda, Poondi and Hyderabad. In addition, there are three ad hoc centres of research located at Jabalpur, Hisar and Bhubaneswar. The main projects under the scheme include studies on the development of design criteria for tube-wells and open wells and investigations on the causes of well failures and their possible remedies. Research is also underway to develop suitable water lifts and pumps suiting to the widely varying situations.

The hydraulic performance of different types of tube-well screens was tested at Pantnagar, Ludhiana and Poondi. The studies indicated that rope wound mild steel rod screen and simple mild steel rod screen with closer space gave better hydraulic performance than slotted pipe screen and other locally available well screen. Studies at the Poondi Centre revealed the suitability of synthetic (nylon) fibres as envelop material in place of coir in tube-well strainers.

The Pantnagar Centre developed a suitable design for propeller pumps of different discharge rates and sizes. These designs are being improved with a view to perfecting the designs and utilize them for commercial manufacture. Propeller pumps could be used suitably under low head high discharge situations commonly prevailing in river and canal-pumping schemes and for drainage pumping. They have also low initial cost than the centrifugal pumps of similar capacity. Studies are also underway on indigenous water lifts. The Centre has also taken up investigations on the performance of hydraulic rams.

The Ludhiana Centre carried out studies on the effects of suction lift on the efficiency of centrifugal pumps. It was revealed that the pumps work most efficiently under suction lifts ranging between one and four metres. The efficiency decreased substantially when the suction lifts was increased beyond the above range.

At Baroda Centre, studies were completed on the effect of entrance velocity through well screens on corrosion. The report is being finalised.

Artificial recharge of groundwater by the syphon method and by direct punching of the impermeable layer were conducted at the Baroda Centre. Field projects based on the results of studies at the Centre are already in operation at Ahmedabad.
At Poondi Centre, influence of percolation on the groundwater recharge was conducted.

The Hyderabad Centre conducted various geological and hydro-geological investigations in the drought-prone areas of Prakasam, Kurnool, Cuddapah and Nellore districts of Andhra Pradesh (where a variety of Lithotypes belonging to the major geological super-groups, viz., Cuddapah, Kurnool and Dharwa, are met with), so that the results obtained from these investigations would enable the development of suitable design criteria for new wells and suitable methods for improving the yields of existing wells. Based on the hydro-geological data maps indicating water-table conditions and depicting optimal depth at which aquifers occur in various areas were prepared.

The Poondi Centre developed a suitable mathematical model to predict the flow of water to wells in hard rock areas. The model was tested in a specially prepared hydraulic model in the laboratory as well as from pumping test data in the field. The model was found satisfactory in predicting well performance in hard rock areas. Further verification with additional field data from different groundwater basins is in progress.

Post-harvest Technology

Research on post-harvest problems of cereals and pulses was carried out under the co-ordinated schemes at ten centres: Bhopal, Kharagpur, Pantnagar, Ludhiana, Jabalpur, Udaipur, Akola, Cuttack, Raichur and Coimbatore. Some of the important problems taken up for study were: time of harvesting, drying, storage, and processing. Results obtained are discussed.

Time of harvesting.—To determine the effect of date of sowing and harvesting on milling yield, grain quality and storability, five rice varieties were included in the experiments conducted at Pantnagar, and data on various aspects were collected and are being analysed. Similar studies were continued at other centres also, with the important crops of the area.

Drying.—(1) A machine for heat-treatment of infested grains reported earlier at Udaipur was tested and improved further with better reflectors, auger fitted with roll-easy bearings, (2) in any solar drier, in order to circulate the hot-air, a blower operated by electrical power is provided. To eliminate the electric motor, studies were conducted at Jabalpur and design of a blower was completed. This is being tried out on solar heaters.
Storage.—Various methods have been tried for applying insecticides to foodgrains during storage but most of them are not very effective, safe and convenient at farm level. At Kharagpur, application of malathion as a prec harvest spray in several concentrations varying from 16 to 56 ppm showed that grains stored were not affected. More observations are needed.

At Jabalpur, a storage experiment was conducted to evaluate the efficacy of different non-toxic seed protectants for the storage of pulses, gram and arhar. Neem-leaf powder was applied on the top of grains, quoting the inner walls with neem-leaf powder in linseed oil and quoting the seeds with coconut oil. All treatments have no insect infestation problems. However, cookability and viability showed market variation.

At Akola, P.K.V. bins were further improved by providing a hopper shape bottom. A flap-type valve is provided to the discharge pipe which controls the discharge of grain easily. A triangular tripod made out of angle iron is fabricated for raising the bin. These have been installed.

Processing.—1. Studies were carried out at Kharagpur on the milling quality of high-yielding varieties of paddy and local varieties. It was observed that all H.Y.V. exhibited an average 56–74% head yield as compared with 38–59% in local varieties. Studies on cooking qualities of the two categories of rice were also undertaken.

2. At Udaipur, laboratory investigations were carried out to separate ergot-affected pearl-millet. Based on differing frictional properties of good and affected grains, a device was developed having endless belts, where the heavy good grains move down leaving the higher ones to move up. Different types of belts, angles, and speeds are being tried out to arrive at the optimum conditions.

3. At Udaipur, based on the working principles of the power-driven unit reported earlier, manually-operated maize dehusker was developed. The output of the machine varies from 39–53 kg/hr. Performance under differing operational conditions is being assessed.

4. Research on stabilisation of rice-bran using infrared radiation as a source of heat, was conducted at Pantnagar. Laboratory studies on temperature distribution pattern, phsyio-thermal properties and effect of radiation, were conducted. Based on them, design criteria of a suitable equipment were worked out and the fabrication is in progress.
5. Groundnut strippers, drum and comb-type evolved at Coimbatore were tested for studies under this scheme. The drum-type stripper was found to be more economical as compared with comb-type. The output was 15 kg/hour as against 11 kg by conventional method.

**IDRC–ICAR Operational Research Project**

This scheme is in operation at Bhopal, Cuttack, Udaipur, Akola and Coimbatore. The main objective of this scheme is to evaluate under actual field conditions in farmers' holdings and residences, results achieved under the main scheme. The following are the important achievements under the project at different centres:

**Bhopal Centre.**—Coal tar drums discarded by the Public Works Department were converted into grain storage bins and installed in 9 villages for storage studies, along with Pusabin and other local storage structures. During the 7 months of storage, the grains in these bins maintained their quality. The local structures did not give satisfactory performance owing to water seepage through the mud walls, rodent attack and insect infestation. Studies need to be continued in the coming year to improve the local structures to make them rodent- and water-proof. In Pusa-bins also, there was some moisture migration into the bin, perhaps due to damaged plastic lining.

**Cuttack Centre.**—(i) The locally available Nanda bins made from burnt earthen rings were constructed for scientific observations at several villages. Periodic observations on moisture, temperature, grain damage and germination were taken up and would be continued in the next year.

(ii) Solar-dryer was fabricated and tested with 'Jaya' paddy. It took 6 hours to reduce grain moisture from 21–12% and the quantity dried was 0.8 tonnes.

(iii) A sun-drying rack consisting of a tray with a sieve to retain grain above the ground level was compared with drying on floor. In all the observations drying was faster in the racks which reduced the time for drying by about 25%.

(iv) A simple parboiling device having a capacity of 200 kg was installed at a village. Observations indicated that it took 3–4 hours to parboil 200 kg of paddy which normally takes 27–28 hours by conventional method.

**Udaipur Centre.**—(i) The coaltar-bins, Pusa-bins and Chittore-bin made of stone-slates, were studied.
(ii) Dehusking is very necessary for speedy drying of cobs for effective storage. Maize dehusker developed at the University which could be operated either manually or by power was tested at a number of villages. The outputs of these were 250 kg and 500 kg per hour.

(iii) The solar-heat-treatment machine designed earlier at the Institute was included for field studies when infested maize grains were treated satisfactorily.

Akola Centre.—A number of Pusa-bins were installed in the nearby villages and storage studies were conducted with wheat and jowar. The entomological observations have shown that the insect infestation after eight months was negligible and it was concluded that the Pusa-bin could be effectively used for storage of wheat and jowar in the area. The University has also developed a simple double-layer bamboo-bin with inter-laying of plastic sheet. It was reported that this has given satisfactory performance. A solar-energy and agro-waste dryer were developed and field tested.

Coimbatore Centre.—For harvesting of groundnut the bullock-drawn digger developed at the University was compared with manual harvesting. The cost of harvesting per hectare was Rs 54 and there was a saving of Rs 18 per hectare by use of this machine. Groundnut threshing was taken up with comb-type and drum-type strippers.

Groundnut drying studies were taken up with a metal-bin dryer at a village. The cost of drying was 50 paise per kg for reducing moisture from 29% to 9% in 12 hours.

Threshing studies were carried out with paddy and bajra at different moisture levels, with locally made thresher which gave an output of 7.5 q of grain per hour.

3. ANIMAL SCIENCES

Research on animal sciences was continued to improve the productivity of livestock and poultry for raising the income of farmers, particularly the small and marginal farmers. Attempts to improve further the genetic make-up of livestock and poultry by introducing exotic inheritance was continued. Efforts were also made to determine the optimum level of exotic inheritance in the cross-breds. Identifying the agricultural by-products and industrial wastes for incorporation into the livestock and poultry
feed to make them cheap, investigating health problems of the livestock and developing suitable vaccines and chemotherapeutic agents against epidemics were other important aspects of work.

CATTLE

Breeding

The research programme for synthesizing new strains of economically viable dairy cattle was continued at the National Dairy Research Institute, Karnal, the agricultural universities, and under the All-India Co-ordinated Research Project on Cattle at the Indian Veterinary Research Institute, Izatnagar, Haryana Agricultural University, Hissar, Mahatma Phule Krishi Vidya-apeeth, Rahuri, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Lam Farm of the Andhra Pradesh Agricultural University, Andhra Pradesh, and at the Bidhan Chandra Krishi Vishwa Vidyalaya, Haringhata, West Bengal. Half-breds of Holstein-Friesian, Brown Swiss and Jersey breeds with Hariana, Gir and Ongole breeds of Indian cattle were produced, as also three-breed crosses comprising one of the above-mentioned Indian breeds with Holstein-Friesian, Brown Swiss or Jersey breed. At present 2,600 half-bred females and about 750 second generation females, viz. with 75 per cent exotic inheritance, comprising three breeds (two exotic breeds and one Indian breed), are available. Performance evaluation in terms of growth, reproduction and milk production was in progress at different research units of the co-ordinated project.

The overall mortality rate in the young cross-breds was about 5 per cent at most of the centres. The birth weight of calves of Holstein-Friesian x (Brown Swiss x Gir) crosses was 8 to 10 kg more than that of the Jersey x Gir crosses or of the Girs. At Hissar, the conception rate in Haryana cows inseminated with frozen semen was 25 to 30 per cent; in the half-breds it was 51 to 56 per cent. The service period of the half-breds ranged from 91 to 162 days only. When management and feeding were optimum females with 75 per cent exotic inheritance weighed more and calved earlier. Brown Swiss x Holstein-Friesian x Gir animals attained an average body weight of 338 kg by 18 months of age. At Rahuri Friesian x Gir cross-bred cows produced 5,468 litres of milk in 300 days, whereas a Jersey x Gir cow yielded 4,100 kg in 300 days. The average butter-fat percentage in milk of half-breds ranged from 3.0 to 4.5, being maximum in
the Jersey crosses. At most of the centres selection of young sires with 75 per cent exotic inheritance was being made for inter-se mating.

At the Punjab Agricultural University, Ludhiana, Red Dane x Sahiwal cross-bred cows produced on an average 3,217 litres of milk in 305 days. Red Dane x Sahiwal females were being bred to Holstein-Friesian to produce three-breed crosses. At the Marathwada Agricultural University, Holstein-Friesian x Deoni cross-breds were being studied.

At the National Dairy Research Institute, Karnal, the data collected from the military and civil farms located in Haryana, Punjab and Uttar Pradesh on the crosses of Friesian, Jersey and Brown Swiss with zebu cattle at different levels of exotic inheritance were being compared for body weights at early ages, body size, production, reproduction and different measures of milk production. The genetic parameters and interrelationship of various characters of growth, production, reproduction and efficiency of milk production were also being studied.

In dairy heifers, it was observed that selection for higher weights could be made on the basis of their weight at earlier ages, especially from 6 months onwards. Heifers weighing more at early age calved earlier, gave birth to heavier calves and produced more milk. The first lactation yield was independent of age at first calving but was positively related to weight at first calving. The first lactation yield was the major factor affecting lifetime production and the first lactation efficiency was the major factor influencing lifetime efficiency.

Among the various levels of exotic inheritance studied, half-breds had the best growth, were more productive and were more efficient in milk production. Inter-se mating accompanied by selection appeared to be an ideal long-term policy for cross-bred cattle. The age at first calving was 27 to 30 months in Friesian, Jersey and Brown Swiss crosses, and the weight at first calving was 350 to 400 kg in Friesian and Brown Swiss crosses, and 275 to 325 kg in Jersey crosses.

The average 305-day lactation yield of Tharparkar half-breds with Friesian, Jersey and Brown Swiss was 3,331, 2,867 and 2,994 kg respectively.

Nutrition

Studies were intensified to develop economic and nutritious rations for cattle of different age groups at the National Dairy
Research Institute, Karnal. Studies carried out on optimum milk production of Karan Swiss cows indicated average dry-matter intake of 12.5 kg per day giving 1.09 kg dry matter per kilogram of milk produced. Similarly, the average protein, DCP and TDN intake per day per kilogram of milk produced was 0.1, 0.09 and 0.68 kg respectively.

Investigations on the effect of feeding of free and molasses-bound urea on rumen metabolism in cattle revealed that ammonia liberated in urea-molasses complex group was significantly lower than in free urea group. The results revealed the usefulness of binding urea with molasses before feeding.

The nutritive value of fish ensilage was determined. The fish ensilage contained 31.18 per cent crude protein, 4.66 per cent ether extract, 10.63 per cent crude fibre and 39.29 per cent total carbohydrates. Calcium and phosphorus contents were 3.20 and 1.97, respectively, indicating the scope for inclusion in the calf-starter rations.

A feeding experiment conducted at the National Dairy Research Institute, Karnal, on adult Sindhi animals on rice-bean (Phaseolus calcaratus) hay at its flowering stage as a sole feed for 30 days indicated that the average dry-matter consumption per day was 1.82 kg per 100 kg body weight. The percentage DCP and TDN on dry-matter basis were 8.67 and 50.05 respectively.

Karan Swiss cows were better converters of feed and fodders than buffaloes. The total butter-fat production was 116.5 kg on 300-day lactation basis in Karan Swiss and 115.8 kg in buffaloes.

At the Indian Veterinary Research Institute, Izatnagar, paddy, wheat straw with 1.5 per cent urea and 10 per cent molasses were successfully compressed into 20 to 25 kg bales with a simple hand-operated press. A prototype was fabricated by a local firm as per the suggestions of the scientists. These bales can be stored for 1 year without any deterioration or moulds growing on them. They were quite palatable and acceptable to animals.

Sun-dried poultry excreta and green maize with 8 per cent molasses was quite acceptable to animals. In the beginning a little crushed maize had to be given along with concentrate to make the latter acceptable.

Petro-proteins prepared at Izatnagar from petroleum hydrocarbons were fed to cattle to study their nutritive value, nitrogen utilization and effect on growth rate and milk production. The petro-proteins were found suitable for feeding the ruminants.
Trace element survey in the Tarai area of Uttar Pradesh, carried out by the Indian Veterinary Research Institute, indicated that about 75 per cent of the animals had less than 60 μg copper per 100 ml of blood, which corresponded to low haemoglobin in the blood of these animals. Copper and zinc were deficient, manganese marginally adequate and iron just adequate in the fodders of this area. Studies carried out at the Veterinary College, Bikaner, on Rathi cows indicated that supplementation of daily ration with cobalt sulphate at 5, 10 and 20 mg per animal per day improved the milk production, reproduction efficiency and general health without any deleterious effects.

Some of the oilcakes, particularly groundnut-cake, contain aflatoxin injurious to the health of cattle. In a study carried out on aflatoxicosis at Jabalpur, 27 out of the 44 samples of groundnut-cake collected from various places in Madhya Pradesh, Rajasthan, Uttar Pradesh and Karnataka were positive for aflatoxin. Research work was in progress for finding out suitable solution for removing aflatoxin from the groundnut-cake before being fed to livestock.

Studies were continued on the utilization of agricultural by-products and industrial waste materials for evolving economic rations for the livestock. A process was developed for treating of sesame-meaL, so that it could be mixed in the ration up to 20 per cent without any deleterious effect on the digestibility of crude proteins. The beneficial effect of treatment of cereal straws with sodium hydroxide for increasing digestibility and intake was well established at Pantnagar centre. A critical review of the work further indicated that dry-matter intake of treated straw was better with increase in groundnut-cake used in the ration.

Rubberseed-cake, another important by-product, whose availability is estimated to be about 0.15 million tonnes, can be economically used at 20 per cent level in the concentrate mixture of milch cows replacing sesameoil-cake without any adverse effect. Even though rubberseed-cake contains linamarin, no adverse flavour in milk of cows fed on rubberseed-cake was observed at the Veterinary College, Trichur. However, toxicity factor present in rubberseed-cake was being thoroughly investigated at Trichur and Anand.

Preliminary work carried out on the use of shrimp-shell powder, mahua flowers and mahua-cake, tapioca leaf-meal, coffee
husk, etc., indicated that these can be incorporated after proper processing in the rations of the livestock.

Studies were carried out at Urli Kanchan on the ensilaging of sugarcane tops with and without the addition of 0.5 and 0.75 per cent urea, and with and without 10 per cent molasses. The silage was fed for maintenance of bullocks and for growth. The silage intake increased when fed along with high concentrate feed. The nutritive value of coarse sugarcane bagasse could be improved by incorporating a fungus *Candida utilis*.

At the Veterinary College, Bombay, feeding of finger-millet straw treated with molasses and supplemented with urea resulted in a significant increase in milk yield and protein content in milk.

**Physiology**

To predict the future reproduction potential of a cow, some parameters were studied at the Veterinary College, Bombay. A gradual increase in the blood glucose level from the 2nd to the 12th week post-partum and a simultaneous higher increase in body weight during the same period were useful indicators of animal coming in heat. Several drugs were tried for inducing heat in cows with prolonged post-partum anoestrus. Certain indigenous drugs were observed to induce heat in 84 per cent of cows studied and were superior to other drugs tried. Comparative study on treatment with ayurvedic and allopathic drugs in anoestrous gonads was undertaken at the Punjabrao Krishi Vidyapeeth, Akola. Ayurvedic preparations were not effective, whereas treatment with allopathic preparations produced significantly better results. Bovi-synchron was very effective in synchronizing heat of cows.

Studies were carried out at the U.P. College of Veterinary Science and Animal Husbandry, Mathura, on the physiology of parotid gland of cattle and buffaloes with particular reference to the total daily saliva secretion. The knowledge of the rate of secretion under various feeding, physiological and climatic conditions, and ionic composition of saliva under these conditions would be helpful in improving the physiological conditions of the livestock.
Breeding

Buffalo, as a domestic animal, plays an important role in optimum utilization of rural labour and in re-cycling of by-product resources into useful products in terms of food, draught and energy supply. To optimize production efficiency of Murrah and Surti buffaloes, a multi-disciplinary research project was in progress at the National Dairy Research Institute, Karnal, the Punjab Agricultural University, Ludhiana, the Udaipur University, Udaipur, the University of Agricultural Sciences, Dharwar, and the Institute of Agriculture, Anand.

Ninety-six Murrah and Surti buffaloes were put under sire evaluation programme at the first four centres of the Project. The transmitting ability of 32 of these bulls was expected to be known within the next year. To exploit fully the superior germplasm of the selected bulls, methods were evolved to freeze and store over long period buffalo semen in liquid nitrogen. The conception rate with the stored frozen semen was on par with the freshly cooled semen.

Progeny testing work was intensified in the farmers' herds surrounding the area at the four centres during the last year. Methodology was standardized for estimating milk production at periodical intervals. This will be used to increase selection intensity by evaluating larger number of bulls and thus augment the annual genetic gain in buffaloes. The milk productivity of buffaloes in the project area increased by almost one-and-a-half times since 1972 as a result of selection and reduction of age of females at first calving from 48 to about 39 months. Work was initiated to establish a Germplasm Centre at the Indian Grassland and Fodder Research Institute to raise surplus male calves from the various centres of the existing project.

The estimates of genetic parameters for various economic traits were made on the basis of data collected from military dairy farms and farms of other institutions. The heritability for age at first calving was 0.12. The heritability of body weight showed a decreasing trend, with the estimates varying from 0.50 at birth to 0.27 at 1 year of age and 0.11 at first calving. The estimate for lactation yield was 0.20. Early selection could be based on the partial lactation record and the 120-day milk production record could be utilized for this purpose.
The average milk yield of Bhadawari breed of buffaloes, found in Agra and Etah districts of Uttar Pradesh as well as in Gwalior District of Madhya Pradesh, was about 3 kg per day, but the butter-fat percentage was as high as 13 per cent. A study made at the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, indicated that the Bhadawari males could stand heat better during work than males of other breeds. This breed appeared to offer much promise for meeting the needs of the village buffalo keepers in the area.

A distinct breed of buffaloes called Berari/Nagpuri was reported from the Punjabrao Krishi Vidya Peeth, Akola. The she-buffaloes produced about 1,600 kg of milk per lactation. It was observed that there was considerable scope for improving its milk production potential.

Biochemical properties of buffalo semen were studied at the National Dairy Research Institute, Karnal. The buffalo had 800 to 1,000 mg of fructose as free sugar per millilitre of semen and glycoprotein in bound sugar. Choline plasmalogens were the major phospholipids of buffalo semen. Glycolipids were also present. Buffalo semen samples with spermatozoa having good initial motility had the capacity to produce cyclic AMP, an enzyme which effects motility, capacitation, maturation and fructolysis. Washed buffalo spermatozoa behaved like whole semen, and the fructolysis indices in both the cases were comparable. Glucose, mannose and pyruvate support respiration of washed spermatozoa over the endogenous levels. Trials with various diluents, e.g. egg-yolk citrate, citric acid whey (CAW), TRIS and different levels of glycerol, were in progress to further develop more efficient techniques for preservation of buffalo semen.

The ultra structure of spermatozoa of buffalo bull semen was studied using electron microscope at the G. B. Pant University of Agriculture and Technology, Pantnagar. Striking differences were observed in the sperms of buffalo and cattle bulls. These differences are likely to throw some clue to the poor quality of buffalo bull semen. A dilutor was developed for the preservation of buffalo bull semen at room temperature for 3 to 5 days without adversely affecting the conception rate. Studies carried out at the University further indicated that vaccination against foot-and-mouth disease adversely affected the keeping quality of semen for 45 days.
Studies carried out at the All-India Institute of Medical Sciences, New Delhi, indicated that buffalo semen contains 'P' factor (antisterility factor) like cattle bull semen or human semen. Addition of 'P' factor to cattle semen or goat semen increases sperm motility. However, addition of 'P' factor to buffalo semen indicated the presence of some inhibitor factor causing only marginal increase in motility. However, after washing of the sperms from the semen and suspending them in skim-milk or in buffer, the motility of the sperm is increased by addition of the 'P' factor. Further work on the isolation and characterization will throw light on the mechanism of 'P' factor and the possibility of its synthesis which will enable to improve the motility and fertility of the buffalo bull semen.

Nutrition

Study was continued at the National Dairy Research Institute, Karnal, on the growing buffalo calves weaned at birth, and fed on whole milk, milk-replacer and calf-starter. In the buffalo calves fed calf-starter, total protozoal and viable bacterial counts were higher than those fed the other two feeding regimes. In the animals fed calf-starter the rumen protozoa established themselves one week earlier than in the other two feeding regimes. With the increase in the population of cellulolytic bacteria, the corresponding increase in cellulose digestion and production of total volatile fatty acids were noticed in the animals up to 12 weeks of age.

Two hundred types of cellulolytic and amylolytic rumen bacteria were isolated. Cellulolytic cocci were more efficient than cellulolytic rods in the utilization of cellulose. For efficient protein utilization in terms of digestibility and milk production, 3 per cent urea could safely be added in the concentrate ration of lactating buffaloes producing 12 kg of 4 per cent fat-corrected milk. Feeding high-protein diet to the weaned Murrah calves, 5 to 12 months of age, accelerated the growth rate and resulted in earlier sexual maturity. Higher levels of protein feeding after two years of age did not affect the growth rate significantly, although it resulted in better digestibility of crude protein. Daily voluntary dry-matter intake of Surti buffalo calves was 2.18 per cent. The dry-matter intake of Murrah buffaloes fed on a balanced diet of wheat straw supplemented with non-leguminous fodder and concentrate was 37 per cent less than that of Tharparkar cows for production of every kilogram of fat-corrected milk. Gross and net energy efficiency of conversion of nutrients into milk was 7 to 16 per cent higher among Murrah buffaloes than in
Tharparkar cows. For obtaining optimum growth rate and dressing percentage in Murrah male calves TDN at 120 per cent of the recommended NRC standard was found to be the best regime of feeding. Selenium content of more than 0.5 ppm level in the fodder resulted in selenium toxicity and deguna disease symptoms in buffaloes. Insulin injection at the rate of 20 units for 20 days to debilitated buffalo calves suffering from dermatitis helped in improving general conditions and curing the disease.

The digestible energy and metabolizable energy of various fodders available for feeding to livestock were studied at the Punjab Agricultural University, Ludhiana, to work out the possible relationship with total digestible nutrients. Under this study, data collected on various fodders like berseem, cluster-bean, maize pearl millet, oat, oat hay and wheat straw were evaluated by feeding to male adult buffaloes at their maintenance level of nutrition. The data were used for developing simple and multiple regression equations for predicting the energy worth of these diets. The data can be used as a rough guide for formulating rations for different categories of livestock. These regression equations would be useful for the evaluation of the nutritional worth of different feeds and fodders.

A study was conducted at Izatnagar on the microbial activity in the rumen. The digestibility of protein of mixed whole rumen bacterial cells and Streptococcus bovis was 81.7 and 96.8 per cent, respectively, in cattle and buffaloes, and the bacterial production rate was significantly correlated with dry-matter consumption, nitrogen intake, digestible organic matter, total volatile fatty acid production in the rumen and total digestible nutrients intake. Digestibility of nutrients in buffaloes fed with limited amount of berseem (0.82 kg DM) was generally somewhat higher than with ad lib. berseem feed (5.0 kg DM).

Studies at the University of Agricultural Sciences, Bangalore, indicated that protein content of microbes in the rumen liquors was higher in buffaloes than in cattle without any difference in volatile fatty acid production. Certain bacteria were predominant in the rumen of both the species.

Studies were conducted on the availability of calcium and phosphorus from feed supplements commonly used for feeding at Ludhiana. The negative calcium balance in the ruminants on the oxalate-rich diets might have been due to less degradation of calcium oxalate present in these diets and resulting alkalosis after
the degradation of soluble oxalates to bicarbonates. Supplementation of these diets with crude limestone was the chief way of supplying additional calcium to the animals.

The effect of diet on the microbial population in the rumen of cows and buffaloes was studied at Pantnagar. The micro-flora of buffalo and cattle kept under similar dietary and management conditions were different, but the organisms belonging to *Bacteroides* group were common in both. Studies on the difference in the rumen, biochemical and microbial activity in buffalo and zebu calves, with special reference to microbial enzyme and metabolic transformation of the nutrients available to them in the feed were conducted at the U.P. College of Veterinary Science and Animal Husbandry, Mathura. *Clostridia* were found only in cattle.

A number of parameters of biological responses like haematocrit and erythrocytic count, plasma protein, alkaline-phosphatase activity and total cholesterol activity were studied in animals maintained under conventional management and under special management at the U. P. College of Veterinary Science and Animal Husbandry, Mathura. The water intake in the buffaloes seems to be determined by body weight, season and dry-matter intake. Summer stress had a depressing effect on the growth potential of the buffaloes.

**Physiology**

In buffaloes 75 per cent of the calvings occurred during July to December, leading to seasonal flush and lean milk availability. Only a few breeding buffaloes exhibit mucus discharge in summer. In winter, there is intense activity accompanied by bellowing and copious mucus 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. Periodic parading of vasectomized bull helped in detecting the females in oestrus and breeding them in time.

The involution of uterus was completed in an average period of 35 days in case of normal calvings and 45 days in case of abnormal calvings. In buffaloes first post-partum oestrus was observed after 50 days in normal calvings.

Studies carried out at Pantnagar indicated that certain types of infertility could be cured by administering a mixture of oestrogen and progesterone subcutaneously twice daily for 7 days. After the last injection, the udders of all the buffaloes treated
were daily massaged for a few minutes. They started giving milk within 7 days following the last injection and gave continuously normal milk for 8 to 10 months.

A new technique was developed at Pantnagar using radioactive iodine to determine thyroid hormonal activity in buffaloes without sacrificing them. In dairy animals the regulation of thyroid activity was found to be directly linked with milk and meat production.

Timely detection of heat would help in overcoming the seasonality of breeding in them. In the studies on buffalo reproduction at Anand, a definite shift was found in the occurrence of ovulatory cycles among the three breeding periods of the year (medium, peak and low). During the medium (monsoon), peak (winter) and low (summer) breeding periods most of the animals were tracked in heat during 2 to 5 PM, 1 to 5 AM and late evening hours respectively. This finding is very important for successful artificial insemination. During monsoon months, the heat period remained for about 14 hours, during winter well over 18 hours and during summer for only 8 to 10 hours. A pre-oestrous behaviour was observed all round the year and this was differentiation from the real heat. Inseminations at pre-oestrus should be avoided. The research work further indicated that frequent urination, about 5 to 6 times in 15 to 30 minutes in small quantities, is a useful criterion for detecting heat in buffaloes.

From a study of levels of hormones in blood in buffaloes carried out at the Punjab Agricultural University, Ludhiana, it was observed that gonadal hormones may be affected adversely by the growth rate. The optimum growth rate in buffalo heifers must be ensured for optimum development of the reproductive systems, as gonadal hormones are responsible to a large degree for the development of reproductive tract in growing animals.

At the Rajendra Agricultural University, Ranchi, histological and histochemical studies on the female genitalia of the Indian buffalo were carried out. These studies would be of help in understanding the reproductive behaviour of buffaloes.

Health

Foot-and-mouth disease continued to be an important animal health problem among cattle and buffaloes, particularly the cross-bred cattle. It affects growth and productivity of livestock thus hampering the milk-production programmes. To have a comprehensive information on the dynamics of this disease under
different agro-climatic conditions and varied animal husbandry practices, and also to gather information on the species susceptibility and pattern of the disease among the vaccinated and unvaccinated herds. An All-India Co-ordinated Research Project for Epidemiological Studies on Foot-and-Mouth Disease was in operation in different states. Under this Project, field samples were collected and epidemiological data from 577 outbreaks were studied and analysed in 1976. During this year type ‘O’ was predominant, followed by types ‘Asia I’, ‘C’ and ‘A’. Since the inception of the scheme in 1971, 2,210 virus isolations were made and identified; of these 1,208 were type ‘O’, 218 type ‘A’, 330 type ‘C’ and 354 type ‘Asia I’. Work on virus sub-typing of the isolates was under progress. The epidemiological data provided information in respect of ‘carrier status’ of animals, spread of the disease, incidence among different age groups, species difference and mode of transmission under field conditions. New and more refined techniques were developed and applied both for virus studies and application in analysis of epidemiological data, investigation of disease in vaccinated animals, study of prevailing conditions in respect of this disease in certain tribal areas, infection in organized farms and selected villages, etc. The basic data collected will be useful for formulation of disease-control programmes. Besides this, the technique for collection of oesophageal fluid samples was standardized to study the carrier status of the foot-and-mouth-disease virus in different species of animals. Detailed studies carried out at the Central Laboratory at the Indian Veterinary Research Institute revealed that cattle can harbour the virus up to 7 months, and virus variation in an epidemic and ‘carrier’ strain can occur. Further research on this aspect was being continued. The main Centre of the Project also provided training to scientists in the application of new laboratory techniques. During the year for the first time an outbreak of the disease was recorded in the Islands of Andaman and Nicobar; type ‘O’ was isolated from the material. Epidemiological data were also collected and are being analysed. Another significant finding was the occurrence of the foot-and-mouth disease in yaks in Himachal Pradesh. In these species also type ‘O’ virus was isolated.

Theileriasis is an important protozoan disease in livestock, particularly in the cross-bred and exotic cattle. Investigations were carried out at the Punjab Agricultural University on different aspects of the biology of *Theileria annulata* including vectors and epidemiology of the disease to develop suitable con-
Control methods. Considerable progress was made at this Centre towards the development of a vaccine against this disease.

One method of immunization, successful under laboratory conditions, comprised deliberate infection with tick tissue stabilates and simultaneous treatment with chlortetracycline at 16 ml per kg body weight per day given orally in capsules, for eight consecutive days. This method was successful in immunizing the experimental animals given 10-tick challenge.

Another method of immunization was tried by inoculating *T. annulata*-infected schizonts attenuated by serial passage in tissue-culture. The results were very encouraging. At the Indian Veterinary Research Institute, Izatnagar, investigations indicated that a vaccine comprising schizonts of *Theileria annulata* could be obtained from the in vitro cell-cultures of infected lymphoid cells. The vaccine was tested in cross-bred male calves under experimental conditions. Further work was in progress.

Studies were also conducted at the Veterinary College, Madras, on the epidemiology of the disease in the endemic areas of the State. Out of the 2,259 blood smears collected from the endemic areas of a milk colony in the city of Madras and different districts of the State, 129 (106 cross-bred and 23 indigenous) were positive for *Theileria* infection. Koch's blue bodies were detected in lymph-node biopsy smears from 31 cross-breds, of which 7 were positive for *T. annulata*. From the cross-bred and indigenous animals 46 collections of ticks were made in different districts of Tamil Nadu. The following ten species were identified: *Hyalomma marginatum isacci, H. hyalomma hussaini, H. h. brevipunctata, H. anatolicum anatolicum, Haemaphysalis bispinosa, Boophilus microplus, B. annulatus, Rhipicephalus sanguineus, R. haemaphysaloides and Amblyomma integrum*. Of the 10 species, 6 were recovered from *Theileria*-positive animals.

At the Assam Agricultural University, Gauhati, research was continued on the epizootology of theileriasis in north-eastern region to evolve effective control measures. As a result of survey over 1,300 specimens of ticks belonging to five genera and six species were collected from different hosts and identified. Different species of ticks which act as vectors of different haematozoa were recorded. The high-producing animals were more prone
to tick infestation. The incidence of *Hyalomma anatolicum anatolicum*, a vector for transmission of *T. annulata*, was not high in this area. Further studies on these are being continued.

At the University of Agricultural Sciences, Bangalore, investigations continued on the biology and control of anaplasmosis. *Boophilus annulatus* was the most common tick involved in its transmission. This was successfully maintained in the experimental calves. The freshly engorged, dropped-down ticks were found infected with *Anaplasma marginale*. Efforts were made to trace the organisms in different organs of the ticks by fluorescent antibody technique. A comparative study of the results using capillary tube and rapid plate-agglutination test antigens was made with those of Giemsa's stained blood smears of sera collected from 18 susceptible cattle. The serological tests were more efficient in detecting *Anaplasma* 'carrier' animals and did not cross-react with *T. annulata*. Direct and indirect fluorescent-antibody techniques exhibited specific fluorescence in the blood smears positive for *A. marginale*. Preliminary studies on pre-immunization indicated that the calves maintained higher antibody titre than the controls.

At the Veterinary College, Madras, studies were continued on the incidence, bionomics, role in the causation of diseases with special reference to transmission of piroplasmosis and control of ticks of domestic animals. Studies on the damage to the skin of cattle, sheep and goats by ticks were continued using histopathological methods. A specimen from skin from the tail of a sheep infested with *H. marginatum isaccl* revealed severe cellular infiltration with neutrophiles and lymphocytes leading to subacute dermatitis. Effectiveness of certain insecticides and their residual effects were also studied. A mixture of organophosphate and carbamate (1% 2, Isopropoxy Phenyl, N-Methyl carbamate propoxur+0.5% 0-0-dimethyl -0-2.2 dichlorovinyl phosphate DDVP) when tried on a bullock infested with *Boophilus microplus*, caused near complete mortality of ticks from the fourth day of this spray, and the animals were free of ticks for three weeks. Thereafter reinfestation started. In another trial an organophosphorus insecticide Pivimiphos methyl (500 mg/cc) when administered orally to a dog with heavy natural infestation of *R. sanguineus*, the ticks began to drop dead, one day after the administration of the drug. After five to six days, the dogs were completely free of tick infestation. Reinfestation was noticed after 23 days when the animals were exposed to natural positive surroundings. These studies indicated that the drug did not have long-term residual effect.
At the Delhi University, detailed studies on morphology and taxonomy of ticks from different livestock and host-parasite relationship were continued. High incidence of tick-borne diseases among cattle and other domestic animals were recorded. The data were being analysed statistically to draw valid conclusions. Important scientific data on the ecology of ticks in the area were collected. The distribution of *Boophilus microplus* was confined to riverine areas. *Hyalomma* ticks were uniformly distributed. However, *Hyalomma marginatum isacci* was restricted to hilly regions. The distribution of these ticks was found to be related mainly to the climatic and physical environmental conditions rather than the availability of the hosts.

Ticks of the genera *Aponomma*, *Boophilus* and *Haemaphysalis*, and of the subgenus *Hyalommina* exhibited host specificity to certain extent. This phenomenon was not well marked among other tick species as many of them are known to attack other hosts fortuitously. Even those exhibiting host-specificity are group-specific, e.g. *Hyalomma a. anatolicum* may parasiticize a number of hosts but all shall be mammals.

At the Allahabad University, studies on host-parasite relationship of common species of amphistomes of ruminants were carried out and efficacy of promising drugs against adult and immature amphistomes was assessed. Development of immunity in ruminants against amphistomes and the biology and ecology of such aquatic snails as are known to serve as intermediate host of the parasite to develop control measures were the other aspects studied. In this programme metacercariae of various amphistome flukes were successfully harvested. This was a step towards the study of host-parasite relationship. Gross infection among different hosts showed that there were no host strains among the three species of amphistome flukes, viz. *Palamphistomum indicum*, *Gastrothylax crumnifer* and *Gigantocotyle explanatum*, under study. Studies on the acquired and age immunity of different host species to infection with three species were initiated.

Immunology of schistosome infection was undertaken at the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, to evolve a vaccine for its control. For this the effect of immunization on mice with irradiated cercariae of *S. incognitum* on 1,000, 3,000 and 5,000 rads, respectively, was observed. The mice were immunized by 100 non-irradiated or irradiated cercariae in a single or two divided doses given at an interval of 7 days. The immunized mice were challenged 21 days thereafter, and subsequently sacrificed at 42 days after the first immunizing exposure. These mice
developed an acquired resistance to *S. incognitum*, which was evident from the highly significant reduction in the number of developing worm from the challenge exposure on the basis of histo-pathological findings. No significant difference in the mean recovery of worms was found in mice immunized with non-irradiated cercariae or with cercariae irradiated at 1,000 rads.

The above experiment was extended to pigs, the natural host of the parasite. In four pigs previously immunized with 2,000 cercariae and subsequently challenged with 6,000 homologous cercariae, a significant reduction in worm recovery was observed when compared with that in the control animals.

At the Haryana Agricultural University, further research was carried out on the ecology, mode of transmission, serological typing, etc., of *Salmonella, Arizona* and *Edwardsiella* organisms. The pattern of *Salmonella* infections revealed that *S. typhimurium* and *S. dublin* infected majority of zebu calves on the farms, whereas *S. typhimurium* infected the cross-bred calves.

Toads were considered reservoirs for certain serotypes, viz. *S. telhashomer, S. brijbhumi* and *S. goverdhan*, because majority of toads examined harbour these organisms. Seven of the 121 *Salmonella*-infected toads harboured two different serotypes.

Nasal carriers of *Salmonella* among young farm animals could be detected only in zebu calves (1.2 per cent) and piglets (2.9 per cent), but not in buffalo calves, lambs, kids and foals. Two strains each of *S. typhimurium* were isolated from calves and piglets respectively. Other enteric organisms isolated from the nasal passages of various animals (cow calves, buffalo calves, lambs, kids, piglets and foals) were *E. coli, Enterobacter, Klebsiella* and *Citrobacter, E. coli* serotype 071 was more frequently isolated from healthy piglets.

The initial study of serological investigation by indirect haemagglutination test revealed that carrier status of *Salmonella* infection might exist in the buffalo. This phase of study was being investigated further.

A total of 768 samples, comprising 105 diarrhoeic stool samples from man, 103 urine samples from urinary-tract-infected patients, 8 operated human appendices, diarrhoeic faecal samples from 99 calves and 101 sheep and goats, faecal samples from 76 healthy pigs, and intestinal samples of 93 toads, 145 wall-lizards and 38 rats, were examined for the presence of some of
the emerging enterobacteria of pathogenic significance, viz. *Citrobacter freundii*, *C. intermedius*. *Edwardsiella tarda*, *Erwinia herbicola*, *Serratia marcescens* and *Yersinia enterocolitica*.

At the Indian Veterinary Research Institute, serological typing of *Salmonella* organisms was continued. This Centre functioned as the National Salmonella Centre (Veterinary) for serotyping of *Salmonella* isolates from animals in India. This Centre has 141 *Salmonella*-diagnostic sera for serotyping.

Serotyping of *Leptospira* was also undertaken to determine the prevalence and distribution of leptospirosis in relation to livestock health and productivity in the country. A total of 442 sera samples from animals received from nine states were tested for the presence of *Leptospira* agglutinin battery of antigens belonging to 11 serogroups. The typing results were classified. The Institute prepared standard anti-*Leptospira* serum for diagnosis of the infection.

To detect the occurrence of *Mycoplasma* in the reproductive tract of cattle and buffaloes and to devise control measures, studies were carried out on bovine reproductive disorders associated with it. Eighty-five samples were collected from different parts of the reproductive tract and were examined for the presence of *Mycoplasma*.

The undermentioned fungal species were isolated from the uteri of buffalo in the following sequence: *Aspergillus*, *Rhizopus*, *Penicillium*, *Trichothecium*, *Alternaria*, *Scopulariopsis*, *Geotrichum*, *Sporotrichum*, one unidentified fungus and one yeast-like cell.

At the Indian Veterinary Research Institute, Mukteswar, adaptation of FMD virus (vaccine strain) in BHK-21 (CL-13) monolayers was studied. A 10 per cent suspension of cattle tongue epithelium in BHK-21 medium of ‘O’, ‘A’, ‘C’ and ‘Asia 1’ types of FMD virus were prepared. ‘O’, ‘A’ and ‘C’ types of the virus showed observable cytopathic effects at 72 hours post-infection whereas ‘Asia 1’ showed after 48 hours in the first passage. Types ‘O’ and ‘Asia 1’ showed cytopathic effects 18 hours post-infection at fifth and fourth passage levels respectively. Types ‘A’ and ‘C’ of the virus showed cytopathic effects 18 hours post-infection at sixth passage level.
At the Centre for the Foot-and-Mouth-Disease Vaccine Production, IVRI, Bangalore, the work on the adaptation of Indian isolates of FMD virus on BHK₂₁ suspension cells was continued. Excepting 'Asia 1' virus isolates, other virus types were adapted to grow in cells both in monolayer and in suspension. A total of 22 experimental batches of vaccines were prepared either on BHK monolayer cells or on suspension cells on monolayer. Three batches of vaccines were also prepared using suspension cells in suspension culture. Ten batches of vaccines were potent when tested in guinea-pigs. Other batches were being tested. Two batches of type 'A' vaccine tested in cattle contained 6.8 and 12 PD₅₀ respectively.

During the year 66 thousand doses of experimental monovalent vaccines were produced. A large number of animals were successfully vaccinated with the vaccine in field trials.

The construction of main vaccine production laboratory is likely to be completed by 31 March 1978.

MILK AND MILK PRODUCTS

Chemistry

A study was carried out on the usefulness of Pro-milk Tester and Milko-Tester under Indian conditions for the estimation of fat and proteins. With these, proteins in cheese could be estimated in about 10 minutes.

An equipment, specially designed and fabricated for the determination of the thermal conductivity of buffalo milk, was found to be very useful in the laboratory.

Thin-layer chromatographic method was developed for the simultaneous detection of two or more foreign fats such as vegetable oil and animal body fats present in ghee. The test was based on the analysis of unsaponifiable matter in ghee, body fats and vegetable oils.

Flavour almost similar to that of desi ghee was introduced in butter-oil, when it was treated under good stirring with skim-milk dahi or spray-dried milk dahi (5% by weight) at 120°C for 3 minutes.

A systematic study on rheological properties of butter made under industrial conditions in three different regions of the country was completed. Certain modifications in the procedure for preconditioning of cream improved the rheological characteristics of butter made from buffalo milk.
Concentration of three trace element minerals, viz., zinc, iron and copper, present in buffalo milk were determined with atomic absorption spectro-photometer.

Milk-fat-globule membrane of buffalo milk had the lowest level of tri-glycerides, whereas milk-fat core and whole milk had the highest level of tri-glycerides. The level of glycerides in cream and skim-milk lay in between the two extremes. The di-glycerides level was maximum and the mono-glycerides level was minimum in milk-fat-globule membrane. The milk-fat-globule membrane had the lowest content of short-chain fatty acids and the maximum amount of medium-chain fatty acids.

**Bacteriology**

The use of bromothymol blue mastitis detection card was popular among local farmers for the quick detection and eradication of mastitis. Simple low-cost whey desoxycholate agar medium was developed for enumeration of coliform bacteria in milk and milk products.

Samples of dried milk, both roller as well as spray-dried, and baby foods were examined for pathogenic and non-pathogenic micro-organisms. Twelve pathogenic as well as heat-resistant strains of *E. coli* were isolated. Other isolates included 25 strains of coagulase-positive staphylococci, and 14 strains of *Salmonella, Shigella* and *Proteus*. Growth of some selected food-poisoning organisms was also studied in re-constituted milk.

During the period under report, large-scale production of bacterial rennet from *Bacillus subtilis* K-26 was taken up by making use of the facilities existing in the Department of Food Technology at the Central Food Technological Research Institute, Mysore. From these trials 5 kg of crude rennet powder was obtained. The enzymes showed milk-clotting activity in the range of 20 to 300 units per gram in laboratory trials. Eight-fold purification of the milk-clotting enzymes from *Bacillus subtilis* K-26 was achieved by Sephadex-gel filtration. Homogeneity of the enzyme was confirmed by ultra-centrifugal analysis.

Crude phospholipids extracted from *Fusarium* species when incorporated into ghee at 0.2 per cent level improved the oxidative stability by 27 times over the control. However, some discolouration was found in the ghee samples. Incorporation of washed cells of *Fusarium* sp. and *Geotrichum* sp. into cream or butter prior to conversion into ghee by heating at 115°C gave greater oxidative stability to ghee.
Technology

Studies on the role of sulphur compounds in sterilized milk, condensed milk and milk powders established that the basic role of SH-compounds are same in cow and buffalo milk. The intensity of flavour development was lower in buffalo milk. The manufacture of weaning food from soyabean and whey was standardized and was being tested by the Home Science Department, Punjab Agricultural University, Ludhiana.

Trials were conducted to standardize the technique for preparation of acidophilus sour milk and acid yeast by varying combinations of different Lactobacillus acidophilus cultures. Attempts were also made to implant L. acidophilus in the intestines of laboratory animals. Preliminary studies showed that the total number of coliforms decreased in the experimental rats than in the controlled ones. Sixteen trials were conducted on the preparation of dahi using a high acid-producing Streptococcus diacetilactis St. Higher acid production and better flavour were obtained in dahi samples prepared with the mutant culture.

The physico-chemical changes during the preparation and storage of khoa were studied. The process for the production of spray-dried channa from cow milk and its use in sandesh was developed.

The design of continuous ghee-making equipment was further modified at the National Dairy Research Institute, Karnal, in the light of experience drawn in the subsequent trials from the first developed model. To make the equipment more compact and economically viable, the number of motors were reduced. For avoiding re-circulation of the product a single-stage equipment with proper disposition of vapourizer and heating unit was under advanced stage of fabrication.

After successful trials of the milk-dispensing unit, more sanitary features in the designs were being incorporated.

Automatic ghee-filling and seaming unit was in the advanced stage of completion. A weightment measuring device and tin-transferring units were being modified. The unit was being used for trials.

Nutritive value

The difference in biological value, protein efficiency ratio, etc., between ice-cream from milk and low-cost ice-cream using milk
and vegetable solids was negligible. It was established that dahi was more nutritive than the milk from which it is prepared. Calcium retention in experimental animal was higher when the raw milk was fed than when the same was sterilized for 10 minutes before feeding.

A comparative study of the market samples of infant foods and humanized milk prepared at the laboratory indicated that the buffaloes were superior in relation to protein composition, lactose level and unsaturated fatty acid contents.

**Economics of Milk Production**

*Cost of milk production.*—A detailed analysis of milk production costs at the National Dairy Research Institute, Karnal, revealed that the cost per litre of milk was 103, 136 and 110 paise for Brown Swiss, Jersey and Holstein crosses respectively. On the other hand, it was 210 paise for buffaloes. No significant difference was observed in respect of age at first calving and cost of rearing up to the age of first calving among the pure-bred, exotic and various crosses of dairy cattle. The age at first calving and cost of calf rearing were higher for pure-bred zebu cattle. Studies based on the data collected from various villages around Karnal revealed that cost of milk production on rural farms was high, and small and marginal farmers and landless labour households incurred annual losses in milk enterprises with existing cattle and buffaloes. The overall per litre cost of milk production was Rs 3.06 for cows and Rs 2.53 for buffaloes.

A comprehensive appraisal of the Indo-Swiss Cattle Breeding Programme in Kerala revealed that cross-breeding had brought forth significant improvements, viz. lower age at first calving, shorter dry period and calving interval, and higher milk yield. These in turn contributed to the lowering of milk production cost and increase in the net annual income per household. The benefit-cum-cost ratio was greater than 1.0; the net value at the time of study was positive and interval rate of return was higher than the prevailing bank interest rate. These findings justify Government's investment in Brown Swiss cross-breeding programme of cattle in Kerala.

**SHEEP**

Sheep is the main source of wool required both for apparel and carpets, and contributes nearly one-fourth of the total meat produced in the country. To improve the productivity of sheep for fine wool and for mutton, an All-India Co-ordinated Research Project
Breeding

Under the All-India Co-ordinated Research Project on Sheep Breeding the cross-breeding programme with Russian Merino and Rambouillet rams for fine wool, and with Dorset and Suffolk rams for mutton component was continued. At the six centres in operation 1,749 half-bred females were produced—944 in the three units of the fine wool and 805 in the three units of mutton component. In cross-bred progeny wool quality in terms of finer fibre improved and medullation percentage was low. In the mutton component there was some improvement in body-weight gain, efficiency of feed conversion and dressing percentage. Dressing percentage ranged from 46 to 55 in the cross-breds. Suffolk cross-breds were, in general, better. Suffolk×Sonadi cross-breds at the Central Sheep and Wool Research Institute, Avikanagar, had a live-weight gain of 16 kg in 90 days of individual ad lib feeding and a dressing percentage of 63 on empty-weight basis.

At the Central Sheep and Wool Research Institute two new strains of cross-bred sheep, viz. ‘Avioon’ a fine wool strain and ‘Avikalin’ a superior carpet wool strain, were evolved. ‘Avioon’ strain was evolved by crossing Rambouillet and Chokla breeds. At yearling age, the new strain produced, on an average, 2.9 kg of greasy fleece giving 20 per cent more income than Chokla through the sale of wool alone. The performance of this strain was extremely satisfactory when kept on re-seeded Cenchrus pasture with density of 5 animals per hectare along with their lambs up to the weaning age (90 days) without any supplementary feeding. The ‘Avikalin’ strain, evolved by crossing Malpura sheep with Rambouillet, produced 2 kg of greasy fleece, with 23μ average fibre diameter and 21 per cent medullation. This wool is suitable for manufacturing superior carpets and medium-quality apparel. The sale value of wool of this strain was 150 per cent higher than that of Malpura breed.

Karakul sheep imported from the USSR were kept under hot arid conditions at Bikaner, and cold arid conditions at Leh, Ladakh. At both these locations, their performance in terms of lambing percentage, survival, wool production and pelt quality was satisfactory. The percentage of lambing in sheep kept at Bikaner was 93,
lamb survival up to 5 months was 94 per cent while adult survival was 99 per cent. Average body weights of adult rams and ewes were 54 and 37 kg respectively. Preliminary studies on cross-breeding of indigenous sheep with Karakul breed were encouraging. Pelts of lambs born were classified as 45 per cent Jacket type, 26 per cent Ribbed type and 29 per cent of Caucasian type.

Sex-libido traits of rams tended to be correlated among themselves in a study made on inheritance of ram fertility at the Haryana Agricultural University, Hisar. At Konkan Krishi Vidyapeeth, preliminary trials for deep freezing of ram semen by the pellet method were made. The extender containing egg-yolk-tris-glucose-citric acid-glycerol gave promising results in terms of higher rate of revival of spermatozoa.

Nutrition, Physiology and Biochemistry

At the Central Sheep and Wool Research Institute, Avikanagar, studies were conducted on the nutrient requirements of different breeds and breed crosses of sheep, and evolving cheap supplementary ration through utilization of agricultural and industrial by-products and non-protein nitrogenous substances. Grazing animals on native pastures indicated that energy supplementation was necessary for the maintenance of body weights. Enough protein was available from natural pasture only during rainy season, and during the rest of the year it had to be supplemented. Kankar (Gymnosporia spinosa) leaves were found to be quite palatable to sheep and could form maintenance ration for adults when fed ad lib. Ardu (Ailanthus excelsa) leaves could be used as fodder to meet the energy requirements and could serve as a good supplement to low-quality fodders. Animals could maintain their body weight when fed wheat straw along with ardu leaf-meal and mineral mixture. Such combinations can be used profitably as a drought feed for sheep. Neem silage treated with mineral mixture was more palatable than dry neem leaves or neem silage with molasses or alone. The requirement of energy and protein for cross-bred hoggets was 65 per cent TDN and 8 per cent DCP to produce most optimum growth of lambs of about 6 months of age.

Enrichment of Pennisetum typhoides x Pennisetum orientale fodder by treatment with biuret at ensilaging did not improve serum-protein concentration. Maize in the concentrate mixture could be replaced without any detriment to growth. Addition of biuret in drinking water with molasses (5 per cent) increased the weight gains of lambs by 25 per cent over that in the control group. The
use of protected proteins in the form of formaldehyde-treated groundnut-cake in the concentrate mixture for lambs did not cause improvement in weight gains but improvement in wool production was of about 10 per cent. In research on reproduction physiology in sheep the major emphasis was on the physical, physico-chemical, and biochemical dilutors. Out of the several diluents tested for semen storage at 50°C and for shipment for use under field conditions, the egg-yolk-citrate with glucose was found to be better. Semen preserved in this dilutor for 14 hours and used in double dose when compared with the freshly diluted semen could give 40 per cent conception rate on first insemination basis. This was quite comparable to the freshly diluted semen. Further work on this aspect was going on.

Cobalt sulphate when fed in field trials at Bikaner to sheep had beneficial effect on the general health and milk yield.

Studies carried out at the Veterinary College, Bombay, indicated that 25 per cent of the groundnut-cake can be substituted by neem-seedcake in the feeds of growing Bannur sheep without affecting the gain in weight.

Studies on environmental physiology were on water requirement and biological causation of canary colouration and its elimination. Water when given to Chokla sheep on alternate days did not affect their health, but further restrictions had deleterious effect, especially in pregnant and lactating ewes. The water regimen had appreciable effect on fleece weight as there was increase in fineness with increase in interval of watering. Investigations on biological causation of canary colouration indicated that it is sequel to adaptive mechanism of sheep to hot and humid climatic condition requiring dissipation of body heat through cutaneous evaporation. Indian sheep and their crosses with Merino and Merino types depend largely on cutaneous evaporative cooling (sweating) for heat dissipation when compared with Merino and the higher crosses which utilize largely respiratory evaporative cooling (panting). Among the Indian breeds the fleece density is the most important factor in determining intensity of colouration. Pre-poning of autumn shearing to the later part of June and providing management practices to protect sheep against radiation and metabolic heat load at least till the wool is about 1 cm in length would markedly reduce the incidence of canary colouration.
Technology of Wool

Major emphasis in research was on the evaluation of end-use suitability of Indian and cross-bred wools. Some work on standardization of sampling techniques for quality assessment of wool as well as the scouring and carbonising treatment for Indian wools was conducted. Addition of 4 per cent oil in finer wools and 6 per cent in coarse wool provides optimum carding and spinning performance on woollen system.

The presence of vegetable fault, an important factor in causing economic loss, could easily be tackled by treating greasy wool with 3.5 to 4 per cent sulphuric acid at 30°C for 10 minutes and later removing the acid by hydroextraction and backing, crushing and dusting of the wool.

Spinnability trials carried out on wools from Chokla and Rambouillet × Chokla (1/2, 5/8 and 3/4), Corriedale and Rambouillet wool indicated that R × C (1/2 and 5/8) wool performed equally well when compared with Corriedale wool. These wools could be spun to 40, 45 and 47 Nm respectively. Rambouillet × Chokla (3/4) wools fared equally well when compared with Rambouillet wools. Both could be spun to 49 and 50 Nm respectively.

The functional properties of hand-knotted carpets made out of wool from Chokla, Nali, Jaisalmeri and Magra and Avikalin were studied. Carpets from Jaisalmeri and Magra wools possessed an ideal compression and recovery behaviour but could retain their initial appearance for shorter period of their use due to high weight loss due to abrasion. Chokla and Avikalin wool carpets had excellent appearance-retention potentialities at all stages of their use combined with moderate compression value. Nali wool carpets possessed good recoveries after compression but lacked appearance-retention power probably due to higher alkali damage to the wool during growth. The blends of Jaisalmeri, Magra, Chokla and Nali wools may provide optimum quality wool for best performing carpets. However, Avikalin in itself can be considered as an ideal carpet wool.

Jute-wool blends were processed on woollen and semi-worsted system for making carpet yarns. Carpets made out of woollenized jute and wool blends acquired excellent sheen on chemical washing, and the blend could thus provide an excellent yarn for high quality chemically finished carpets and wall hangings.
Carpet Wool and Karakul Pelt Production

The Division of Carpet Wool and Karakul Pelt Production of the Central Sheep and Wool Research Institute was established in 1975 in the arid region at Bikaner to study the performance of Karakuls as pure-breds and in crosses with the native carpet wool breeds for pelt production, and to improve carpet wool production and quality through selection.

Karakul sheep performed well during the last two years. The performance of Karakul in terms of lambing percentage, lamb and adult survival, wool production and pelt quality was highly satisfactory. Preliminary results of cross-breeding Karakul with native carpet wool breeds gave very encouraging results; the pelt quality was satisfactory and there was also a wide variation in the pelt types and pelt colour.

Work on improvement of carpet wool production and quality was initiated by superimposing the research effort on the project on determining optimum breeding season. The project envisages selection for greasy-fleece weight and against medullation and average fibre diameter to bring the wool to an ideal carpet quality.

Health

At the Regional Centre of the Indian Veterinary Research Institute, Rawalpora, Srinagar (Kashmir), 90,200 doses of lungworm vaccine were produced and supplied to the Sheep Department of Jammu and Kashmir State for use in the field during the period under report. Efforts were being made to further increase the production of this vaccine with the existing facilities.

In view of the close association between sheep and goats in this country, at the above centre studies on the comparative susceptibility of these two species of animals to infection with *Dictyocaulus filaria* were also undertaken. Groups of healthy and worm-free male lambs and kids were infected with 100 infective larvae of *D. filaria* per kilogram body weight per animal. Judging by the severity of the disease produced, the worm establishment in lungs and the larval counts in the faeces, the kids appeared more susceptible to *D. filaria* than the lambs.
Detailed investigations were also conducted to study the effect of different quantum of infection given only once to the lambs, on the length of the pre-patent period, onset and duration of peak patency, LPG (larvae per gram) in faeces, mortality, clinical disease produced and the establishment of the worms in the lungs of the animals. The differences in infection doses, viz. 100, 150, 200 or 300 of infective larvae per kilogram body weight, did not significantly affect the length of the pre-patent period or the onset of the duration of peak patency in the lambs. There was a significant decrease in the percentage establishment of worms in the lungs of the lambs as the infection dose increased. The mortality and the severity of the disease produced in the lambs was directly related to the level of infection, being more severe in lambs receiving infection of 200 and 300 larvae per kilogram body weight respectively. The animals receiving the highest level of infection showed maximum larval output in their faeces. Judging by the percentage survival of producer animals and the expected larval recovery from them during peak patency, the present findings confirmed that a dose of 150 larvae per kilogram body weight was a suitable dose for raising a good producer animal for the vaccine production work.

At the Central Sheep and Wool Research Institute, Avikanagar, studies were conducted on a number of diseases in collaboration with the Indian Veterinary Research Institute, Izatnagar. One of these was the studies on pneumonia in sheep. During the period under report, 1,326 sheep were necropsied and examined for different pathological lesions; of them 364 sheep showed pneumonic lesions on mortality basis. The incidence of pneumonia was 27.4 per cent. The incidence was higher in suckling lambs (36.96 per cent), followed by that in weaners (30.2 per cent), hoggets (28.2 per cent) and adults (20.5 per cent). The most affected breed was Chokla (25.16 per cent) followed by Sonadi (21.1 per cent), Malpura (18.8 per cent) and Nali (17.2 per cent). Among the exotics, Russian Merino suffered the maximum (43.05 per cent), followed by Suffolk (23.01 per cent), Rambouillet (22.5 per cent) and Dorset (22.2 per cent). Cultural and swab examination of heart blood, lung exudate, etc., revealed the isolation of streptococci, diplococci, E. coli, and Gram-positive and Gram-negative organisms.

Studies were conducted to find out the most efficient diagnostic technique for Johne's disease in sheep under organized field conditions. A total of 461 faecal samples including 94 pooled
samples were examined for the presence of acid-fast organisms. Of these 19 samples were positive for the disease and the animals were declared as clinical shedders. Post-mortem examination of these animals revealed extensive lesions from duodenum to rectum. The smears from different sites were prepared, stained and examined. These findings confirmed the clinical findings.

Epidemiological studies carried out revealed that pneumonia was the most prevalent single pathological factor responsible for mortality in sheep, followed by non-specific gastro-enteritis where the lesions were confined to abomasum and intestines. The other conditions were toxaeemia, Johne's disease, parasitic gastro-enteritis, internal haemorrhage, sheep-pox, septicaemia, bloat, impaction and predation.

GOAT

Goat is an important source of meat and milk, and its improvement can be one of the means of improving the rural economy of the country, particularly of small and marginal farmers. In view of this research was intensified during the Fifth Plan for improving the productivity of goat for milk, meat and mohair. To enable the small and marginal farmers to derive the maximum benefits, the Indian Council of Agricultural Research has set up a National Goat Research Centre at Makhdoom Farm near Mathura in Uttar Pradesh under the administrative control of the Indian Veterinary Research Institute, Izatnagar.

Breeding

Under the All-India Co-ordinated Research Project, research was continued on goat breeding for developing better strains for milk, meat and fibre (pashmina/mohair). Cross-breds of Saanen and Alpine yielded 30 to 50 per cent more milk and gave better reproductive performance than the does of local breeds. The research units for evolving meat breeds have established the necessary infra-structure facilities and the mating programme has started. Sangamnerry x Angora half-breds at Mahatma Phule Krishi Vidyapeeth at Rahuri had finer fibre with lower medullation percentage than the Sangamnerry pure breed but the staple length did not show much improvement. With increasing Angora inheritance there was a linear increase in the area of secondary follicles but the follicular area of the primaries decreased. The local goats in Leh (Ladakh) yielded 200 g of pashmina per goat per year.
Studies carried out at the National Dairy Research Institute, Karnal, on cross-breeding of Beetal goats with exotic breeds indicated highly significant correlation coefficients between lactation length and lactation yield, and between post-partum oestrus and service period in all the three genetic groups, i.e., Beetal, Alpine and Alpine x Beetal. Post-partum oestrus was significantly different in the three genetic groups of the goats, but the service period and services per conception did not vary between the three breeds. The 120-day lactation yields for Beetal, Alpine, Saanen, Alpine x Beetal, Saanen x Beetal and Saanen x Alpine x Beetal were 144, 208, 123, 212, 197 and 211 kg, respectively, indicating thereby that the crosses were significantly superior in milk production than their dams. Kidding interval was 313 days in Beetal, 338 days in Alpine, 309 days in Saanen, 346 days in Alpine x Beetal and 330 days in Saanen x Beetal.

The performance of half-bred Alpine x Beetal goats revealed heterotic effect of about 30 per cent in milk yield. Out of the 738 kiddings recorded on the farm, abortions and still-births were 9.4 per cent. These were mostly observed during the first three kiddings in all the breed groups. The abortions and still-births were practically nil after the fourth kidding.

The ratio of male to female births was 87 : 100. The litter size of the farm was 1.58. Single births were more common in first and second kiddings, while twin and triple births increased with the increase in kidding orders.

Male kids were slightly heavier than females at birth and continued to be so at different ages in Alpine, Beetal, Alpine x Beetal crosses. The maximum growth rate was noticed during 1 to 2 months of age in females and 4 to 8 months of age in males. Cross-bred kids showed better growth rate.

Large-scale use of artificial insemination was practised in goats at Kerala Agricultural University, Trichur, using liquid semen. About 2,831 inseminations were made as a result of which 930 kids were born. In a preliminary trial undertaken for deep freezing of bulk semen by pellet method at Konkan Krishi Vidyapeeth, a diluter containing egg-yolk with fructose-citric acid and glycerol was found to be quite suitable.

Nutrition

Metabolic trials were initiated at the National Dairy Research Institute, Karnal, on the protein requirement for maintenance and
milk production in goats. Group 1 animals were fed a nitrogen-free diet consisting of sago, sugar, oils, salt, and mineral mixture as concentrate part and alkali-treated bagasse as roughage part. Group 2 animals were fed low nitrogen (1.3 per cent crude protein) diet with concentrate as above but the roughage was wheat straw. The endogenous urinary nitrogen in groups 1 and 2 was on an average 0.0474 and 0.0471 per kg body weight respectively. Further work was in progress. Based on the data obtained, protein requirements for maintenance and milk production will be worked out. Work was also in progress on the effect of feeding protein concentrate as such and after treatment with heat, formaldehyde and tannic acid on growth and milk production.

A study was carried out on the effect of urea and biuret on feed utilization, growth and milk production using in vitro technique, taking index of $S_{35}$ incorporation in microbial protein at 0, 10, 20, 30 and 45th days of feeding of the biuret (50 per cent DCP requirement). The net per cent incorporation of $S_{35}$ into microbial protein was 4.82, 2.76, 2.80, 2.88 and 2.95 for urea, and 2.5, 4.49, 5.20, 5.72 and 5.69 for biuret respectively. The results indicated that per cent incorporation of $S_{35}$ and microbial protein synthesis were higher on the supplementation of biuret in the diet. The studies further showed that the adaptation period for the micro-organisms in the rumen was a minimum of 30 days for optimum utilization of biuret in the ration.

At Ludhiana studies were carried out on alkali treatment of wheat straw at 3.3, 8.0 and 12.0 per cent level; 8 per cent level of alkali treatment gave best results in terms of digestibility of nutrients and body-weight gain in goats.

Studies carried out at the Veterinary College, Bombay, indicated that urea can be safely added at 1 to 2 per cent of the ration of goat, thereby saving an equivalent quantity of protein and thus reducing the overall cost of the feed.

**PIG**

*Breeding*

Observations were continued to be recorded on certain economic traits at each of the four research units under the All-India Co-ordinated Research Project on Pigs. The average maximum litter size at farrowing was 9.0 and 8.9 in Large White Yorkshire and Landrace stocks, respectively, whereas at weaning it was only 7.9 in both the breeds. At the Rajendra Agricultural University, Ranchi, the average litter size from a small herd of
Landrace pigs at farrowing and at weaning was 12.0 and 8.5 respectively. At Patna Campus of the University the average litter size in Yorkshire pigs was only 7.7 and 6.8 at farrowing and at weaning respectively. This trait was apparently affected considerably by the managemental regimes.

**Nutrition**

Studies at Bhubaneswar indicated that water hyacinth when fed had no deleterious effect on the growth of piglets. Besides, this will help in getting rid of the weed and enable the use of tanks for pisciculture. Another work carried out at this Centre indicated that mahua flower which is not utilized for distillary purposes can replace maize at 100 per cent level in the ration of growing pigs, thus lowering the cost of rearing by 30 per cent.

Feeding trials at the Tamil Nadu Agricultural University on Large White Yorkshire pigs indicated that replacing maize with tapioca chips at 100 per cent level did not have any deleterious effect on growth, besides, the cost of conventional feed was reduced from Rs 1.36 per kg to Rs 1.07 per kg.

Research for developing economic rations for pigs was continued at the Allahabad Agricultural Institute. In the feeding trials on White Yorkshire and Landrace piglets, it was noted that 7 to 16 per cent protein for growers and 14 per cent for freshers was better than high- and low-protein rations.

**CAMEL**

**Nutrition**

Research was carried out at the Veterinary College, Bikaner, to develop economic and nutritious rations for camels. The evaluations for nutritive value of roughages like moth chara (Vigna aconitifolia) (Jacq.) (Marechal); missa bhusa (Cicer aritinum L.), berripala (Ziziphus nummularia (Burm. f.) Wight and Arn.), bekariya (Indigofera cordifolia), guar phalgati (Cyamopsis tetragonoloba (L.) Taub.) and khejri loong (Prosopis spicigera L.), and two concentrates, viz. moth and clusterbean, were carried out by the conventional techniques—digestion/metabolism. This study was followed by balanced studies taking camels of uniform conformation as experimental animals. The nutritive value of the different feeds was ascertained with regard to the chemical composition and gross energy. In general, comparatively high digestibility of nutrients
and lower dry-matter consumption in proportion to the body weights was noted. Utilization of proteins increased with increase in digestible crude protein (DCP) level in the rations as evidenced from the balanced studies. The feed consumption increased in animals kept on higher levels of DCP in the rations but did not show significantly high body weight, indicating thereby that there was no need for increasing the level of DCP in the rations. The experiments indicated that to obtain adequate growth rate camels weighing up to 350 kg and of 3½ years of age needed 0.34 kg of DCP and those weighing 450 kg and of 4½ years of age needed 0.59 kg of DCP.

FORAGE CROPS

There is a wide gap between the requirements and availability of livestock feed. To narrow down the gap, research was in progress at the Indian Grassland and Fodder Research Institute, Jhansi, and under the All-India Co-ordinated Research Project on Forage Crops at different agricultural universities to develop high-yielding, disease-resistant short-duration varieties of fodders and forage crops, and to improve pasture and grazing areas in the country.

Breeding

A number of high-yielding varieties of forages were identified during this year for cultivation. Lucerne variety ‘Anand-2’ was high-yielding and nutritive. It gave 10-15 per cent higher yield than the existing varieties. The leafy and quick-growing forage berseem varieties ‘BL-1’, ‘BL-2’ and ‘B-1’ were found suitable for irrigated areas. They yielded 20 per cent more green forage than ‘Pusa Giant’ and ‘Mescavi’.

In oat, varieties ‘HFO 54’, ‘UPO 130’, ‘HFO 114’ and ‘77-32’ were found promising. They were leafy, green, tall growing, early to medium in maturity. They were identified as single-cut varieties. Oat varieties ‘S-2660’, ‘HFO-163’ and ‘Kent’ were fast-growing, medium to mid-late maturing, leafy and high-yielding. They had quicker and uniform regeneration capacity. As such these varieties were recommended as two-cut promising varieties of oat.

In sorghum, varieties ‘IS 4776’, ‘HFS-26’ and ‘SL-21’ were identified as quick-growing, high-yielding and medium in maturity. These were single-cut varieties suited for early summer or late kharif sowing. They recorded low hydrocyanic acid
(HCN) and were comparatively free from leaf-spots. Among the late types, 'Pusa Chari 6', 'S 134' and 'S 136' were high-yielding and nutritive. Besides, these varieties were better seed producers than many other local varieties. Varieties 'Vidisha 60-1', 'Nilva', 'J 6' and 'J 304' were identified as the most suitable varieties for the areas where sorghum was grown for late supply of forages till November. These were tall-growing dual-purpose varieties. In Sudan grass, variety 'SSG-59-3' (*meewi sugan*) was recommended for release by the Central Committee on Release of Varieties. It was a vigorous-growing, thin-stemmed, sweet, high-tillering and leafy variety with very low HCN content, and a variety suitable for multicut supply of forage during summer. It had as high as 10–20 per cent crude proteins and high dry-matter digestibility. It was recommended for general cultivation in all sorghum-growing areas of the country.

In case of *Pennisetum* spp., 'IC 74', 'K 667', 'D 1941' and 'PHB-10 FZ' were identified as high-yielding forage types. In hybrid Napier, 'NB-5', 'NB-21' and 'BNZ' were high-yielding and nutritive perennial hybrids.

Cowpea varieties 'C 26' from the Gujarat Agricultural University, Anand, 'IC-1' from the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, and 'UPC 5286' and 'UPC 287' from the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, were identified as the most promising forage types giving about 15–20 per cent more green forage yield than the locals and 'Russian Giant'. These were mid-early varieties and were prolific seed producers. 'HFG 119', 'HFG 408' and 'Pusa Sonal' were the most productive forage varieties of clusterbean. In moth, 'T 9' and 'T 23' were the most productive and nutritive varieties for forage production in dry areas. Rice-bean variety 'K 1' was identified as promising and was recommended for further multiplication.

**Agronomy**

Agronomic practices indicated that high seed production in berseem could be obtained when the crop was left for seed latest by the first fortnight of March, irrespective of the number of cuts taken. Less number of cuttings by manipulation of sowing dates gave more seed yield. Spray of phosphorus and micro-nutrients at bud stage increased seed yield in some areas where these nutrients were deficient in the soil.
Experiment on multistoried cropping showed that forage trees, forage crops and low-growing legumes could be grown together. This type of work was in progress at the Indian Grassland and Fodder Research Institute, Jhansi, and at the All-India Co-ordinated Research Project centres.

Results from the Central Arid Zone Research Institute, Jodhpur, indicated that plantation of spineless cactus in hot deserts and drought-prone areas could serve as a reserve for animals at maintenance level in years when monsoon failed. *Opuntia* was promising as a scarcity feed. It was highly drought-resistant and could be grown in areas getting 200 mm rainfall if supplemental runoff was available.

**Silvipastoral Studies**

The palatable or sometimes less palatable leaves of *Albizia procera*, *Cassia auriculata*, *Kydia calycina*, *Morus alba*, *Pithecellobium dulce*, *Pongamia pinnata*, *Ziziphus mauritiana*, *Ailanthus excelsa*, *Cordia dichotoma*, *Artocarpus integrifolia*, *Hardwickia binata*, etc., are often lopped for feeding to the livestock during fodder scarcity. Of these trees *Albizia amara*, *Hardwickia binata*, *Kydia calycina*, *Morus alba*, *Pongamia pinnata*, *Ailanthus excelsa*, *Cordia dichotoma*, *Artocarpus* sp., *Ficus* sp., etc., were identified as useful for planting wastelands and road sides. These trees, besides providing nutritious green leaf forage, give good amount of fuel wood after 5-10 years in rotation. To meet the urgent and acute need of forage during lean period the following very-short-rotation species with great potential for forage production were tried at the Indian Grassland and Fodder Research Institute, Jhansi.

Many plant forms of *Leucaena leucocephala* (*koo-babool*) suitable for cultivation as forage bush or tree were identified. The plant yielded more than 30 tonnes of dry matter/ha/year in 7 cuttings. Its nutritive value was (in per cent): crude protein, 21-32; total digestible nutrients, 22; crude fibre, 14-25; calcium, 2.7; and phosphorus, 0.17. It was highly palatable and had more than 35 per cent of dry matter. With proper management in grasslands, it could provide two-tier grazing with balanced feeding of animals. Seeds were available during December and June in bulk quantity. The propagation takes place by seeds. In addition, the plants yield quality gum which will give additional income to the farmers.
Sesbania grandiflora leaves have more than 33 per cent crude protein, 2.33 per cent calcium, 0.34 per cent phosphorus and 9,000 IU of vitamin A. Fast growth enables it to establish quickly. Due to high protein and vitamin A contents it is valued highly as a forage crop. The forage production is quite high with good regeneration. This plant can be taken up with crops as a component of agro-forestry.

Sesbania sesban, commonly known as sevari, is widely cultivated along the field bunds as hedge or windbreak in many parts of this country. It grows very fast, seeds twice in a year, gives heavy branching, is easy to establish, has good regeneration and has high forage yield with more than 20 per cent crude protein in the leaves. Its seeds yield gum. The plant can also find a place in agro-forestry.

When intercropped Sesbania grandiflora and Sesbania sesban have beneficial effect on the wheat crop.

Desmanthes virgatus is an under-shrub with many a properties and high nutritive value. The protein-rich forage can be harvested at very frequent intervals because of its better and quick field establishment. It can be grown mixed with grasses for higher and nutritive forage yields.

**POULTRY**

**Breeding**

Research was continued to evolve strains of poultry for increased egg and meat production under the All-India Co-ordinated Research Project on Poultry.

Fourteen White Leghorn strains were being utilized for research on poultry for eggs. During the period, evaluation, selection and regeneration of pure-bred strains and evaluation of their performance in cross combinations constituted the main features of the investigation. Selection was practised for the single-trait egg production up to 280 days of age utilizing a family index.

Studies on different strains of pure-bred birds indicated that selection on the basis of family index was very effective in bringing about improvement in part record egg production in all the strains studied. The response however varied from strain to strain. In some strains response was considerably more than what could have been expected on the basis of known genetic theory, thus implying that a part of the response was due to better environment provided during the course of selection.
Average age at first egg also consistently declined in all the strains as a correlated response to selection for increased egg production. Maximum amount of correlated response was observed for age at first egg when compared with other correlated traits. In some strains improvement for age at first egg was as much as 30 days. Egg weight at 40 weeks of age behaved erratically during selection.

Most of the strains under test were capable of laying more than 200 eggs within 500 days of age. Body weight at 40 weeks of age had increased concomitantly due to selection for increased egg production thus suggesting a positive correlation between the two traits. It was however inferred that there was need for standardizing environmental conditions such as feeding practices, managerial conditions and disease-control measures for fullest exploitation of the genetic potentialities of the strains under study. The average egg production in 1976-77 for the different strains for 280 days was 81.0, the egg weight being 53.3 g and the age at first egg being 163 days. The age at first egg was much less than the figures 190.5 and 184.5 days for 1974-75 and 1975-76. The average fertility and hatchability for the different strains were 82.6 and 76.9 per cent respectively. The low hatchability of some strains could be improved by optimum hatchery management and sanitation practices.

Test crosses were carried out at all the centres during the period. A significant feature of the test-cross data was that several single crosses were identified which had more than 220 eggs up to 500 days of age. These cross combinations were further being tested under the random sample test.

Significant improvement was also made in all the 11 broiler strains available under the All-India Co-ordinated Project for Research on Poultry for Meat. These included 4 strains of Rocks, 5 of Cornish and 2 of New Hampshire.

Under this Project two more centres, one in Sikkim and the other in Akola, and one sub-centre at the Punjab Agricultural University, Ludhiana, were established during the year. Evaluation, selection and regeneration of pure-bred broiler strains, evaluation of their performance in cross combinations, testing of promising crosses at the random sample test and studies on the economics of broiler production constituted the major objectives of this Project. Comparative performance of the various broiler strains with regard to broiler and reproduction traits were studied.
for different generations of the birds and compared with the previous data on performance. Selection was continued for high eight-week body weight in all the strains and other traits such as feed efficiency, viability, dressed weight performance and the reproduction traits like egg production, fertility and hatchability. Response to selection for eight-week body weight was slow but steady for the strains IR 3, IR 4, IC 5 and IH. In the other strains the results were uniform.

For the evaluation of test crosses, crossing was carried out involving IC 1, IC 2, IC 3, IR 1, and IH 1 strains at the Madras Centre, and IR 2, IR 3, IC 2 and IC 3 strains at the IVRI Centre. At the Madras Centre Cornish strains performed better as male line and Rock or Hampshire strains as female line, although cross between IR 1 as male line and IC 3 as female line exceeded the other combinations both for eight- and ten-week body weight. The feed efficiency was better when IC 3 was used as male line (2.42) than when IC 2 (2.89) was used. The average feed efficiency when IC 1, IR 1 and IH 1 were used as male lines were 2.67, 2.45 and 2.85 respectively. General and specific combining ability effects as well as reciprocal effects were significant on analysis of variance. It was therefore concluded that besides additive genetic effects, non-additive genetic effects and also maternal and sex-linked effects were important in the inheritance of growth rate.

Test crosses at the Indian Veterinary Research Institute were carried out utilizing two Cornish strains (IC 2 and IC 3) as male line and two Rock strains as female line (IR 2 and IR 3). Although appreciable differences were not observed for per cent fertility in the four-cross combinations studied, hatchability on the basis of fertile eggs set was superior for IC 2 x IR 2 cross (73.7\%) followed by that for IC 3 x IR 2 (66.4\%), IC 2 x IR 3 (58.1\%) and IC 3 x IR 2 (53.7\%). Body weight and feed efficiency both up to 8 and 10 weeks of age were better when IC 3 was used as male line than when IC 2 was used. Among the Rock strains IR 3 performed better at eight weeks and IR 2 at ten weeks. The differences among the Rock strain, however, were not significantly different from each other within the male lines. Per cent viability was also slightly more when IC 3 was used as male line than when IC 2 was used. No appreciable differences were observed among the cross combinations for dressed weight percentage.

At the Punjab Agricultural University, Ludhiana, the cross between two White Leghorn strains (PB 1 and PB 2) developed
at the University gave an annual egg production of 239 eggs per pullet. The cross of the two broiler strains attained a body weight of 1,376 g at eight weeks of age. The performance of both the egg-type and meat-type stocks compared favourably with those of imported stock. These are being put to further field tests before release.

At the Veterinary College, Ranchi, the highest rate of gain in the body weight of chicks was in the parental cross-bred stock from a commercial hybrid strain. This was followed by White Rock, White Cornish, New Hampshire, Black Australorp and White Leghorn. The effect of sex on the growth rate was highly significant in White Cornish, White Rock and parental broiler stock.

Another study showed that the dressing percentage increased with the increase in the body weight but the giblet per cent decreased progressively with subsequent growth. There was a highly significant correlation between live weight and dressed weight, but correlation between live weight and giblet weight was not significant.

**Nutrition and Physiology**

At the Punjab Agricultural University, Ludhiana, studies indicated that the protein requirements of different categories of chickens were higher in summer than in winter when expressed as percentage of the rations. The food consumption was about 20 per cent less in summer than in winter indicating proportionate increase in the requirement of all other nutrients except energy. Findings suggest that the year-round seasons in India except coastal areas can be grouped into winter (October to March), and dry and humid hot (April to September) months from practical feed formulation point of view.

At Hyderabad in studies on protein and energy ratio in poultry rations, the diets containing 24 per cent protein produced higher weight gains in summer than in winter, whereas there was no difference in winter in weight gains of chicks fed either 22 or 24 per cent protein diets. Thus a lower level of protein appeared to be adequate for the optimum performance of chicks in winter than in summer. Secondly the low energy concentration (2,250 and 2,340 ME Kcal/kg) of diets produced significantly better weight gains in summer than high energy levels (2,520 and 2,430 ME Kcal/kg), whereas there were no significant differences in
weight gains of chicks fed different energy levels in winter. High growth rate of chicks in summer was recorded in groups fed 24 per cent protein diets with energy levels ranging from 2,250 to 2,520 ME Kcal/kg with C/P ratios 94:1, 98:2, 101:2 and 105:1 respectively. On the other hand diets containing a C/P ratio of 126:1 or below proved economical in winter.

In summer the feed efficiency was best with diets containing 24 per cent protein having C/P ratios ranging from 94:1 to 105:1, but in winter the dietary protein levels of 20, 22 and 24 per cent with C/P ratios ranging from 94:1 to 126:1 were beneficial.

The efficiency of protein utilization was better with 18 and 22 per cent dietary protein levels in summer and winter seasons respectively.

Irrespective of protein content in the diet, the efficiency of energy utilization was maximum with diets containing 2,430 ME Kcal/kg during both summer and winter.

At the Veterinary College, Madras, studies were aimed at developing high-producing strains of chicken on the basis of serum-alkaline-phosphatase activity mainly through (i) spotting out high-producing birds at an early age, and (ii) selective breeding for high-producing ability with high level of serum-alkaline-phosphatase activity. In these studies birds having high plasma-alkaline-phosphatase activity were produced. These birds matured earlier than the low level group, and egg production ranged from 200 to 215 eggs. These birds can be used for strain-cross experiments to produce hybrids.

At the Veterinary College, Ranchi, it was observed that karanjia-cakes, available in large quantities throughout the country, could not be included in the poultry ration as such but could safely be included after deoiling up to a significantly high level, replacing other conventional costly oilcakes like groundnut or til-cake.

Studies were carried out at the Konkan Krishi Vidyapeeth, Dapoli, on the effect of different energy levels and two housing systems on broiler growth. The weight gain during nine weeks was significantly high when high-energy diet was provided. It was also significantly high in cage-housing system than in deep-litter system. A combination of high-energy feed and cage-housing system was therefore recommended.
At the Veterinary College, Madras, studies indicated that 10 per cent of the maize in a commercial feed could be replaced by gobar-gas slurry, reducing the cost by 10 paise per kg. Besides this, agricultural wastes like brewery waste, dried grains, spent tea dust can also be incorporated in poultry feed.

At the Punjab Agricultural University, Ludhiana, studies indicated that clusterbean-meal or the decorticated cottonseed-cake could replace 50 per cent of groundnut-cake in the ration of layers and growers. This was adopted on a large scale by poultry farmers in the State.

Health

Research on poultry coccidiosis was continued at the Punjab Agricultural University, Ludhiana. During the year under report activity of ten anticoccidial compounds were evaluated against different levels of infection with *Eimeria tenella, E. necatrix* and *E. acervulina*, and the effect of medication on the development of immunity studied. All the ten compounds were tested at different levels (5,000, 20,000 and 100,000 per chick) of the first two coccidia. For *E. acervulina*, only six drugs were tested at 500,000 oocysts/chick level. The criteria kept in view for evaluating the resultant immunity were growth rate, mortality, lesion score and total oocyst production. Six compounds, viz. Pancoxin, Amprol Plus, Bifuran, Clopidol, Nicarbazin and Embazin, fully protected chicks against mortality due to *E. tenella*, whereas control chicks suffered 10 to 80 per cent mortality. The drugs were almost 100 per cent effective in preventing weight loss due to lower levels of infection (5,000 and 20,000 oocysts), but the protective effect decreased against the higher level of infection (100,000 oocysts). Similarly against *E. necatrix* prophylactic medication of Pancoxin, Amprol Plus, Coyden, Nicarbazin, Embazin and Bifuran fully protected chicks against mortality when given in feed as a prophylactic. Used therapeutically, i.e. medication started 96 hours after infection, the most effective drug was Pancoxin. Coyden when given with feed against *E. acervulina* was superior to other drugs in suppressing infection with 500,000 oocysts.

At present Marek's disease vaccine is being imported. To save the foreign exchange and stop dependence on the import, MD vaccine using a standard seed virus (FC 126) was prepared at the Indian Veterinary Research Institute. About
20,000 doses of the vaccine prepared when tested in the laboratory and the field gave quite good results.

For protection against Marek’s disease the following immuno-prophylactic agents were tried: HVT vaccine; killed *M. gallisepticum*; thymosin, a hormone from calf thymus (prepared at the Indian Veterinary Research Institute); Issatin, an antiviral drug; and gluteraldehyde-treated MD antigen (from feather follicles). Of these, HVT and killed *M. gallisepticum* vaccines gave almost equally good protection against MD. Killed *M. gallisepticum*, if found satisfactory, can possibly cut down the cost of vaccine production, storage and transport, and foreign exchange. It may also prove good for control of the disease in an outbreak.

At the Punjab Agricultural University, a scheme on the study of epidemiology, pathology and control of reproductive disorders in poultry terminated during the year. A total of 6,891 birds were necropsied. Over 300 birds within 20 weeks of age had reproductive disorders, comprising oophoritis, floating yolk, with discoloured ova and several other conditions. The histopathological examination revealed acute, subacute and chronic inflammatory changes in ovaries. The oviduct had gross lesions of salpingitis, impaction of oviduct, egg peritonitis, etc., with varying degrees of inflammatory changes. Histopathological examination carried out in 334 tumors revealed Marek’s disease. The studies revealed inflammatory conditions of ovaries and oviduct to be commonly prevalent and to be caused by bacteria and *Mycoplasma*. The majority of the bacteria isolated were resistant to antibiotics commonly used in poultry indicating that indiscriminate use of antibiotics in poultry should be avoided.

At the University of Agricultural Sciences, Bangalore, further studies on MD were undertaken and a technique of directly adapting the field isolate to fibroblast cultures was evolved. Further work was done on the serology of the disease, and the distribution of precipitating antigen in various portions of the feather follicles was determined by immuno-diffusion test. The concentration of this antigen was more at the superior umbilicus. Immuno-peroxidase test was extended to detect viral-specific antigens in tissue sections, tissue homogenates and stained sections. The serological survey carried out under the scheme showed higher incidence of MD in White Leghorn breeds followed by that in White Rock. *Desi* birds showed a low inci-
idence of the disease. A systematic pathogenicity study in controlled experimental models was taken up. The viral antigen appeared first in blood, then in spleen after 7 days and in the other organs after 15 days. Muscle and brain tissues exhibited the antigen after 35 days. MD antibody was demonstrated in the serum after 15 days and MD antigen in the feather follicle after 21 days.

At Pantnagar, sero-epidemiologic survey for MD was carried out on 29 farms. Out of the 1,420 sera tested 571 (40.2 percent) were positive. The percentage of positive birds were: broilers, 32.7; growers, 51.9; and layers, 44.5. In addition, some of the wild birds and snakes caught near the University Poultry Farm were tested for the presence of MD antibodies using feather-follicle antigen. Out of the 44 sera samples from different animals 2 from pigeons were positive, the total pigeons tested being 6. At this Centre, passive haemagglutination test was standardized using tannic-acid-treated sheep red blood cells sensitized with antigen prepared from infected chick embryo fibroblast cells. In another experiment the effect of cortisone on the development of MD was studied. The chicks were administered hydrocortisone acetate inoculated with blood from birds infected with MD. The results were evaluated in respect of body weight. Cortisone prevented the development of antibodies, probably because of its influence in the development of bursa of fabricius and spleen.

At the Punjab Agricultural University, Ludhiana, 6,891 necropsies were performed. The district-wise and breed-wise incidence of MD was recorded.

An experiment conducted under laboratory conditions showed that the tender and dry feathers remain infective when kept at room temperature for eight weeks. A total of 49 samples (kidneys) from domestic fowl with gross lesions of MD were examined for the presence of the virus. In 21 samples examined by the yolk-sac method, only 3 gave pock lesions on CAM, whereas out of the 28 samples examined by direct fluorescent-antibody technique (FAT), eight gave positive fluorescence for MD. Sixty-four wild birds were examined for the virus isolation on the basis of pock lesions on CAM, cytopathology in cell-culture and direct fluorescent-antibody technique; four wild birds appeared to be carriers of the MD virus.

At the U.P. College of Veterinary Science and Animal Husbandry, Mathura, studies on epidemiological and diagnostic aspects of MD were carried out using pathomorphological and
serological studies, by isolating of viral agents, and by conducting immuno-fluorescent transmission experiments. Government and private poultry farms in some parts of Uttar Pradesh were covered by these studies. Pathomorphological studies were conducted with materials of 218 birds out of the 3,769 dead birds autopsied. MD lesions were found in 24 broilers and 116 WLH birds. Gross and microscopic lesions of MD in different organs were described, and the organotrophic pattern of lesions in different age groups of broilers and White Leghorn birds were presented. Out of the 840 serum samples tested by AGPT, the MD precipitins were present in 462 (55 per cent) sera samples indicating a wide exposure of MD virus infection. The occurrence of MD precipitinogen in FFE was more frequent in birds having MD lesions than in those showing MD precipitins in their sera. This indicated a better correlation of MD precipitinogen to MD lesions. Viral agents producing cytopathic effects characteristic of MDV were isolated from MD-affected birds. Experimental studies revealed the role of carrier birds in the wide dissemination of MD infection. Efforts for the application of FAT were being made. Studies with serum iodine agglutination test were done.

4. FISHERIES

INLAND FISHERIES

Aquaculture and fish seed production.—Sustained high yields were obtained at different centres of composite fish culture this year also. At the Gauhati centre, where the soil is acidic, the rate of production went up to 6,537 kg/ha/12 months, whereas at the Kargaral centre it was 6,267 kg/ha/8 months and 7,859 kg/ha/12 months. At the Pune centre, production was 5,446 kg/ha/8 months. The significance of the magnitude of production achieved becomes obvious when compared with the average Indian production of 600 kg/ha/year under traditional fish-culture methods. Experiments were conducted at Jaunpur centre to show the contribution of supplementary feed and fertilizers in increasing production in composite culture. With feed and fertilizers the rate of gross production per hectare per year ranged from 5,100 to 5,886 kg when compared with 3,612 to 4,330 kg with only supplementary feeding, 1,680 to 2,745 kg with fertilizers alone and 1,422 kg when no feed or fertilizers were utilized. This showed clearly the magnitude of increase of rate of production with supplementary feeding. Experiments in composite fish culture and fish-seed production at the Govind Ballabh Pant
University of Agriculture and Technology were successful. The produce was supplied to the State Government. Culture of the freshwater prawn, *Macrobrachium malcolmsonii*, with rohu, catla, mrigal, silver carp and common carp in composite fish culture showed encouraging results at Badampudi centre in Andhra Pradesh. West Bengal got excellent results of composite fish culture in the state farms. If composite fish culture is similarly initiated, other states can also get the same degree of success.

Studies on the enhancement of genadal maturation of *Lates calcarifer* at the University College of Medicine, University of Calcutta, had brought out the histomorphology of the male and female gonads in relation to its age and growth. This would serve as a sound basis for further experimental work which would be of relevance to the culture of this fish. A fairly comprehensive survey of parasites and diseases of the carp *Cyprinus carpio*, being cultivated in West Bengal, was concluded in the Department of Zoology, Calcutta University. Intensive studies on the role of minerals and vitamins in the nutrition of some of the economic species of culture fishes were continued in the Department of Zoology, University of Rajasthan. The results obtained have far-reaching implications in aquaculture operations.

Breeding of exotic carps was successfully carried out at Kalyani, Karnal, Jaunpur, Bhavanisagar, Poona, Badampudi, Ranchi and Kausalyaganga centres of the All-India Co-ordinated Research Project on Composite Fish Culture and Fish Seed Production. Grass carp was bred for the first time in Ranchi Centre. Another important achievement was at Gauhati where 11 sets of rohu were bred twice in the monsoon at an interval of about 3 months when they were injected again with pituitary extract. *Puntius gonionotus*, imported four years ago from Indonesia, was bred successfully at Kalyani centre.

Experiments carried out at the Fisheries College, Mangalore, definitely established the possibility of inducing breeding in major carps using the pituitary extract of the marine catfish, *Tachysurus* sp.

The Fisheries Faculty of the Konkan Krishi Vidyapeeth developed various models of fish egg incubators superior to the traditional practice of incubating fish eggs in cloth hapas. These incubators were extremely efficient in field operations and were supplied to various state fisheries departments.
Catfish in composite fish culture.—As an additional component in composite fish culture, the catfish *Clarias* brought maximum gain in biomass when compared with carps, despite its sufficiently high stocking density and half the culture period of the operation.

<table>
<thead>
<tr>
<th>Species of fish</th>
<th>Initial biomass (kg/ha)</th>
<th>Final biomass (kg/ha)</th>
<th>Growing period (days)</th>
<th>% of mortality</th>
<th>Gain in biomass (kg/ha)</th>
<th>% of total gain</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Catla catla</em></td>
<td>14.7</td>
<td>693</td>
<td>257</td>
<td>13.54</td>
<td>678.3</td>
<td>22.8</td>
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<tr>
<td><em>Labeo rohita</em></td>
<td>8.8</td>
<td>622</td>
<td>252</td>
<td>6.25</td>
<td>613.2</td>
<td>20.62</td>
</tr>
<tr>
<td><em>Cirrhina mrigala</em></td>
<td>2.3</td>
<td>227</td>
<td>257</td>
<td>2.09</td>
<td>224.7</td>
<td>7.55</td>
</tr>
<tr>
<td><em>Hypophthalmichthys molitrix</em></td>
<td>0.9</td>
<td>188</td>
<td>240</td>
<td>43.75*</td>
<td>187.1</td>
<td>6.30</td>
</tr>
<tr>
<td><em>Ctenopharyngodon idella</em></td>
<td>3.1</td>
<td>245</td>
<td>240</td>
<td>31.25*</td>
<td>241.9</td>
<td>8.13</td>
</tr>
<tr>
<td><em>Clarias batrachus</em></td>
<td>171.0</td>
<td>1200</td>
<td>134</td>
<td>25.00</td>
<td>1029.0</td>
<td>34.6</td>
</tr>
</tbody>
</table>

*High rate of mortality is due to periodic pilferage by the pond owner.

Canal breeding.—The major carps generally breed in running waters in rivers during monsoon months. Their breeding in captivity in ponds was made feasible by hypophysation technique. The dry and wet bundhs are also known as good sources for carp seed production, particularly in West Bengal and Madhya Pradesh. The velocity of water current in bundh breeding is largely dependent on the gradient of the inlet, the topography and expanse of the catchment area and also on the incidence of rainfall. Recently, spawning of the Indian major carp was successfully achieved for the first time by the Riverine and Laccustrine Fisheries Division of the Central Inland Fisheries Research Institute in the plains in a shallow depression, by flooding it from an irrigation canal. The canal water was rushed by gravity. This led to establishing a new technique termed canal breeding technique.

A shallow grassy depression (about 4–5 m wide) by the side of a distributary of Balan canal near Basehra (75 km from Allahabad) was selected for the purpose. The depression between the natural bundh of the canal and the field was converted into a rectangular pool by erecting suitable bundhs on the other two sides across its length. The main flow of the canal water was diverted through this chamber having sieves guarding the inlet and the outlet of the same. The depth of the water in the pool was maintained at 30 to 120 cm. In the evening of 30 July 1977 at about 18.00 hours two sets of *Cirrhinus mrigala* (2♀+4 ♂) and one set of *Ctenopharyngodon idella* (1♀+2 ♂)
were introduced into the chamber. It was a rainy day and the
pool water temperature was 26°C. Only one set of mrigal bred
while partial spawning of grass carp was noticed within an hour
of their release into the breeding pool. Canal breeding technique
opens up a new avenue for boosting quality fish seed production
in the country with a vast network of irrigation canals.

Mass culture of fish food organisms.—For enhanced fish pro-
duction an adequate supply of fish food organisms is essential.
Both phyto- and zooplankters form the chief food of many fresh-
and brackishwater cultivated fishes.

*Pinnularia gibba*, a freshwater diatom, was successfully cultur-
ed in laboratory and yard. The technique employed included
the use of urea, single superphosphate and sodium silicate in the
ratio of 100:10:5 as nutrients in the medium @ 385 ppm.
Pure culture of *Pinnularia gibba* maintained on agar plates and
slants in the laboratory was used to inoculate the nutrient medium
@ 48,524 cells/ml, which resulted in a cell density of 1.3
million/ml in 10 days.

*Daphnia lumholtzi* was mass cultured successfully in labora-
tory conditions, providing different feeds such as dried brewer's
yeast and freshly cultured unicellular alga *(Chlorella vulgaris)*.
The propagation and growth of *D. lumholtzi* were remarkably
high in 0.1 per cent uniform suspension of dried brewer's yeast.
The density of *D. lumholtzi* could be increased to 12,650 organ-
isms per litre from an initial inoculum of 10 organisms within
a culture period of 7 days, leading to possibilities of its large-
scale production in field conditions.

The sun-dried eggs of the brine shrimp, *Artemia* sp., a prime
requirement for successful prawn culture operations, are being
imported at considerable cost. To overcome this constraint and
obtain sustained culture of the species, laboratory and yard
experiments were in progress at this Institute. During initial
experiments in the laboratory, both the reproductive phases, viz.
viviparous and oviparous, were noticed in the life-history of the
same individual of *Artemia*. Each female bred 4-5 times in
batches producing 500 nauplii in 15 days. The optimum salinity
and temperature of the ambient water for successful hatching of
*Artemia* eggs were 45 ppt and 26°±2°C respectively. Eggs
collected from subsequent reproduction were sun-dried and pre-
served for future use. These sun-dried eggs when culturéd
showed highly promising results, thereby pin-pointing the tremendous possibilities of attaining self-sufficiency in the procurement of *Artemia* eggs, without involving any foreign exchange.

The Fisheries Faculty of the Konkan Krishi Vidyapeeth succeeded in isolating and making pure cultures of 12 species of marine and 3 species of freshwater phytoplankters which constitute natural food of fishes.

*Makhana-cum-fish culture.*—An experiment was taken up at Gunsar Experiment Fish Farm, Darbhanga, Bihar, by the Darbhanga Research Centre of the All-India Co-ordinated Research Project on Air-breathing Fish Culture to demonstrate the feasibility of exploiting makhana ponds for culturing air-breathing fishes like singhi, magur and koi which not only by nature flourish under such adverse ecosystem but are also highly valued for their nutritional and therapeutic qualities. The 0.04 ha pond was stocked with singhi, magur and koi (average weight 9, 10 and 12 g respectively) @0.1 million/ha in the ratio of 7.3 : 2.4 : 0.3, and 55 seedlings of makhana were planted. Fish stock was fed with *choora* husk. The gross and net productions of fish obtained after completely dewatering the pond were 2,250 and 1,200 kg/ha/10½ months, respectively, with a survival rate of 61.0, 52.4 and 33.0 per cent in respect of singhi, magur and koi.

*Aquatic weeds as pond manure.*—*In situ* killing of aquatic weeds by herbicides in fish pond and allowing them to decompose enriches the nutrient status of the pond ecosystem chemically and biologically, and leads to enhanced fish production. Decomposing aquatic weeds also support a rich bottom fauna and gives rise to a population of periphyton useful for browsing on by carps. In a recent field trial in a 0.25- ha pond stocked with common carp, catla, rohu, silver carp and mrigal (1 : 3 : 3 : 1 : 2) @ 6,000 fingerlings/ha, an estimated production of 1,700 kg/ha (against an Indian average of 600 kg/ha/year) was obtained in 10 months when about 9,000 kg of weeds, mostly *Pistia* sp. and *water hyacinth* (*Eichhornia* sp.), were allowed to decompose. No other measures such as conventional fertilization of pond and supplementary feeding of fish were adopted, thus reducing the cost of inputs in fish-culture operation and bringing it well within the means of the poor fish farmers.

*Rural aquaculture project.*—Under the IDRC-assisted project on rural aquaculture, being carried out in selected villages in West Bengal and Orissa, substantial quantities of table-size fish and fish seed were produced. Besides passing on the benefits to
the farmers themselves in whose ponds the work was done, a short training course was also organized for the workers of the Socio-economic Development Project in Keorapukur, West Bengal. There is a possibility of cultivating some of the air-breathing fishes along with Indian major carps, thereby making better utilization of the food riches of the pond ecosystem and thus increasing the overall per hectare production.

*Brackishwater fish culture.*—Productions of about 1,000 kg of *Penaeus monodon*/ha/year in two or three crops in monoculture and of 2,670 kg of prawns and mullets/ha/year in polyculture, having 670 kg of *P. monodon* and 300 kg of *P. indicus* (white prawn), were obtained at the Brackishwater Fish Farm of the Central Inland Fisheries Research Institute at Kakdwip. This established the technical and economic viability of prawn and fish culture. Based on this the West Bengal Government initiated prawn culture in a 10-ha area in Lower Sunderbans with encouraging results.

*Reservoir fisheries.*—Detailed observations on ecology in respect of physico-chemical features of water and soil, plankton, benthos, fish biology as well as various aspects of stock structure in relation to fishing effort were continued in Bhavanisagar (Tamil Nadu), Nagarjunasagar (Andhra Pradesh), Kangsabati (West Bengal), Getalsud (Bihar), Rihand (Uttar Pradesh), Ukai (Gujarat) and Govindsagar (Himachal Pradesh) under the auspices of an all-India co-ordinated research project.

The soundness of ecology-based management principles adopted for Bhavanisagar is reflected by the continuing high yield, the estimated annual yield for 1977 being 284 tonnes, i.e., 77 kg/ha for the same effort (25 units) as in 1976. Enhanced fishing effort also brought in changes in the stock structure of large catfish populations. Intensive cropping favoured the productivity of *Wallago attu* as reflected by the yield, which rose from 11 tonnes in 1971 to 28.4 tonnes in 1977. The increase in the productivity in *W. attu* brought a corresponding decline in productivity of *Mystus aor* indicating interpopulation competition. This observation is of great importance in stock manipulation of *M. aor* and *W. attu* using cropping intensity as a tool.

Studies in 1977 in Nagarjunasagar confirmed the earlier observation that there is hardly any natural breeding or recruitment of Gangetic major carps. The annual fish yield from the reservoir was estimated at 132 tonnes and was dominated by catfish.
Increase in mesh bar (from 65 to 200 mm) and in fishing effort (taking 1973 as base) led to remarkable increase in fish yield in 1977, i.e., 673 tonnes. This was equivalent to 61.5 kg/ha. The yield rose from 21.6 kg in 1974 to 61.5 kg in 1977. The Gangetic major carps alone formed 55 per cent. The common carp formed as much as 16.5 per cent, i.e., 113.7 tonnes. Sustained large-scale stocking firmly established common carp in Govindsagar and the remarkable yield of this fish from 1976 onwards is attributed to the enlargement of mesh size and enhanced fishing effort. There are strong indications of natural breeding of silver carp *H. molitrix*, 47 adult fish of which had escaped into the Govindsagar reservoir in 1971 due to a breach in the pond where they were kept. While the recent recoveries weighed between 4 and 6 kg, young ones weighing less than 250 kg were captured for the first time in October 1977, indicating successful breeding and recruitment. This is the first known case of natural breeding of silver carp in reservoir in India. Large-scale breeding of Gangetic major carps was observed in Lunkhar Khad in the lentic zone of the reservoir.

**Frog culture.**—The possibility of breeding the frog *Rana hexadactyla* in captivity by providing simulated natural environment was demonstrated. Similarly, 80-90 per cent metamorphosed early frogs could be raised in yard experiments by feeding them with *Hydrilla* and *Lemna*.

Besides making a survey of the availability of tadpoles of the different species in and around Hyderabad, the water-quality requirements for the tadpoles of *Rana tigrina* alone with other relevant information relating to its culture were ascertained under an *ad hoc* scheme functioning in the New Science College, Hyderabad.

**Extension, education and training.**—Composite fish culture was taken up in one 0.45-ha pond of the Indian Veterinary Research Institute, Izatnagar, stocked with 6-species combination. The pond was not fertilized and fishes were not artificially fed but the pond was connected by a drain through which washings from the cattle shed were allowed to flow into the ponds. A total of 1,759.85 kg of fishes were harvested in 11 months, though the survival was only 43.96 per cent.

The trainees of Trainers' Training Centre and Krishi Vigyan Kendras were imparted practical training in various aspects of fish culture, including nursery management and breeding of Chinese carps, and they actively participated in breeding these fishes.
Lectures on composite fish culture and fish-seed production were arranged for trainees of Senior and Junior Statisticians’ course from the Institute of Agricultural Research Statistics, New Delhi, Rural Bank Managers of United Commercial Bank, trainees from the Staff Training Institute, Madras, Agricultural Research Service Probationers, Block Development Officers, Zoology Summer Institute participants, and graduate and post-graduate students of different universities at different centres.

To intensify research and training, a Freshwater Aquaculture Research and Training Centre was established at Dhauli near Bhubaneswar in Orissa. Necessary infrastructure facilities like experimental ponds and laboratories are being built up.

MARINE FISHERIES

Marine resources survey and assessment.—The Central Marine Fisheries Research Institute continued the routine assessment of marine fishery resources and maintenance of relevant information for the benefit of the fishing industry. There was a slight decline in the total marine fish landing for the year 1977. As against 1.35 million tonnes of fish landed in 1976, the provisional estimate for 1977 is only 1.15 million tonnes. The scientists of the Institute participated actively in the marine fishery survey programmes and collaborated in the Indo-Polish Fishery Survey carried out along the north-west coast of India.

Mariculture.—The Institute made further progress in improving the techniques of culturing marine fishes, prawns, lobsters, molluscs and seaweeds. Without much complicated management procedures, culture of mullets and milkfish with a production rate of 857.5 kg/ha/annum was made possible on a demonstration basis. Eight of the commercially important prawns were successfully reared from egg to marketable size under controlled conditions. Through intensive culture on scientific lines, it was possible to raise some of these species at the rate of 1,000 to 1,500 kg/ha/annum.

A new system of rearing prawn larvae was developed at Narakkal, using plastic pools of 1.8-m diameter and illuminated with fluorescent tube-lights. The prawn larvae and food organisms were cultured together in seawater fertilized with nitrates, phosphates and silicates. The tube-lights provided the necessary light energy for photosynthesis.
At Narakkal, *Chanos* stocked with prawns at 3,000 fingerlings/ha grew rapidly, without any artificial food, from 45 to 330 mm in about 3½ months and yielded 435 kg/ha with a survival rate of 60–70 per cent.

For the first time, the prawn *Penaeus semisulcatus* spawned under controlled conditions in the field laboratory at Kovalam near Madras. The eggs were reared up to post-larval stage. The larval development was completed within 13–14 days.

Experiments conducted at the Marine Biological Station, Ratnagiri, led to partial success in the mass rearing of the prawn, *Penaeus merguiensis*. In one of the experiments with 10 females, about 0.6 million larvae were obtained. The methodology is being refined to achieve greater percentage of recovery.

In the Karappad creek near Tuticorin, experiments were conducted in the farming of edible oyster, *Crassostrea madrasensis*, with significant results. The oysters were reared in rectangular iron-framed trays with nylon-netting, serially arranged on racks made up of casuarina poles erected across the creek. These oysters, collected from natural beds when they were only 25–35 mm in length, registered faster rate of growth than those in the natural beds and within 12 months reached the marketable size of 100–110 mm in length. The mortality rate, which was as high as 25–30 per cent in natural beds, was brought down to 5 per cent in the experimental farm.

Pen culture was introduced at Mandapam and Tuticorin. The pens were simple in design, with the enclosures built up of double-layered seasoned split-bamboo screens fastened together with straps. The pens were stocked with *Chanos chanos*. The fingerlings of this species are available in good numbers in the coastal waters. This fish grew fast and attained a weight of 1 kg in a year. As the farming depends upon fry collected from littoral waters, there is a possibility of developing ancillary industries in which trained women and children can be employed for fry collection as in the Philippines, Taiwan and Indonesia. Similar pens were set up at Kovalam (near Madras) and Mulki near Mangalore.

At Vizhinjam experiments were initiated to culture anchovies in cages made of nylon-mesh reinforced with framework made of cane. Each cage could hold up to 3,000 anchovies and these were suspended from rafts in the bay. The success of this experiment would be helpful in supplying bait fishes for the tuna live-bait fisheries of Lakshadweep Islands where bait fishes are scarce.
National tagging programme.—During the year 4,186 prawns were marked and released off Cochin and 40 were recovered. Prawns were also released in the Cochin backwaters and about 2,000 prawns were tagged and released in confined waters for studying the growth rate. Catfishes were also tagged and released off Waltair for studying their growth, migration, etc.

Pollution monitoring.—The scientists of the Institute investigated the causes of fish mortality in the Chaliyar River near Calicut. The organic wastes discharged from the Movoor Rayon pulp factory into the river created high BOD during summer when the flow of water in the river was meagre. Experiments conducted on phyto-toxicity using C14 methods showed that toxicity extended down to 16 km down-stream. The effect of pollution got dissipated only during monsoon when the river flow improved.

Extension, education and training.—At Tuticorin, a six-month training course in pearl-culture was successfully completed during the year. The nine trainees mainly comprised those sponsored by the governments of Gujarat, Kerala and Tamil Nadu. The trainees were given full theoretical and operative training on all aspects of pearl-culture. All the trainees were able to produce cultured pearls by themselves and were in a position to take up the work independently in their respective states.

Another batch of 8 trainees were imparted a short-term five-week course on pearl-oyster farming and production of cultured pearls. The intensive training concluded on 23 September 1977, and the trainees expressed that they attained sufficient proficiency in pearl-culture operations.

At the Krishi Vigyan Kendra set up at Narakkal a one-month training course was given to fish-farmer trainees on the methods of mariculture of fishes, prawns and molluscs so that they could take up this work in their own fields or farms.

A Summer Institute in breeding and rearing of marine prawns was conducted at Cochin between 11 May and 9 June 1977. The Institute was attended by 16 participants sponsored by various state governments, universities and other institutions. The programme included lectures in taxonomy, biology and ecology of the cultivable species, and practical demonstration and training in the collection of spawners, their identification, transportation, and breeding and rearing of eggs and larvae. They were also familiarized with various aspects of industrialized farming.
The Institute participated in exhibitions organized by the Central Plantation Crops Research Institute at Kasargod between 27-10-1976 and 8-1-1977 in connection with the Diamond Jubilee of coconut research in India. The Institute participated in the exhibition organized on the occasion of the foundation laying of the Fresh-Water Fish Culture and Training Centre at Dhauli during January 1977.

The Central Marine Fisheries Research Institute also participated in the ‘Open House’ and fair organized by the Integrated Fisheries Project at Cochin in connection with the Silver Jubilee celebrations. These exhibitions attracted large crowds and were visited by many distinguished personalities. The Institute depicted its activities and achievements especially in the field of mariculture of fishes, prawns, molluscs and seaweeds.

To help in the assessment of fish stocks of coastal and offshore waters covering the economic zone and related environmental studies, a 32.1 m (107 ft) research vessel is being built by Messrs Garden Reach Ship-builders and Engineers Ltd., Calcutta, the keel of which was laid early in 1977.

FISHERIES TECHNOLOGY

Craft and gear technology.—The design of a 260.5-m purse-seine developed by the Central Institute of Fisheries Technology was standardized for operation from small class of vessels. This gear could be operated successfully during mackerel and sardine seasons from small boats of the size around 9.2 m (32 ft) engaged in prawn fishing without any modification or difficulty. Twin-body-trawl experiment carried out using single cable with sled showed an improvement over bulged-belly trawl in catch of both fish and prawn by 39.9 and 23.1 per cent, respectively, and better horizontal spread of the gear and lesser utilization of horsepower. Comparative studies showed that the bulged-belly trawl was efficient, with the long-wing trawl and six-seam trawl coming next in order. Technology of fishing boat construction using cheaper construction materials as well as fibreglass-reinforced plastic and ferrocement was perfected at this Institute for their extensive industrial applicability.

Corrosion in fishing boats and the consequent breakdown of materials in seawater were controlled, and suitable preventive measures worked out. Experiments carried out with ternary aluminium alloy anodes in place of conventional electrolytic zinc anodes for
hull protection gave valuable results. The protection given by the ternary aluminium anodes was adequate, but the wearing of these anodes was comparatively less than that of the zinc anodes.

Fish preservation and processing.—Solubility of skeletal muscle proteins of oil-sardines increased continuously as the ionic strength of the extracting media increased from 0.05 to 0.5. Electrophorograms of the white and red meat of tuna were noted along with those of cooked ones. The red meat contained more protein bands than the white meat which actually gave only a predominant protein band of intermediate mobility with a higher concentration. Analysis of the pearl-spot (Etroplus suratensis) under frozen storage recorded a rapid loss of constituents such as nucleotides and reducing sugars during the first week of storage; thereafter, the loss was comparatively small unlike that in marine fish.

Filleting and freezing of fish such as catfish, Kalava, bigger Jew-fish and ribbon-fish were given more attention. The yield of fillets from the whole fish was worked out. It was also shown that hand filleting of the fish including skinning could be done manually reasonably fast and the skinless and boneless fillets could be frozen and stored for sufficiently long period without affecting the quality. The process was taken up by a few industrialists who have already produced frozen fillets for internal as well as for export markets.

Studies on the preservation of less utilized shell-fish like clams, mussels and crabs showed that high-quality products conforming to international standards could be prepared from the above. These products are expected to have very promising future. Methods for canning of smoked Jew-fish and other less utilized fish, and for obtaining quality canned products were worked out. More importance was given to problems connected with the curing and dehydration of fish like mackerel, sardine and Jew-fish. Smoking of fish gives fine products with better taste and keeping quality. Attempts were made to improve the bacterial quality of cured fish by working out suitable treatments as well as by suggesting hygienic conditions to be followed in the process. Good-quality cured products from squid were also obtained. Of the different methods tried to incorporate appealing flavours in laminated Bombay-duck, dipping the product immediately after drying in a hot aqueous solution of the essence (ginger and pepper) for 5 minutes and subsequent redrying gave improved penetration of the flavour. The final product had a distinct flavour.
The University of Agricultural Sciences, Bangalore, succeeded in making highly acceptable canned products out of two species of clams and green mussel. Canning procedure for a variety of fish, crabs and cuttle-fish was provided for the industry to make use of. They also developed a process of smoke-curing of oil-sardine resulting in a product of appealing flavour and appearance.

The biology of an important acarine pest, *Lardoglyphus konoi*, of stored fish was studied at the Kerala University. The seasonal variation of its infestation and possible ways of minimizing it were found out. To ward off infestation by this mite at least 2 per cent by weight or above of salt was required to be retained within the flesh.

*Utilization of fish wastes.*—A simple method for separating protein from *Squilla*, a shell-fish caught abundantly along with prawn and which is now being thrown away, was worked out. The non-protein fractions of nitrogen contained peptones, proteases and amino acids, and could be concentrated to yield a product which can support the growth of bacteria as efficiently as the imported peptone. The shell portion yielded good-quality chitosan. A pilot plant for semi-commercial production of chitosan was set up.

Filleting of fish results in fish waste estimated to be around 60 per cent. The economics of filleting would depend on the effective utilization of the waste. From the waste 10 per cent meat could be separated by employing meat-bone separator. The remaining waste could be converted into fish-meal containing 50-55 per cent protein. Frog waste also could be utilized for making protein-rich meal.

*Trash fish utilization.*—At the Trash Fish Utilization Project Centre, Cochin, a fish protein hydrolysate in dry powder form was successfully developed employing enzymolysis and a fish flour by deodorizing the meat, drying and pulverizing, both suitable for human consumption. At the Mangalore Centre, work on the development of suitable preservatives and synthetic casings for fish sausages, and formulation of fish pickles and fish sauces was taken up. Good-quality smoked sardine flakes with a shelf-life of 8 weeks could be prepared by dry-salting the fish for 48 hours prior to smoking. A dry feed-mix containing 32.38 per cent crude protein and 6.5 per cent crude fibre was developed at the Madras Centre by incorporating one-third the weight of rice-bran into fish ensilage prepared from silver-bellies by methods
worked out earlier. This mix at 7 and 10 per cent levels produced significantly better results than fish-meal in feeding experiments on chicks. Dry shark-flesh-cake prepared by instant salting of minced flesh, pressing and drying remained in good condition for more than a year. Urea could be removed almost completely from fresh shark fillets by leaching in water at 10°C, and a good protein concentrate prepared out of it by pressing, drying and pulverizing.

**Extension.**—In view of the proposed introduction of compulsory implant inspection of seafood-processing establishments, these were voluntarily surveyed and suggestions for improvement conveyed to them. The occurrence of very fine sand particles in commercial raw shrimp meat was detected and remedial measures suggested. A new composition of permitted phosphates was formulated for application in shrimp meat meant for freezing to prevent thaw-drip-losses in place of the one which was banned in early 1977 due to objections from foreign buyers. The proper thawing method to determine weight of prawns in a frozen prawn slab was worked out and recommended to the Export Inspection Agency for adoption in their routine pre-shipment inspection. Field trials on a large scale on the usefulness of the deodorant and antiseptic ointment formulated previously showed that they are highly acceptable to the trade.

5. **ECONOMICS AND STATISTICS**

**Agricultural Statistics**

Data from experiments conducted under the All-India Coordinated Agronomic Research Project were analysed at the Indian Agricultural Statistics Research Institute. It was found that the paddy strains ‘Vikram’ at Mangalore, ‘Pankaj’ and ‘8431’ at Maruteru, ‘RPW-6-17’ at Nandyal and ‘Mahsuri’ at Bhubaneswar gave high yields ranging from 30 to 70 q/ha as well as good responses to moderate levels of fertilizer application (60 kg N/ha). Responses to the micronutrients zinc, molybdenum and manganese, applied to the rice crop, generally varied from 3 to 10 q/ha.

Under dryland conditions, moderate responses to fertilizer application on groundnut were obtained on cultivators’ fields (1.5 to 3.5 q/ha).

The results of about 300 experiments during 1972-73 to 1976-77 on gram under dryland conditions indicated about 58 per
An 18 per cent possible increase in yields from 8.3 q/ha in ‘no fertilizer plots’ to 13.1 q/ha in ulots receiving (20 kg N+60 kg P₂O₅) per hectare.

In a study on the impact of new technology on labour employment in a IADP district of Bihar, it was observed that the per hectare labour employment in high-yielding varieties of paddy and wheat was 16 per cent higher as compared with the non-high-yielding varieties. Moreover, it provided regular jobs throughout the year.

In a pilot sample survey for estimation of cultivated fodder in Karnal district of Haryana, the estimates of area of berseem and jowar were 14.2 and 21.6 thousand hectares with percentage standard errors of 7.8 and 8.9, respectively. The estimated production of berseem and jowar was 1208 and 507 thousand tonnes, with percentage standard errors of 7.9 and 9.4, respectively.

A suitable methodology has been developed for:

(i) Assessing the impact of milk supply schemes on rural economy in milk collection areas, and

(ii) Estimation of availability and cost of production of milk in milk-shed areas.

These are being tested in different areas. The results will be of value in formulating a sound price policy for milk, and in drawing up of dairy development plans on efficient lines.

Under the project ‘National Index of Animal Experiments’ a Compendium based on experimental data pertaining to animal nutrition at National Dairy Research Institute, Karnal and its regional centres at Bangalore and Kalyani was prepared, covering the period 1960—70.

An integrated sample survey for the estimation of livestock products conducted in the Northern region comprising Punjab, Haryana, and Himachal Pradesh (1969-72) and in Andhra Pradesh in the Southern region (1971-74) indicated the feasibility of simultaneously estimating all the principal livestock products, viz., milk, eggs, wool and meat from a single survey. The average milk yield per cow per day was about 2.4 kg in the north and only about 0.5 kg in the south. Similar results were obtained for the other characters.

A new selection index in poultry breeding, which includes the individual’s performance for a correlated character, such as egg
weight combined with the information about rate of lay of eggs of the individual bird with those of its full-sibs and half-sibs, was developed and proved to be more efficient than the usual index.

Several new types of designs for a symmetrical factorial experiments, mixture experiments, and group-divisible incomplete block designs for use in crop as well as animal sciences were developed. In the field of sampling techniques some estimation procedures utilising incomplete auxiliary information were established.

A new powerful third generation Computer System, Burroughs-4700, was installed during the year at the Indian Agricultural Statistics Research Institute, New Delhi, for the benefit of agricultural scientists and other research workers in the country. Periodic courses in computer programming were also organised by the Computer Centre at the Institute.

**Agricultural Universities**

A study on the regional pattern of agricultural growth in Rajasthan, carried out by the University of Udaipur, revealed that the growth in crop output was different in different zones. The hypothesis that the increase in production was mainly due to increase in area did not hold true. Foodgrain production increased significantly in Kota zone. Production of cereals in the State increased at a rate of 1.7 per cent per year. There was no significant increase in the production of pulses in any zone of the State. Oilseed production in the State increased at a compound rate of 3.0 per cent. The highest growth rate was recorded in Sirohi, Chittorgarh and Jaipur zones.

Studies on the economic feasibility of wheat and its competing crops in irrigated areas of 24 Parganas, undertaken by the Bidhan Chandra Krishi Vishwa Vidyalaya, West Bengal, indicated the following findings:

(i) the large-sized farms demonstrated their superiority over the small ones in respect of productivity, cost and profitability of wheat, mainly due to scale economics;

(ii) The average yield of wheat was noted to be 24.5 q/ha.

(iii) Cash expenditures per hectare in the cultivation of wheat, boro-paddy, potato and pulses were of the order of Rs. 1770, Rs. 2280, Rs. 3150 and Rs. 460,
respectively. The corresponding net returns from these crops were of the order of Rs. 1180, Rs. 3750, Rs. 500 and Rs. 430 per hectare.

It was further observed that whereas the small farmers cultivated wheat mainly for their consumption, the large farmers cultivated boro-paddy as it promised more profit.

Studies on the marketing of potatoes carried out by the Haryana Agricultural University showed that the compound growth rates for the State as a whole, in area, production and yield rates were of the order of 4.5, 5.4 and 0.9 per cent, respectively. In another study on the estimated production potential and cost of milk production in Haryana, it was observed that the average milk yield per buffalo per day was 6.5 litres in winter, 5.0 litres in summer and 4.9 litres in the rainy season. The milk yield was also found to be dependent on the quantity of concentrate fed to the animals.

Some research studies in agricultural economics carried out by the G.B. Pant University of Agriculture and Technology revealed that:

(1) The disparities in income and expenditure of farm households are very high among the small and large operators of farms in all the regions of Uttar Pradesh. This calls for more concerted efforts and proper policy for raising the production and income on small farms.

(2) The following factors were observed to be affecting non-adoption of hybrid maize in western Uttar Pradesh:

(a) Non-availability of early maturing varieties.

(b) Delicate nature of the crop in respect of waterlogging, fertiliser deficiency and timely agronomic practices.

(c) Limited market in comparison to local varieties because of consumer preference for softness and sweet tasting local varieties.

(3) The high-yielder animals were found to be a lot more economical over the local low milk yielders in Aligarh district.
Returns from Investment in Research

Significant progress was achieved during the last decade in strengthening national agricultural research capacity in a number of developing countries including our own. Besides, increasing emphasis is now being placed on agriculture in our national development plans. In this context, the twin problems of measurement of research productivity and the determination of priorities for research resources allocation have assumed vital importance.

To develop an efficient methodology for handling the above problems, and to initiate an objective assessment of the agricultural research programmes in the country, the Indian Council of Agricultural Research constituted in January, 1973 a Special Panel for the Study of Returns on Investment in Agricultural Research under the Chairmanship of Dr. A. S. Kahlon, Dean, Punjab Agricultural University, Ludhiana.

The Panel prepared a critical review of the literature on research evaluation methodology as also on cost-benefit studies conducted in India and abroad in the field of agricultural research.

Subsequently, the ICAR sanctioned a two-year ad-hoc research project, entitled “Cost-benefit analysis of agricultural research project”, at the Punjab Agricultural University. State level data for 16 major states of India were analysed in this study by using a production function relationship between output and inputs of the double-log type, together with a linear term representing the time trend. A dummy variable was also introduced in order to allow for measurement of the shifts in returns owing to the ‘green revolution’.

The results showing the return on an investment of one rupee in research and development, using suitable time-lags ranging from 5 to 7 years, have been presented in Table 1.

Table 1. State-wise returns on investment in agricultural research and development and internal rates of return

<table>
<thead>
<tr>
<th>State</th>
<th>Time-lag (years)</th>
<th>Returns (Rs.) to one rupee invested</th>
<th>Internal rate of return(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>5</td>
<td>30.29</td>
<td>97.8</td>
</tr>
<tr>
<td>Assam</td>
<td>5</td>
<td>8.99</td>
<td>55.2</td>
</tr>
<tr>
<td>Bihar</td>
<td>5</td>
<td>17.52</td>
<td>77.3</td>
</tr>
</tbody>
</table>
The returns per rupee invested in agricultural research were the highest in Uttar Pradesh followed by Gujarat and Karnataka (Table 1). The lowest returns were obtained in Himachal Pradesh and West Bengal.

The topic was also discussed in detail at the recent Annual Conference of the Indian Society of Agricultural Economics held in New Delhi in December, 1977. Some of the important results presented at the Conference are summarised below:

H. K. Bal and A. S. Kahlon (P.A.U., Ludhiana) have formulated an analytical model for estimating the returns to investment in agricultural research and development. The special features of this model are:

(i) The effects of general trend in input use are eliminated.

(ii) The effects of investments made prior to the study period are also accounted for.

(iii) A method has been suggested to isolate the effects of agricultural research and agricultural development.

Using this model, it was estimated that the return to one rupee expenditure in agricultural research in India was Rs. 1.91 during
the period 1960-61 to 1964-65, and Rs. 14.91 during 1967-68 to 1972-73. The corresponding internal rates of return were 14.0 and 71.7 per cent.

P. Kumar, C. C. Maji and R. K. Patel (IARI, New Delhi and NDRI, Karnal) have estimated the returns on investment in the pilot cattle improvement programme of the Indo-Swiss Project in Kerala by computing the benefit-cost ratio and the external and internal rates of return. The external rate of return (93 per cent) and benefit-cost ratio (9.3) at 10 per cent discount rate are high enough to suggest that the project is economically viable. The internal rate of return was found to be about 29 per cent.

R. G. Patil and R. E. Waghmare (Mahatma Phule Krishi Vidyapeeth, Rahuri) studied the impact of research and development expenditure on sugarcane output in Maharashtra. The results indicated that the growth rates in area, production and average yield of sugarcane were not commensurate with that of research expenditure on sugarcane.

The Conference devoted considerable attention to a number of wide-ranging issues. The conclusions reached or the recommendations made concerning them are given below in brief.

Methodological issues.—Three specific areas were identified for methodological refinements and analytical rigour in the specification of models for measurement of returns from research:

(i) Determination of lags, between investment and realisation of benefits, as also the subsequent time-path of these benefits.

(ii) Identification and sorting out of the interacting influences of research, extension and education.

(iii) Evolution of techniques to account for the contribution of researches—national or international—in other regions.

It was also emphasised that when research was directed towards multiple goals, measuring the contribution purely in terms of increments in output could be misleading, e.g. in the case of research directed towards yield stabilisation.

Research expenditure data.—It was recognised that properly classified data—sectorwise (Central, Private, State), commodity-wise, regionwise, and problem-area-wise, etc. on research expenditures was a pre-requisite for any useful empirical work in this
area. The Conference recommended that the Indian Council of Agricultural Research should assume the responsibility of collecting, compiling and publishing this data series.

Efficiency and equity considerations in agricultural research.—It was suggested that ex-ante identification of institutional adjustments needed in the wake of a technological change would help reduce the inter-farm disparities. It was also important to identify and to study the implications of technologies which were not consistent with the factor endowments of the target population.

Research resources allocation.—It was stressed that, in the absence of a satisfactory formal model, economists could contribute greatly to the efficiency of research resource allocation by improving the information base relating to costs and benefits of the proposed research projects, and their likely impact on parameters like employment, income distribution, crop mix, nutrition, etc.—available to the decision makers. In order to accomplish this objective, it was essential to solicit information on expected benefits and costs in the project proposal format itself. The Conference recommended that the job of designing such a project proposal format needed immediate professional attention of the agricultural economists. In addition, at each research centre and also at the national level, there should be a cell for the analysis of this information.

Organisation of agricultural research.—Finally the contribution of different facets of organisation, like size and location of research centres, complementarity between research and teaching, etc., was also emphasised, as these factors have an important bearing on the efficiency and productivity of any research system.
V. AGRICULTURAL EDUCATION

Agricultural Universities

The Education Division of the ICAR continued to promote and co-ordinate higher agricultural education in the country mainly through the development of agricultural universities. The stress on consolidation was maintained. Only a few constituent colleges in new areas such as fisheries, agricultural engineering, home science and dairy science were established as part of agricultural universities to even out regional disparities. No new affiliated college was recognised for the ICAR assistance. The only exception was in the case of Nagaland where the Government of India and the ICAR agreed to assist in the establishment of an Agricultural College in view of the unique needs of the North-Eastern region. To meet the demand for diversified education on the one hand and for increasing specialisation on the other, a number of new educational programmes were started in areas such as agrometeorology, farm forestry, agricultural communications and ecology.

Intimate contact was maintained with agricultural universities through periodic meetings with Vice-Chancellors and through ICAR assistance for the Association of Agricultural Universities.

The Agricultural Universities Review Committee completed its visits to 18 agricultural universities. Their report is expected to be submitted by March, 1978.

The Council also assisted ten agricultural universities in implementing the Fifth Plan UGC pay scales. Keeping in view the immediate needs, agricultural universities budget for 1977-78 was increased from Rs. 8 to Rs. 9.50 crores.

Krishi Vigyan Kendras

Having worked in the areas of formal higher agricultural education and research for over two decades, the Council came to the conclusion that in an agricultural country like India where literacy percentage was below 30%, there was no alternative to the adoption of innovative non-formal education system for the spread of technology among the masses. With this aim, the establishment of Krishi Vigyan Kendras was continued during this year.
Out of the 25 Krishi Vigyan Kendras (KVK)/Teachers' Training Centres (TTC) approved for the Fifth Plan, twenty-four (18 KVKs and 6 TTCs) have already come into existence. This includes two specialised Kendras for women, one at Indore (M.P.) and the other at Jharnapani (Nagaland). All except two Kendras (Jharnapani and Raindheja) have started offering institutional and non-formal skill training to farmers, fishermen, farm women and field level extension workers based on their knowledge of the training needs. However, in order to plan relevant training programmes for the future, village farm and farm-home surveys have been undertaken to identify the felt needs for skill training.

A bulletin entitled, 'Krishi Vigyan Kendra—an Innovative Institution', has been published by the ICAR for the benefit of the trainers of KVKs/TTCs as also for others who are interested in the growth of the Kendra as an instrument to modernise the farmers' training as well as in-service training programmes.

**Fellowships and Scholarships**

The Council continued to provide Merit-cum-Means Scholarships to about 75% students admitted at recognised undergraduate colleges in the country. The ICAR Junior Fellowship of the value of Rs. 300 p.m. was awarded to 312 candidates selected through an all-India competitive examination. 125 Senior Fellowships including 25 fellowships under Teaching Faculty Improvement Scheme (value of Rs. 400 per month for first 2 years and Rs. 500 p.m. thereafter) were awarded. In adoption, the Council is operating the Science Talent Search Scholarship Scheme for higher studies in Agriculture and Allied Sciences.

**Jawaharlal Nehru Award**

Six awards of the value of Rs. 5,000 were given to six young scientists for their outstanding work at doctoral level in the fields of:

(a) Plant Breeding, (b) Agronomy, (c) Agricultural Engineering, (d) Agricultural Entomology, (e) Agricultural Economics, and (f) Animal Physiology.

**Chairs of Professors of Eminence and National Fellows**

To develop strong centres of research and education around outstanding scientists of proven competence and leadership, the ICAR sanctioned a scheme for the creation of ten chairs of
Professors of Eminence (with a fixed salary of Rs. 3,000 p.m.) and 25 chairs of National Fellows (salary to be fixed in the scale of Rs. 1500-2500 p.m.). In pursuance of this scheme, the first awards are being finalized and are likely to be announced shortly. The main objective of the scheme is to promote mission oriented research basis to applied research in some of the priority areas of national importance.

**ICAR-IBRD Project on Agricultural Research**

To strengthen the regional research capability of agricultural universities for finding solutions to location-specific problems, the ICAR undertook the preparation of an Agricultural Research Project to be implemented with the assistance from IBRD. The efforts under this project would be centred on foodgrains (cereals, pulses and oilseeds) in each agroecological zone, particular attention being paid to foodgrains grown under rainfed conditions and under mixed farming systems involving Crop-Livestock and Crop fish production systems. The main approach to this project has been finalized in consultation with the Planning Commission. Under this project, the IBRD is expected to contribute to the setting up of an agricultural research fund to be administered by the ICAR for assisting agricultural universities for strengthening regional research. The project is likely to become operative during 1978.

**ICAR/UNDP Project on Postgraduate Agricultural Education and Research**

The ICAR/UNDP Project on Postgraduate Agricultural Education and Research made satisfactory progress. The Project became fully ‘National’ in character, with the transfer of the project implementation responsibility entirely to the Project Director after the Chief Technical Advisor’s term expired in May 1977. UNDP assistance to the Agricultural Economics Centres at the IARI was resumed during the year. Thus all the six centres in Agricultural Economics (IARI), Poultry Production (IVRI), Dairy Production (NDRI), Soil and Water Management (HAU) Agricultural Engineering (PAU) and Plant Protection (UAS) remained fully functional. Exchange of scientists with some of the best institutions of higher education in the world was maintained. Fourteen scientists from six centres received advanced training abroad and fourteen scientists from the sister institutions abroad visited these centres. Besides direct participation in research and
teaching, these scientists assisted in the organization of high level workshops and seminars, thus benefitting co-professionals from different institutions in the country.

The Phase-III programme of this project was expected to start in 1979. Proposals for Phase III were prepared for seven new advanced centres viz. Agricultural Communication at G.B. Pant University of Agriculture and Technology, Pantnagar, Agricultural Microbiology at T.N.A.U., Coimbatore, Plant Physiology at IARI, New Delhi, Marine culture at CMFRI, Cochin. Tropical Horticulture at IIHR in collaboration with UAS, Bangalore, Temperate Horticulture of the H.P. University, Solan, Dairy Technology and Dairy Engineering at the NDRI, Karnal. These were currently under review by a UNESCO/FAO mission after an agreement was reached in principle with the Project Director at the time of his visit to Rome and Paris in September 1977.

The UNDP contribution to this project is about (dollar) 2,500,000 up to Phase-II (1978-79) and the counterpart contribution from the Govt. of India is Rs. 70 lakhs.

**IDA Education Project**

The IDA Education Project in respect of (1) Assam Agricultural University, Jorhat (AAU), (2) Rajendra Agricultural University, Bihar (RAU), and (3) Computer Centre at the Institute of Agricultural Research and Statistics, New Delhi, completed the fourth year of its operation with a long-term loan of 12 m dollars being provided by the World Bank. The main objective of this project is to strengthen the educational components and also to bring out qualitative improvement by developing infrastructure facilities.

In the case of AAU, the progress of the civil works was in full swing. Contracts amounting to 0.26 m dollars were awarded raising the total to dollars 3.38 m during the year under report. Twelve buildings were completed, thus raising the number of completed buildings to 47, almost 27% of the total buildings provided under the project.

Eleven fellowships for various training programmes in Agriculture, Home Science and Veterinary Science were awarded, thus raising the awarded fellowships to 140.

At the RAU the progress was comparatively slow because of frequent changes in the top administration of the University. The RAU project has, however, shown much better progress lately. The construction work of 7 buildings out of 17 was undertaken
during the year. The fellowship programme for the staff development has been accelerated by awarding 18 fellowships for advanced training under various disciplines.

At the IARS, New Delhi, a new Third Generation Computer System Burroughs B-4700, was installed in March 1977. The link-age of this computer system with other research institutes and agricultural universities was under study with a view to making the maximum use of this unique facility.

**ICAR/UNICEF Project on Nutrition Education and Training**

In collaboration with the UNICEF, the Council made efforts to incorporate nutrition education as part of the curriculum in agricultural universities at the undergraduate and postgraduate levels. During this first phase of this programme, the following universities were covered. The Punjab Agricultural University, Ludhiana; G.B. Pant University of Agriculture & Technology, Pantnagar; Agricultural University, Udaipur, Andhra Pradesh Agricultural University, Hyderabad, University of Agricultural Sciences, Bangalore; Tamil Nadu Agricultural University, Coimbatore.

During the Second phase, six more Universities were included in the programme namely; Marathwada Agricultural University, Parbhani; Kerala Agricultural University, Vellayani; Konkan Krishi Vidyapeeth, Dapoli; Punjabrao Krishi Vidyapeeth, Akola; Assam Agricultural University, Jorhat; Mahatma Phule Krishi Vidyapeeth, Rahuri.

It was proposed to organise orientation course for agricultural university teachers in human nutrition.

Two teachers from the Universities of G.B.P.U. & T. Pantnagar and UAS, Bangalore were deputed to attend the International Conference on Nutrition held in Oxford during August/September, 1977. The post of Assistant Director-General (Nutrition) has also been filled up during the period. An interim proposal for the continuance of the project till 1980 was prepared and submitted to the Department of Social Welfare, the coordinating agency of UNICEF projects in India.

**Utilization of Internal Competence Scheme**

The scheme was initiated to reduce the dependence of agricultural universities on foreign advisors by providing experienced and competent scientists and educationists from more mature agricultural universities to help in the development of new agricultural
universities. In the light of ICAR's experience during Fifth Plan, the scheme was reviewed by an ICAR Committee. Necessary modifications have been made in the revised Sixth Plan Scheme in the light of the Committee's recommendations. The scheme was, however, considered very useful.

Summer Institutes

The Council organised 23 Summer Institutes during the year including 14 in Agriculture, two in Agricultural Engineering, four in Animal Sciences, one in Fisheries and two in Home Science. The scheme contributed greatly towards updating the knowledge of teachers and research workers. It is proposed to concentrate in future mainly on the organisation of Summer Institutes in the main subject matter areas so as to use the mechanism of Summer Institutes to revise the courses and produce practical manuals. Consideration is also being given to reviewing the question of honorarium to organisers at the ICAR Institutes and Agricultural Universities.

Sixth Plan Schemes

Sixth Plan proposals, starting from 1978, were prepared in consultation with the Working Group on Agricultural Education of the ICAR. The main objectives and approach of the education programmes were defined and approved. The main elements of the proposed programmes are:

(a) Improvement of quality and relevances of education,
(b) Increase in the practical training content and to introduce apprenticeship in the first degree programmes,
(c) Orientation of curricula and courses to meet the needs of agricultural development,
(d) Improvement of teaching faculties,
(e) Production of text books and teaching materials,
(f) Rural orientation of home Science education,
(g) Development of facilities for technological education,
(h) Strengthening of extension education facilities through establishment of communication centres and development of correspondence courses,
(i) Establishment of Krishi Vigyan Kendras,
(j) Incentives to attract students from rural and backward areas,
(k) Relating education planning to man-power needs.


The proposals envisage greater diversification of agricultural education and addition of new programmes in new areas like nutrition, agro-meteorology, agro-physics, population education, agro-forestry, veterinary public health and epidemiology, ecology, and food science technology, etc. The working groups particularly stressed the need for augmenting budgetary provisions during Sixth Plan period to ensure that about 15 per cent of the outlay on agriculture is directed to agricultural research and education. The group has recommended an outlay of Rs. 200 crores for agricultural education in order to speed up the development of agricultural universities and develop programmes relevant to rural development.
VI. EXTENSION EDUCATION
NATIONAL DEMONSTRATIONS

The National Demonstrations Project on major food crops continued in 50 districts in the country with the objective of demonstrating the potentialities of the new agricultural technology on farmers' fields.

Twenty-five demonstrations on multiple cropping in each selected district with two or three crops were conducted. In addition to the demonstrations under assured irrigation, some demonstrations were also conducted in moisture-deficit areas and problem soils (alkaline). The minimum yield targets for 2 or 3 foodgrain crops in the multiple cropping sequences adopted in national demonstrations remained the same, i.e. 9 and 11 tonnes/ha, respectively. In all 3,158 field days were organised which were attended by approximately 80,000 farmers during the period under report.

The number of demonstrations conducted during the last few years along with the percentage cases exceeding targetted yields as under:

<table>
<thead>
<tr>
<th>Year</th>
<th>Multiple-crop demonstrations</th>
<th>Single-crop demonstrations</th>
<th>Total</th>
<th>Percentage cases exceeding target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965-66</td>
<td>-</td>
<td>416</td>
<td>416</td>
<td>-</td>
</tr>
<tr>
<td>1966-67</td>
<td>-</td>
<td>999</td>
<td>999</td>
<td>-</td>
</tr>
<tr>
<td>1967-68</td>
<td>920</td>
<td>547</td>
<td>1467</td>
<td>55</td>
</tr>
<tr>
<td>1968-69</td>
<td>929</td>
<td>171</td>
<td>1100</td>
<td>58</td>
</tr>
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<td>1969-70</td>
<td>1256</td>
<td>457</td>
<td>1713</td>
<td>58</td>
</tr>
<tr>
<td>1970-71</td>
<td>1441</td>
<td>342</td>
<td>1783</td>
<td>57</td>
</tr>
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<td>1971-72</td>
<td>1671</td>
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<td>1901</td>
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<td>1972-73</td>
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<td>1973-74</td>
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<td>1974-75</td>
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<td>303</td>
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<td>1975-76</td>
<td>1043</td>
<td>321</td>
<td>1364</td>
<td>55</td>
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On the basis of the results obtained during 1975-76 and the experience gained therein, some of the rotations found more promising in various districts are given below:

**Crop Rotations**

**Paddy-Paddy rotation.**—Paddy-paddy rotation proved more successful in districts Chittoor, Ganjam, Hyderabad (Andhra Pradesh); Bellary, South Kanara (Karnataka); Trichur (Kerala), Chandrapur (Maharashtra), Ganjam (Orissa), Madurai (Tamil Nadu) and Pondicherry. The mean yield obtained in various states ranged from 72.84 q/ha to 137.57 q/ha. The all India mean yield was 111.96 q/ha.

![Fig. 8. National Demonstrations (1975-76): yield in bajra-wheat rotation](image)

**Paddy-wheat rotation.**—The paddy-wheat rotation was followed more successfully in districts of Hyderabad (Andhra Pradesh), Kaira (Gujarat), Ganjam (Orissa), Amaravati, (Maharashtra), Bhatinda, Ferozepur, Jullundur, Kapurthala (Punjab), Bharatpur (Rajasthan), Kanpur, Pilibhit, Meerut, Devaria, Gorakhpur, Nainital, Muzaffarnagar (Uttar Pradesh). The average yield was 97.01 q/ha. The targetted yield was exceeded in 46 per cent cases.
Fig. 9. National Demonstrations (1975-76): yield in paddy-wheat rotation
Maize-wheat rotation.—In all 127 demonstrations were conducted with maize wheat rotations in 10 States. The all India average yield was 73.29 q/ha. It was observed that this rotation was found popular in the districts of Giridih, Santhal Parganas (Bihar), Bellary (Karnataka), Chhindwara (Madhya Pradesh), Dhule, Parbani (Maharashtra), Rampur, Meerut (Uttar Pradesh). The poor yield of maize crop was responsible primarily for low yields in this rotation.

Fig. 10. National Demonstrations (1975-76) : yield in maize-wheat rotation

Fig. 11. National Demonstrations (1975-76) : yield in paddy-paddy rotation
Bajra-wheat rotation.—Eighty-four demonstrations were conducted in 8 States with this rotation. The all India average yield was 55.46 q/ha. The low yield was due to the poor performance of Bajra variety that suffer from downy mildew and ergot diseases. Only in one demonstration i.e., in Jaipur (Rajasthan), this rotation gave yield of 90 quintals per hectare. In all other districts the performance has been very poor.

Jowar-wheat rotation.—Seventy-three demonstrations were conducted in Karnataka, Madhya Pradesh and Maharashtra with this rotation. The average yield was 72.08 q/ha. This rotation was observed more successful in the districts of Dharwar (Karnataka), Yeotmal, Dhulia, and Wardha (Marhashtra).

Fig. 12. National Demonstrations (1975-76): yield in jowar-wheat rotation

Paddy-ragi rotation.—This rotation was followed in Andhra Pradesh, Karnataka, Orissa, Tamil Nadu and Pondicherry. The average yield was 81.10 q/ha.

Paddy-groundnut rotation.—In all 10 demonstrations were conducted in Andhra Pradesh, Karnataka, Maharashtra and Goa, Daman and Diu. The mean yield of groundnut pods was 20.36 q/ha and grain 53.18 q/ha.
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Groundnut-wheat rotation.—The average yield of grain was 40.95 q/ha and groundnut pods 20.77 q/ha. In all 13 demonstrations were conducted with this rotation. From Soyabean-Wheat rotation from 7 demonstrations conducted with this rotation in Uttar Pradesh, the average yield was grain 32.40 q/ha and Soyabean 24.84 q/ha.

Arhar-wheat rotation.—Eight demonstrations were conducted in Madhya Pradesh, and Uttar Pradesh. The average yield was grain 43.92 q/ha and arhar 24.94 q/ha.

Wheat-moong rotation.—Nineteen demonstrations were conducted with this rotation in Orissa, Uttar Pradesh and West Bengal. The mean yield was grain 39.87 q/ha and pulses 6.79 q/ha.

Paddy-paddy-paddy rotation.—Three crops of paddy were taken and could successfully be grown in Andhra Pradesh, Tamil Nadu and Pondicherry. The average yield recorded was 172.20 q/ha. The highest individual yield 247.25 q/ha (Andhra Pradesh).

Forty-one demonstrations were conducted with paddy-wheat-moong rotation. The average yield was grain 93.39 q/ha and pulse 76.8 q/ha. 7 demonstrations were conducted with Bajra-Wheat-Moong rotation. The average yield was grain 64.45 q/ha and pulse 10.50 q/ha.


‘IR-8’ was included in 9 states in 67 demonstrations. The mean yield was in the range of 41.19 q/ha (Goa), 75.80 q/ha (Gujarat). Excluding the states of Rajasthan and Goa, the mean yield in all other states was above the target of 45.00 q/ha.

‘Jaya’ was included in 221 demonstrations conducted in 14 states. The mean yield ranged from 41.42 q/ha (Jammu & Kashmir) to 73.93 q/ha (Gujarat). In West Bengal and Jammu and Kashmir, the yield did not exceed the target of 45.00 q/ha, whereas in all other states it was higher than the targetted yield.
‘IR-20’ was included in 7 States in 54 demonstrations. The highest average yield in Karnataka was 74.37 q/ha and the lowest was 38.00 q/ha in West Bengal. In all other states wherever the variety was included, the yield was above the target, i.e. 45.00 q/ha. ‘Ratna’ was included in 7 States in 49 demonstrations. The mean yield ranged from 40.20 q/ha (Uttar Pradesh) to 62.50 q/ha (Maharashtra).

‘T. Hamsa’ in Andhra Pradesh gave mean yield of 70.84 q/ha in 34 demonstrations. In Madhya Pradesh the yield from one demonstration was 40.00 q/ha.

‘IET-1991’ was included in 5 states in 31 demonstrations. The mean yield ranged from 38.92 q/ha (Goa) to 65.17 q/ha (Madhya Pradesh).

Comparing the performance of different varieties, ‘Jaya’ gave the highest average yield of 59.03 q/ha followed by ‘IR-8’, (56.21 q/ha) ‘C-16123’ (55.56 q/ha), ‘T. Hamsa’ 55.42 q/ha and IR-20 (54.17 q/ha).


‘Sonalika’ was used in 348 demonstrations. The average yield was 37.99 q/ha. The variety ‘Kalyansona’ was included in 11 states and average yield was 40.07 q/ha (207 demonstrations).

65 demonstrations were conducted with ‘WG-357’. This was mainly used in Punjab and the average yield was 26.74 q/ha.

‘WG-377’ variety of wheat was also used in laying out 14 demonstrations in Uttar Pradesh and Jammu & Kashmir. The average yield was 30.33 q/ha.

‘Raj. 911’ variety of wheat was used in Rajasthan and MadhyaPradesh in 16 demonstrations and the mean yield obtained was 39.38 q/ha.

‘HD-2009’ was used in 46 demonstrations. The mean yield was 43.23 q/ha. ‘HD-1982’, ‘U.P.-319’ were used in Uttar Pradesh in 41 and 25 demonstrations. The mean yield was 49.25 q/ha (HD-1982) and 47.98 q/ha (U.P.-319).
Maize.—The popular varieties of maize were 'Ganga-2', 'Ganga-5', 'Vijay' and 'Deccan' and 'Chandan'. 87 demonstrations were conducted with 'Ganga-2', followed by 'Ganga-5', (34 demonstrations) and 'Vijay' (18 demonstrations). The variety 'Ganga-2' gave mean yield of 45.07 q/ha from 4 demonstrations in Bihar. The overall mean yield of this variety was 29.06 q/ha from 87 demonstrations.

The performance of 'Ganga 5' was good in Andhra Pradesh 58.00 q/ha and Bihar 44.00 q/ha). The performance of 'Deccan' was excellent in Karnataka and Maharashtra. The average yield was 45.61 q/ha (Maharashtra) and 48.04 q/ha (Karnataka).

'Vijay was included in Punjab and Himachal Pradesh and the average yield was 31.78 q/ha from 18 demonstrations.

Bajra.—'HB-1', 'HB-2', 'HB-3', 'HB-4', and 'HB-5' varieties of bajra were included in national demonstrations. The variety 'RB-5' was the most popular. 94 demonstrations were conducted with this variety.

The overall performance of bajra varieties was not satisfactory due to their susceptibility to downy mildew and ergot diseases.

Jowar.—In four States various high yielding varieties of jowar, namely, 'CSH1', 'CSH-2', 'CSH-5' and 'B-60-4' were used. The highest numbers of demonstrations were conducted with variety 'CSH-1'. The mean yield of this variety ranged from 30.25 q/ha (Madhya Pradesh) to 50.50 q/ha (Karnataka).

The variety 'CSH4' was included in four demonstrations in Maharashtra and the mean yield obtained was 39.44 q/ha.

Size of land holding and yield.—Data on the size of land holdings of the farmers in whose fields the demonstrations were organised, were collected to test whether agricultural technology demonstrated on their fields in national demonstrations was equally successful, irrespective of the size of land holding. The data primarily on cereal crops were analysed. It was revealed that there was no significant relationship between the size of land holdings and yields of the cereal crops.

Demonstrations in Rainfed and Problem Soils

In all 30 demonstrations were conducted in rainfed areas during the year. 8 demonstrations had more than one crop. The major crops included in these demonstrations were maize, wheat, paddy and jowar.
Seventeen demonstrations were conducted particularly on alkaline and acid soils. At fourteen places, multiple cropping was followed. These demonstrations aimed at demonstrating the crop management technology to be deployed on such soils or their reclamation resulting in increased yields of the crops.

OPERATIONAL RESEARCH PROJECTS

The Operational Research Projects initiated by the Indian Council of Agricultural Research during the Fifth Five-Year Plan envisage the integrated approach to rural community problems through joint efforts of local agencies, voluntary organizations, state agricultural departments, etc. Twenty five operational research projects sanctioned by the Council continued to be implemented by various Agricultural universities/research institutes of the Council. In addition, 4 operational research projects being implemented with the assistance from the outside agencies also continued.

The operational research projects that were in operation for more than two years were evaluated by Review Teams constituted by the Council. The terms of reference for the Review Teams were:

(i) To review the progress of the Operational Research Project from the point of view of optimum resource utilization and identification of operational constraints in the transfer of technology.

(ii) to examine how far the Project has been successful in introducing an inter-disciplinary scientific effort;

(iii) to examine whether the principle of 'Social Audit' has been practised in the Project area; and

(iv) to make recommendations as may be relevant to achieving the goals of the Project.

A brief report on the operational research projects is given below:

1. Arid Land Management

Demonstrations on crops with improved agricultural technology were laid out with emphasis on the use of economical doses of fertilizers and efficient irrigation system. With the recommended management practices and the use of fertilizer based on
soil analysis, the yield of bajra in such demonstrations ranged from 30 to 45 q/ha as against 12 to 20 q/ha obtained from local varieties and with conventional cultivation practices. The introduction of 'Aruna' castor variety not only increased the yield of castor but also gave a net profit of Rs. 2,200 per hectare. Under the Sand Dune Stabilization, seedlings of Acacia tortilis and Prosopis juliflora were planted and in between the rows of these trees, seeds of grasses were sown. The establishment of the seedlings was to the extent of 90 per cent. It is estimated that the plantation on the sand dune will make it possible for the farmers to obtain 5 tonnes of fuel wood from each hectare for over 10 years and one ton of grass every year per hectare besides checking the movement of sand significantly.

Rodent control, installation of solar appliances and gobar gas plants were other activities initiated under the Project. The Review Team expressed satisfaction over the implementation of the Project and on the participation of the farmers in the same. The Team advised the plantation of budded ber under the programme in the Sand Dune Stabilisation Programme.

2. Drip and Sprinkler Irrigation Project

Under the Drip and Sprinkler Irrigation Project at the Central Arid Zone Research Institute, demonstrations were laid out to compare the conventional irrigation system and the sprinkler irrigation system with the objective of saving water, increasing irrigation, labour economy and yield of crops. It was observed that with the sprinkler system, the same quantity of water could be used to irrigate the area twice, thus giving 100 per cent increase in water use efficiency and similar increase in the irrigation command. Water thus saved was used to irrigate additional 4-5 hectares. In addition, the farmer could save Rs. 30 per acre on labour engaged for making bunds and ridges for surface irrigation system. The yield of wheat through sprinkler system was 25 quintals/ha whereas that with conventional system only 20 quintals/ha. Hence the efficiency of the system in increasing the water use, irrigation command area, yield of crops, facilitating irrigations on undulating lands and for giving supplemental and life-saving irrigations, has been demonstrated under the Project.

As regards the drip irrigation system, testing of various materials suitable for manufacturing drippers/pipes has been undertaken. Nearly 1,00,000 drippers have been made so far. The cost of drippers comes to Rs. 300-350 per thousand pieces. Depending upon the number of drippers thus made, the drip irriga-
tion system has been installed in approximately one hectare each of the potato and orchard of pomegranate and citrus. The system has good access into the village but high cost of installation and non-availability of the ready-made system are the major hurdles in its adoption.

3. Reclamation of Alkali Soils at the Central Soil Salinity Research Institute, Karnal (Haryana)

The research carried out at the Central Soil Salinity Research Institute has been amply demonstrated on the farmers' fields representing alkali soils of the Indo-Gangetic Plain. It is estimated that about 7 million hectares land is affected by salinity and alkalinity and 40 per cent of its area lies in Uttar Pradesh, Punjab and Haryana. During 2½ years of implementation of this project, 295 demonstrations were laid out in farmers' fields. Impressed by the success of demonstrations, the farmers themselves have reclaimed their own land in about 500 hectares. In the demonstrations, the cost of operations like land levelling, bunding, installation of tubewell, planting of crops, fertilizer application, irrigation and other farm operations was borne by the farmers themselves. By this kind of involvement of the farmers, a lot of confidence has been created about the practicability and economic feasibility of the technology. They got convinced that good crops of paddy and wheat could be grown on the land which remained barren for several decades, provided the proper application of technology is given. The average yield of rice on alkali soils obtained in such demonstrations was about 2-3 times more than the average yield of rice obtained in Haryana.

The use of alternative materials for reclamation of alkali soils, such as pyrites and paddy husk, have also been demonstrated. The results have shown that the Pyrites containing 15 per cent sulphur was equally effective in reclamation of the soil. The paddy husk in combination with little gypsum has proved equally successful in reclamation of such soils. However, the yield of wheat crop in paddy-husk treated soils has been lower as compared to the yield obtained in plots treated with gypsum alone. Ber trees in addition to eucalyptus have been transplanted in thousands in the operational area on alkali soils. This is indicative of the fact that the farmers are interested in promoting agri-silvi system of farming in such areas. The Project has created a new hope into the farmers for raising good crops on their
earlier barren alkali fields. The poor class of farmers has especially been assisted under the Project. The technological and other socio-economic constraints identified under the Project, are being looked into and necessary solutions are being found.

4. **Sheep and Wool Development**

Under the Operational Research Project on Sheep and Wool Development, implemented by the Central Sheep and Wool Research Institute, Avikanagar, three clusters of 20 villages were covered. After carrying out the detailed bench-mark survey of all the sheep owning farmers, it has been found that a majority of the farmers own roughly 10-25 bighas of land. Culling of the animals is not a regular feature. Unwanted males are disposed of at the market when they are 8-9 months old. The commonly available trees for top feed are babool, khepuri, neem, hargad, imli, etc.

It was observed under the Project that if grazing lands were protected for some time during the rainy season, the perennial grasses performed well. However, there were practically no fodder trees in a common grazing land. Under the Project, breeding and health cover were provided. In all, 34 cross-bred adult rams were distributed in addition to 8 demonstration units, each comprising 5 ewes and one ram. It was estimated that at present there were nearly 300 half-breds and quarter-breds sheep under different categories of farmers.

Breeding through artificial insemination with the semen of exotic fine wool breeds like Russian Merino and Rambouillet was undertaken. Under health cover, vaccination, drenching and dipping treatments were undertaken. There was about 20 per cent increase in sheep population in the operational area as a result of health cover. Efforts were made to provide feed and fodder resources by laying out silvi-pastoral demonstrations in common grazing lands through reseeding and planting of fodder trees. Inter-cropping of legumes with grasses was demonstrated in the operational area. Other important management practices, such as, shearing through machines, were introduced and about 3,700 sheep were shorn during the year 1975-76. Seeing the benefit of improved technology, demonstrated under the Project, a few marginal farmers/agricultural labourers came forward to take up sheep farming after obtaining loans from various agencies.
The Review Team Commended the Project as a whole and advised for formation of Sheep Breeders Co-operative Society for making it possible for the members to obtain loans from different sources of institutional finances and to undertake provision of inputs and marketing of wool and live animals.

5. Livestock and Fodder Improvement

The Project was implemented by the Indian Veterinary Research Institute, Izatnagar, in 14 villages in Chainpur block of Bareilly district (U.P.). The bench-mark survey of the operational area was completed. Artificial insemination work was initiated for uprasing cows with Holstein Friesian liquid semen and Murrah liquid semen for buffaloes. The gynaecological camps were organised regularly at Rithoura on 7th and 20th of every month where a team of scientists from the Indian Veterinary Research Institute examined not only the healthy animals for pregnancy but also others suspected for reproductive disorders. Training camps were organised for farmers in the operational area to educate them in feeding animals and disease-control practices essential for maintenance of cross-bred animals.

6. Integrated Milk and Crop Production

The Project covered a total cultivated area of 9,760 hectares with assured irrigation facilities, mostly from tubewells. The land use of the Project area was designed in such a way so as to provide optimal return per unit area, time, irrigation water and milk animals. Paddy and maize in kharif season and wheat, barley, gram and toria in rabi season form the principal grain crops while maize, jowar, berseem occupied the major area under fodder crops. 183 demonstrations were laid out both for grain and fodder crops on the farmers’ fields. Grain crops, mainly, paddy and wheat, needed income of Rs. 2,200 and the returns obtained from fodder crops, especially lucern + hybrid napier gave an income of Rs. 3,750. 30 per cent of the small and marginal farmers housed in each village under the programme were covered under Minikit Programme for berseem, lucerne and oats where they were supplied with small quantity of seeds of these crops together with fertilizers and legume cultures. To ensure all-the-year-round fodder supply particularly from small-land holdings, a three-plot system for fodder cultivation was introduced in the operational area. Under this system one acre plot was divided into three sub-plots—in the first one-third area, maize + cowpea in summer, Maize + cowpea and maize + cowpea + lucerne in kharif and oats + mustard in rabi. In 2nd
sub-plot, lucerne, interplanted with Hybrid Napier, was established as a perennial crop and in the 3rd sub-plot, MP chari + sweet Sudan + bajra + teosinte during the hot and summer months followed by berseem+mustard in winter season. This pattern balanced the energy and protein requirements during most part of the year and regulated the supply of green fodder for the milch cattle.

Under artificial insemination programme, indigenous cattle were mated with pure bred Holstein Friesian bulls, half-bred cows and other higher crosses were covered by 50% Brown Swiss bulls. 160 cows were purchased by farmers from National Dairy Research Institute in the operational area. The cross-bred population of animals in the area registered an increase of 300% during the last one year i.e. from 231 to 739. Necessary health-cover was provided to the milch cattle through Dairy Vikas Kendras to all the villages under the Project. Cattle insurance was provided to all the cross-bred cows purchased by the farmers through bank loan. Dairy demonstration units with at least 3 good cows per acre under typical rural setting were also set up. Continuous training of farmers through group discussions, supplemented by films and slides, proved very effective in motivating farmers to adopt cross-breeding, growing of leguminous fodders, etc.

7. Integrated Pest Management in Cotton and Rice

The Project on cotton was implemented at Ludhiana and Coimbatore and that on rice at Burdwan, Sambalpur, Raipur Kuttanad, Guntur and Warrangal. Pesticides were used on an extensive scale. In cotton, it was possible to sustain the crop against pest to a certain extent but same success was not achieved in case of rice. Seized with this problem and also the major question of environmental hazards due to indiscriminate use of pesticides these two projects on integrated pest management were initiated.

In addition, a project on white grub control was in operation in Nanded district (Maharashtra). The results of Operational Research Projects on integrated management of cotton pest, both at Ludhiana and Coimbatore, were very encouraging. It was shown that as against 15-20 sprays of insecticides on cotton crop to control the pests, it was possible to apply 7-10 sprayings with equal success.
Similarly, in the project on integrated management of rice pest, non-chemical approaches, such as, pest surveillance, conservation of natural enemies of pest coupled with cultural practices showed that considerable reduction in the indiscriminate use of pesticides could be achieved without endangering the crop from pest attack. The fact that brown plant hopper, a highly destructive pest of rice crop, was kept under control is an evidence of the success of this Project.

As regards the control of white grub in jowar, the control technology, comprising chemical and mechanical methods, was demonstrated to the farmers in the operational area. In rainy season at night, white grub beetles settled on babool and neem trees and returned to the soil at dawn. This habit was exploited by controlled methods where adult beetles were killed by mechanical and chemical methods and the larvae by applying minimal insecticides to the soil. The technique for the preparation of the insecticides spray solution and operations was demonstrated to the farmers and training in their proper use was conducted.

8. Production of Jute, Mesta, Other Agricultural Crops and Fisheries

The Project was implemented by the Jute Agricultural Research Institute, Barrackpore, in the five selected villages in Barrackpore district where the new paddy varieties, namely 'Aman', 'Boro', 'Pusa 2-21', 'IR-22', 'Cauvery', 'Ratna' and 'Jagannath' with 'C-1014' were introduced. Wheat varieties, namely, 'Janak' and 'Sonalika' replaced Boro paddy in over 100 acres since adequate irrigation facilities were not available for raising paddy crop. Jute varieties, namely, 'JRO-878', 'JRO-7835' and 'JRO-3690' were introduced in the operational area. Regular training of farmers was organised to train them in necessary plant protection measures against mango insect pests and new technology required for raising of new varieties of paddy, wheat, jute and other agricultural crops. Demonstrations on Composite Fish Culture were undertaken with the assistance of the Central Inland Fisheries Research Institute, Barrackpore.

9. Transforming Rural Economy through Technological Changes

The Project on transforming rural economy through technological changes was undertaken by Punjabrao Agricultural University, Akola, in Wardha district in three blocks, each block comprising 5 villages. The programmes covering agricultural crops, dairy development, recycling of agricultural wastes, development
of feeds and fodders, gobar gas plants, lift irrigation and additional employment were introduced in the operational area. Under crop protection measures, dusting and spraying of chemicals were carried out on community basis including school children and teachers. Control of rodents proved very successful where community action was initiated. With the increase in dairy cattle and with the introduction of cross-breeding, problem of feeds and fodders became more acute. To solve this, introduction of leguminous fodders like berseem and lucerne was taken up. The manure from banana stems was used for compost making. It was estimated that 25 tonnes of compost per hectare having 6 per cent nitrogen could be obtained from banana stems. As a result of the programme on recycling of organic wastes, approximately 3,000 tonnes of farm manure is expected to be ploughed in the operational area every year. Co-operatives for brick and tile making workers was formed which helped them to have increased wages per day and provided additional employment to 100 labourers. Special programmes for farm women in sewing, vegetable preservation, storage of grains, kitchen gardening, community health and hygiene, management of dairy cattle, bee-keeping, etc. were organised where 25-50 trainees participated. 300 farm women were trained so far. Efforts were made to meet the credit requirements of farmers in the operational area by pursuing the Lead Bank to provide necessary loans, especially for purchase of milch cattle, installation of water pumping sets, etc.

The University staff at Akola visited the operational area from time to time and provided necessary guidance on the spot for solving-day-to-day problems faced during the course of the Project implementation.

10. Production of Groundnut and Cereals in Acid Soils

The acidity of the soil could be rectified by applying papermill sludge without much investment. This was found especially suitable for raising groundnut on acid soils where its production increased on an average by 30%. To demonstrate the technology of raising groundnut and other cereal crops profitably in acid soils, the Project was undertaken by the University of Agriculture and Technology, Bhubneshwar in Puri district in Jatni block. Large number of demonstrations on application of waste material from the paper mills and the application of rhizobium culture, alongwith phosphate fertilization, for raising groundnut crop were carried out in the very first year of the implementation of the Project. As a result of these demonstrations, a block of 100
acres of the acid soils was used for raising groundnut crop. For the farmers of the operational area, it was a unique experience since they have never taken groundnut on acid soils. In addition, demonstrations on high yielding varieties of paddy namely, Annapurna, Shakti, Pusa-2-21, Mausuri were also undertaken. Mixed cropping of arhar and groundnut was demonstrated in the operational area and large number of farmers took to this farming.

As a result of the Operational Research Project, the groundnut yield increased by 50-75% on acid soils and paddy yields by approximately 50%. Oilseed crops like Mustard (M-27) were introduced in between the rows of groundnut in high lands after the harvest of groundnut crop. By this, it was possible to raise 3 crops from same piece of land in one year. As regards the improvement of milch cattle, artificial insemination work was undertaken alongwith the introduction of forage crops, namely, Hybrid Napier and Cowpeas. Composite fish culture was also undertaken in the ponds of small farmers and it is expected that by the end of year 1977-78 about 40% of the pond area would be covered under composite fish culture. This programme became very popular with the farmers and resulted in increased demand of fingerlings of carps from the Fisheries Department of the State Government. Principle of Social Audit was kept in mind while undertaking the programme in the operational area. By and large, demonstrations on composite fish culture, plantation crops, green manuring, etc. were taken up with the marginal and small farmers. Only these marginal farmers were supplied with the rams, poultry birds, etc. so as to supplement their income. These farmers were motivated to start dairy as a subsidiary enterprise alongwith crop production. Credits were arranged to them through State Bank of India. Even landless agricultural labourers were assisted by arranging credit at the rate of Rs. 100/- to expand their cane and bamboo business to improve their way of life.

11. Production of Oilseeds and Cereals in Chittorgarh

Chittorgarh district in Rajasthan has approximately an area of 3,000 hectare under oilseed crop, namely groundnut, til, sunflower, mustard. Mostly these crops are rotated with cereal crops. To introduce the technology for raising production of oilseed crops, the Operational Research Project on Oilseed Crops Farming System was initiated in Chittorgarh in Rajasthan in three Panchayats. Regular training courses were organised for the farmers of the operational area to acquaint them with the
agricultural technology for raising oilseeds and cereal crops. Sowing techniques, placement of fertilizers, use of pesticides and plant protection measures were greatly stressed in such courses. Over 1000 Minikit demonstrations were laid out in the fields to disseminate the technology of raising good crops of groundnut, mustard, sunflower and castor. The yield obtained in such demonstrations was higher by 60-75% than that obtained by farmers on their own fields. New wheat varieties, namely, ‘Kalyansona’, ‘Shera’, ‘Raj-911’, were introduced under irrigated conditions and mustard varieties, namely, ‘T-51’ in barani conditions. With the active participation of the farmers, over 80% of the area of groundnut was covered by improved varieties. Application of rhizobium culture was getting popular with the farmers along with the use of phosphatic fertilizers to raise the groundnut crop. Other programmes like tree plantation, rodent control, improvement of cattle, were undertaken in the operational area.

12. Integrated Land-use Planning of Plantation Crops

Two Operational Research Projects for Integrated Land-use Planning of Plantation Crops and Control of Root-wilt in Plantation Crops were implemented by the Central Plantation Crops Research Institute, Kasaragod. After carrying out bench-mark survey of the operational area, production plans were formulated for over 400 households. Fertilizers, especially, rock phosphate and the seedlings of the plantation crops were supplied to the farmers in the operational area on subsidized rates in which the amount of subsidy was released by Small Farmers Development Agency, Cannanore.

As regards livestock and fisheries programme under the project, loans were made available for purchase of 46 milch animals including cows, buffaloes and goats. The newly introduced fingerlings of common carp in 21 tanks of the village under the operational area created an insight to the concept of composite fish culture and an increased demand for the fingerlings. Subsidiary employment avenues for the women identified as suitable for the area were papad making, pickle making and beedi making. With the assistance of SFDA, beedi making was introduced with the farming community even with the marginal farmer’s families. The most attractive feature of the Project was introduction of paddy, namely, ‘Jaya’, ‘Sabiri’ in the plantation area. These varieties yielded 100% more grains as compared to the local varieties grown by the farmers.
The technology of composite fish culture evolved by the Central Inland Fisheries Research Institute, Barrackpore, has enabled attainment of extraordinarily high production of fish from ponds. Experiments, indicated that about 9,400 kg of fish per hectare per year could be obtained from the ponds. To test this technology and to make it suitable for adoption by the fish farmers, an Operational Research Project on Composite Fish Culture was implemented at Krishnagar in Nadia district (West Bengal). In the first stage of demonstrations conducted during the year 1975-76, fish yields ranging from 2600—4300 kg per hectare per year were obtained as against the average production of 462 kg per hectare per year from the same very pond. In the 2nd and 3rd year of the demonstrations, the results obtained in the first year were confirmed and an average yield of 3500 to 4080 kg per hectare was obtained in one year. During 1976-77, integrated approach was introduced with combinations with horticulture, agriculture, poultry, pig rearing, etc. involving the principles of nutrient utilisation of water. The progress so far made in this direction was very encouraging and the results obtained in such demonstrations would be of immense utility for rural development where increase of fish, other compatible combinations of agriculture and animal husbandry form the major elements of the concept.

In fact, the impact of the Project was such as to influence the price of fish in the whole area. 75 such demonstrations have been arranged so far showing various steps of the technology to the local fish farmers. Besides, a few training courses were organised for such farmers where over 100 participants were trained in the technology of composite fish culture. Even the unemployed educated youth have taken to composite fish culture by forming Cooperative Societies. Based on the results of these demonstrations on composite fish culture, the West Bengal Government has taken up an Extension Scheme in a big way for propagating the composite fish culture in the same.

Projects Supported by Foreign Agencies

The Indo-U.K. Project on Dry Farming in Indore district involved an integrated approach to problems on dryland technology on water-shed basis. The operational area comprised 3 villages having 20,000 hectares. Emphasis under the Project
was on introduction of better water management practices, improved cropping system, livestock improvement and assessment of creditworthiness of the Dry Farming Technology. Efforts were made under the Project to convince the farmers of the advantages of growing crops in *kharif* season instead of keeping land fallow and exposing the soil to severe erosion. Quite a large number of farmers have adopted kharif planting of crops like sorghum and pigeon pea in addition to crops like maize, soybean and other forage crops. The project helped to dispel the doubt in the farmers that maize crop could only be grown in fields closer to villages but it could be raised equally well on well-drained fields with shallow soil and gradual slope, if proper management practices were followed. Double cropping was also introduced to increase the crop intensity for full utilisation of farmers’ resources. The yields obtained in a cropping pattern having sorghum followed by wheat was 3-4 times more than what was obtained by the farmers earlier to the initiation of the Project under the irrigated conditions. Improved varieties of not only popular crops like sorghum, pigeon pea, wheat and gram were introduced but also all new crops like maize, groundnut, soyabean, cotton, cowpea, etc. Under the Animal Husbandry Programme, the main emphasis was on improving standard of feeding and management. Facilities for artificial insemination of cows and buffaloes were made available by the cooperation of Intensive Cattle Development Project, Indore. A few forage crop demonstrations were laid out every year to support animal husbandry programme.

Rural Aquaculture Project was implemented with the assistance of International Development Research Centre, Canada, with the objective of popularising fish culture in rural areas of the country. The project at present is being implemented both in West Bengal and Orissa. All technical programmes beginning with the preparation of ponds and relevant scientific studies of various aspects of fish culture up to the harvesting of fish would be executed under the technical supervision of the scientists under the Project. Efforts are being made to develop Fishermen Cooperative Society with the help of State Department to ensure full participation of the fishermen of the village, and to market their produce. The fishermen under the Project were given training on aquaculture. For economic evaluation, the assistance from International Development Research Centres of Canada is being solicited. The Project was in operation at present in 46 ponds in 20 villages in West Bengal. Most of these ponds were of smaller size and were used for raising fish.
in traditional manner and purely for domestic consumption with the average yield of 300 kg of fish per hectare. Techniques of induced breeding of Indian major carps were also demonstrated to the village fish farmers.

The Project for improving farm economy through dairying was undertaken with the assistance of New Zealand at Palampur in Himachal Pradesh. One hundred and eighty cattle heads of Jersey breed, including 5 breeding bulls, were imported during 1975 from New Zealand under the Project. The deep frozen semen Centre was also established for breeding, processing and distribution of semen for use in cattle improvement in the Operational area. Necessary training was imparted to the farmers in the technique of artificial insemination. Seeds of improved fodder crops imported from New Zealand were distributed to the farmers. A beginning was made to improve the quality of milch cattle in Himachal Pradesh. However, the project has yet a long way to go.
VII. INTEGRATED RURAL DEVELOPMENT

INVENTORY OF RESOURCES

The ICAR was entrusted with the responsibility of preparing Integrated Resource Inventories for the Projects to be taken up under the Integrated Rural Development programme. It has been consistently emphasised that employment generation programmes must spring from scientific resource utilization strategies. Agricultural universities are helping in the preparation of resources inventories in the following districts:

1. Rohtas, Bihar
2. Kutch, Gujarat
3. Hissar, Haryana
4. Kangra, H.P.
5. Tumkur, Karnataka
6. Puri, Orissa
7. Hoshiarpur, Punjab
8. Banswara, Rajasthan
9. Dharmapuri, Tamil Nadu
10. Tehri Garhwal, U.P.
11. Mirzapur, U.P.
12. Bankura, West Bengal

Necessary funds have been made available to these universities within a certain overall budget ceiling and draft resources inventories have been completed in the following four districts: Hissar, Hoshiarpur, Dharmapuri and Tehri Garhwal.

The Water Technology Centre at the Indian Agricultural Research Institute, New Delhi, has worked in close collaboration with the Punjabrao Krishi Vidyapeeth, Akola, in completing Resources Inventories for the districts of Chandrapur and Wardha, Maharashtra. The WTC has also completed the resources inventory for Cannanore district, Kerala. The WTC has also been entrusted with the responsibility for preparing resources inventories for the following five districts: Meboobnagar (in collaboration with the Andhra Pradesh Agricultural University), Kamrup, Garo Hills, Anantnag and Bastar.
The model resource inventory has been divided into the following four chapters:

**CHAPTER I : Inventory of Natural Resources**

Climate; Agriculture and Land Use; Animal Husbandry; Fisheries; Forests; Relief; Soil and Water Resources; Irrigation and Drainage; Geology and Mineral Resources; Population; and Tribals.

**CHAPTER II : Inventory of Infrastructure**

Communications; Transport; Posts and Telegraphs; Education and Literacy; Health and Medical Services; Banking Credit and Insurance; Industries; Power; Agriculture; Animal Husbandry; Fisheries and Rural Development; Forest Department; District Administration, Panchayati Raj and Voluntary Organisations.

**CHAPTER III : Inventory of Participants**

Inventory of participants drawn from the rural poor including marginal farmers, landless labourers, artisans, women and children (and where such a concentration exists, tribal groups), and

**CHAPTER IV : Analysis of Resources Inventory**

The most significant part is the analysis of the resources inventory to identify the areas which hold out the maximum growth potential.

Thus, Chandrapur district, Maharashtra, generally considered a backward area with low income and high unemployment rates, is actually endowed with rich soil, water and mineral resources, favourable climate, adequate manpower and a low density of population. In specific terms, the Resources Inventory has identified the following areas of maximum growth potential:

(a) *Agriculture*. The present low yield of rice, jowar and other principal crops points to the existence of a substantial untapped yield reservoir;

(b) *Irrigation*. The ultimate irrigation potential has been estimated at 318,000 hectares of which only about 40 per cent (115,000 hectares) has been developed;
(c) **Ground-water.** There are 17,300 irrigation wells in the district and another 72,000 wells could be sunk in areas identified by the State Ground Water Organisation;

(d) **Water management practices.** A careful analysis of rainfall trends, soil characteristics and existing cropping patterns has shown that *khari* crops can be grown without irrigation by using the right package of management practices. The water saved could be used for irrigating a *rabi* crop and intensifying the existing cropping patterns;

(e) **Fisheries.** Out of an estimated water spread area of 24,000 hectares, 50 per cent is suitable for developing fisheries and raising fish production from the present low level of 7,000 tonnes to as much as 50,000 tonnes per year;

(f) **Milk production.** With the largest cattle population in the State and access to ample grazing facilities, milk production can be raised significantly from the present low yield of 1½ to 2 litres a day; and

(g) With the active co-operation of the State Forest Department, there is considerable scope for developing wood-based industries and sericulture through tribal community organisations.

The developmental opportunities have been further analysed in terms of the specific projects to be taken up and the participants from the rural poor who can be drawn into the programme.

Flowing from this resources inventory, the first batch of projects for Chandrapur district were approved by a Steering Committee and cleared by a Sanctioning Committee headed by Secretary, Department of Rural Development in June 1977. The Projects include:

(a) Paddy-based farming system; (b) tobacco-based farming system; (c) jowar-based farming system; (d) cattle development; and (e) fisheries development.

A second batch of projects for Chandrapur district that have come up for consideration by the Sanctioning Committee include the expansion of the above mentioned programmes for the *rabi* season, 1977-78 and a scheme for the development of homestead farms.

15—1080Deptt. of AR Edu/77
The resources inventory for Cannanore district has thrown up quite a different set of developmental opportunities based on local resources, priorities and existing community organisations. These projects include

(a) replacing traditional cropping patterns with mixed, multi-level and multiple cropping patterns, combined with animal husbandry programmes;

(b) doing away with uneconomic holdings by organising farmers’ co-operatives for taking up integrated land development works and introducing multiple cropping and scientific farming practices;

(c) developing the ultimate irrigation potential from the present level of 27,000 hectares to 150,000 hectares through a combination of lift irrigation, sinking of wells and construction of diversion works;

(d) raising milk production through the organisation of co-operative units;

(e) development of poultry and piggery units;

(f) making effective use of the rich fisheries potential available along a 150 km. coast line through the introduction of integrated sea-farming techniques and the organisation of ancillary processing units;

(g) setting up of a cooperative industrial complex for exploiting the major China clay deposits; and

(h) providing support for the expansion of traditional industries such as handlooms and beedi rolling.

State Governments as well as representative village groups have been involved in discussions relating to the identification of developmental opportunities, viable projects and potential participants from the rural poor. No new surveys have been undertaken; as far as possible the Resources Inventory has been compiled on the basis of available data. It is only in cases where a major gap in resources data has been noticed that separate surveys have been initiated. The ICAR intends organising training courses for institutions and individuals interested in compiling and analysing such resources inventories in terms of participation of and benefits for the rural poor.
VIII. INTERNATIONAL CO-OPERATION

Agreements and Protocols

The following Agreements/Protocols/Memoranda of Agreement were signed during the year.

(i) Indo-New Zealand agreement for Livestock Improvement Project, Palampur (H.P.) was signed at New Delhi on 12 May 1977, though with mutual goodwill and understanding, the Project was in operation since 1 February 1975. The main objectives of the project are to improve the diet and income of the people in that area of Himachal Pradesh by increasing milk production through cross-breeding programmes using genetically superior livestock from New Zealand and raising their feeding standards.

(ii) Memorandum of Agreement between the Indian Council of Agricultural Research (ICAR) and the Aquaculture Department of the South East Asian Fisheries Development Centre for scientific and technical cooperation was signed at Manila on 23 July 1977. The work plan as provided in the Memorandum of Agreement is being jointly developed.

(iii) Protocol on scientific and technical cooperation in the field of agriculture between the Ministry of Agriculture & Irrigation of India and the USSR Ministry of Agriculture for the years 1978 and 1979 was signed at Moscow on 23 November 1977 and its implementation has since started.

(iv) Memorandum of Agreement between the ICAR and the West Africa Rice Development Association, Monrovia, Liberia, for scientific and technical cooperation on rice was signed at New Delhi on 24 November 1977. It provides for the development of work plan by both the parties and necessary action has been initiated in this regard.

(v) A protocol was signed with the Foundation of Scientific Research (FSR), Iraq, for scientific and technical collaboration in the field of agriculture. This protocol provides for joint follow-up committee to review the programme of cooperation from time to time. The last meeting of joint committee was held at Baghdad, Iraq, from 29 August to 6 September 1977 to which a
4-member delegation was deputed from ICAR/DARE. In this meeting proposals for collaboration between ICAR & FSR were finalized.

During the year under review the work plans of the following agreements which provided for exchange of visits, exchange of scientific information, holding of symposia and exchange of germplasm were implemented to the extent possible.

(i) Indo-USSR Protocol for scientific and technical cooperation in the field of agriculture:

(ii) Memorandum of Agreement between the ICAR and IRRI for scientific and technical cooperation in research on rice; and

(iii) Memorandum of Agreement between the ICAR and CIMMYT for scientific and technical cooperation in research on maize and wheat.

Participation in Meetings/Conferences Abroad and Training

During the year, 101 scientists and officers of the Department of Agricultural Research & Education (DARE) and the Indian Council of Agricultural Research (ICAR) and its Institutes and 27 scientists and officers of Agricultural Universities were deputed abroad to participate in International Conferences/Seminars/Symposia, Workshops and study tours, etc. Fifty-eight agricultural scientists from the ICAR, its Research Institutes and Agricultural Universities were sent abroad for training under various foreign aid programmes, such as Colombo Plan, Ford Foundation Grants, cultural exchange programmes, UNDP assisted Projects and Bilateral Agreements, etc. Four scientists from the ICAR Institutes were deputed on assignment and as visiting scientists.

Dr. M. S. Swaminathan, Director-General, ICAR and Secretary, DARE led a seven-man Indian delegation which also included the Director, Central Arid Zone Research Institute, Jodhpur, to the U.N. Desertification Conference held at Nairobi (Kenya) from 28 August to 9, September 1977. Over 100 countries were represented at the Conference. Dr. Swaminathan was unanimously elected the Chairman of the Committee of the whole Conference called “Committee of the Whole” which was assigned the job of preparing a world map of areas affected/likely to be affected by Desertification process, assessing available data and its consequences and to prepare an effective, comprehensive and coordinated action programme against desertification etc. Besides, Country
Report on desertification problems in India and the remedies adopted was prepared. The Central Arid Zone Research Institute, Jodhpur, also prepared a case study of desertification problems in Luni Development Block in Rajasthan for the Conference. A book on “Desertification and its controls summarising 25 years of research on desertification in India was distributed at the conference and this was highly commended by the delegates.

*International Seminars, Training Courses, etc. held at ICAR Institutes*

(i) An International Symposium on Improving Crop and Animal Productivity by Nuclear and Allied Techniques was held at the IARI, New Delhi, from 1st to 4 February, 1977.

(ii) FAO/IAEA Inter-Regional Training Course on Plant Breeding for disease resistance including the use of induced mutation techniques was held at the IARI, New Delhi, from 14 November to 13 December 1977.

(iii) FAO/SIDA Seminar on Veterinary Pathology was held at the Indian Veterinary Research Institute, Izatnagar, from 14 November to 3 December 1977.

In addition approval of the Government of India has been given for organisation of the following international conferences, symposia, etc. during the coming years:

(i) Regional Course on Integrated Natural Resources Survey to be jointly organised by the UNESCO and the CAZRI, Jodhpur, from 21 January to 20, February 1978 in conjunction with the International Symposium on Arid Zone Research and Developments being sponsored by the Arid Zone Research Association of India from 14-18 February 1978 at Jodhpur.

(ii) An International Symposium on Plant Genetic Resources for South-Asian countries to be jointly organised by the International Board of Plant Genetic Resources (IBPGR), Rome, Italy and National Bureau of Plant Genetic Resources (NBPGR) at the IARI, New Delhi, in May, 1978.

(iii) An International Symposium on Cashewnuts at the Kerala Agricultural University, Trichur, in March-April, 1979 which may be jointly sponsored by the ICAR and the International Society for Horticultural Science, The Hague, Netherlands.

Project Assistance

(i) The IDRC has offered to provide an amount of $72,500 over a period of 3 years to support a research proposal for stimulating rural women towards better utilization of local foods for combating malnutrition at the Home Science College at the Andhra Pradesh Agricultural University, Hyderabad.

(ii) The Ford Foundation has agreed to give supplementary grant of $190,000 to the ICAR for Central Soil & Water Conservation Research & Training Institute, Dehradun, for Management of Soil and Water and Land Use Planning.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

During 1977 the ICRISAT continued work on sorghum, pearl-millet, pigeon-pea and chickpea. The research on groundnut, taken up later, was also continued. The All-India Coordinated Research Project for Dryland Agriculture, Hyderabad, and other institution/centres of the ICAR have been extending their cooperation to the ICRISAT in their respective fields.

Based on the recommendations made by the ICAR-ICRISAT Policy Committee which met in August 1976, the ICRISAT had sought clearance of the Government of India to take up the undermentioned two cooperative projects:

1. Physical facilities for experimental work on the five crops mentioned above at Haryana Agricultural University, Hissar, Bhavanisagar Farm of Tamil Nadu Agricultural University, Srinagar (J&K), Gwalior Agricultural College of the Jawaharlal Nehru Krishi Vishwa Vidalaya and Dharwar Campus of the University of Agricultural Sciences, Bangalore.

2. Resource Development, Conservation and utilization with reference to Soil & Water (Inter-terrace land treatment) to be taken up in cooperation with All-India Coordinated Research Project for Dryland Agriculture.
Both these projects have been approved with the exception of the Sub-Station at Srinagar mentioned in the first Project.

The second meeting of the ICAR-ICRISAT Policy Committee was held on 29 November 1977 to review and discuss the joint programmes of action.

**Training of Foreigners**

Training of foreigners in India under the Indian Assistance Programmes, commonly known as Technical Co-operation Scheme of Colombo Plan and Special Commonwealth African Assistance Programme (SCAAP) was continued. Thirteen candidates left India on the successful completion of their courses during the year. There were 111 candidates receiving training under the Colombo Plan by the end of December 1977. The details thereof are: Afghanistan 15; Burma 3 and Nepal 93.

The number of trainees under SCAAP was reduced to 3 by the end of 1977 from African countries as compared with 5 in the previous years. The details are: Uganda 1 and Mauritius 2.

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 undergraduate courses would be covered by Technical Co-operation Scheme of the Nepal Aid Fund and students joining Post-graduate courses would be eligible for assistance from the Colombo Plan.

Ad-hoc training in various fields was also provided to 23 nominees of different Governments.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Country</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.T.D.A.</td>
<td>Bangladesh</td>
<td>4</td>
</tr>
<tr>
<td>U.N.D.P.</td>
<td>Indonesia</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Sudan</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Burma</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Nepal</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>2</td>
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<tr>
<td></td>
<td>Tunisia</td>
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<td></td>
<td>Afghanistan</td>
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</tr>
<tr>
<td>UNICEF</td>
<td>Bangladesh</td>
<td>3</td>
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</tr>
<tr>
<td>ESCAP</td>
<td>Nepal</td>
<td>1</td>
</tr>
</tbody>
</table>

23
The Screening Committee of the Ministry of Agriculture had two meetings in March and November 1977. It approved 15 proposals for additional funds for the research schemes financed from the U.S. held rupee funds at an estimated total cost of Rs. 20 lakhs. Ten new schemes of the valuation of Rs. 55.32 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. Thirteen schemes were proposed for assistance from this fund. These were considered by the Committee of Scientists in three meetings during the course of 1977. Eleven projects of the total valuation of Rs. 45 lakhs were approved.

Free foreign exchange to the extent of Rs. 45 lakhs was released in favour of Institutes of the ICAR and Agricultural Universities and the releases under India-UK Trade Agreements and other Aid agreements during the year amounted to Rs. 6 lakhs and 8 lakhs, respectively.
IX. PUBLICATIONS AND INFORMATION

The Publications and Information Division brought out several topical publications during the year, viz. 'Desertification and its Control' on the occasion of United Nations Conference on Desertification, 'Strategy for Crop Planning in Drought and Flood-Prone Areas', 'Operational Research Projects', and 'Krishi Vigyan Kendras'. Among other important publications issued were 'Myxomycetes of India (Monograph)'; Handbook of Animal Husbandry', 'Agricultural Research and Education (1966-76)', 'Research Highlights—1977'. Publications were also brought out for the Agricultural Scientists' Recruitment Board and on the Scientific and Technical Services of the Council. In all 33 publications were brought out during the year, 26 in English and 7 in Hindi. Another 10 publications were in advanced stages of printing.

Two publications of the ICAR received first prize and another two publications second prize in the National Exhibition of Farm Publications organised by the Directorate of Extension in connection with Agri Expo 77. The award winning publications were: 'Bougainvilleas' (First Prize) and 'Insects and Mites of Crops' (Second Prize). Among the journals Indian Horticulture got the First Prize and Kheti Second Prize.

The programme of original books in Hindi made further progress with the arrival of more manuscripts from authors. A standard work on Horticulture, 'Phal Vigyan' was brought out during the year. The sixth 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, The Indian Journal of Animal Sciences, Indian Farming, Indian Horticulture (Quarterly) and Kheti (Hindi monthly). The research journals The Indian Journal of Agricultural Sciences and The Indian Journal of Animal Sciences, which were in arrears for some time, were put on time. The following Special Numbers of Journals were brought out during the year.


Sales and Advertisements

The Council earned Rs. 5,74,800 from the sale of its Publications including journals and Rs. 1,55,200 from advertisements during the year 1976-77. Sales promotional activities were continued to step up sale of the Council's publications. Selected books were sent through National Book Trust for display at Book Exhibitions abroad in Fiji, Brazil, Hong-kong, Frankfurt and Singapore.

The Council participated in 15 exhibitions, Book fairs, Workshops, Kisan Melas, Seminars, etc. during the year.

Films

At the instance of the Council, the Films Division of the Ministry of Information and Broadcasting continued to produce newsreels on Agriculture, Animal Sciences and Fisheries subjects for screening in the various cinema houses in the country.

Publicity and Public Relations

Features, articles and news items on the research and development activities in agriculture and animal sciences were released to the mass media.

The Council organized visits by groups of Hon'ble Members of Parliament to different Research Institutes/projects and agricultural universities to acquaint them with the research activities in progress.

Facilities were extended to representatives of Indian and Foreign Press, TV, Radio, Film Teams to visit different ICAR Institutes, Projects and Agricultural Universities for projecting our research efforts through national and international media.
Newsletters and releases on latest research findings in agriculture and allied disciplines were also sent to the newspapers and journals in Assamese, Bengali, Kannada, Malayalam, Oriya, Punjabi, Tamil and Telugu. These received wide publicity in the language journals. Stress was laid in these dispatches on the respective problems of the region and measures taken to combat them.

**Exhibition**

The ICAR participated in the AGRI EXPO '77 organised by the Ministry of Commerce during November—December, 1977. Important research activities of Institutes were depicted in the panels set up at the Pavilion. Visitors appreciated the efforts being made by the ICAR in evolving suitable crop varieties and technology for improving production particularly in dryland areas. Among the visitors were groups of farmers from various parts of the country, several foreign delegations, and scientists from international organizations.

**Farm Journalists' Workshop**

The Council organized four Regional Farm Journalists' Workshops at Bangalore, Hyderabad, Indore and Anand. These Workshops were attended by journalists from the regions concerned as also the local journalists. In all nearly 200 journalists participated in the Workshops. These Workshops provided an occasion for acquainting the journalists with the agricultural research and development efforts in the regions. These Workshops created greater awareness among the farm journalists about the importance of agricultural research in the national economy, and enabled them to report agricultural research and development activities in proper perspective.

An All India Farm Journalists' Workshop was also organized by the Indian Agricultural Research Institute, New Delhi, during December, 1977 in which over 40 farm journalists from different parts of the country participated.

**ICAR Library**

During the period under report (April-December 1977) 1557 publications, including books, bulletins and theses were added to the Library. 544 current titles of periodicals were received. About 1941 readers used the Library and 1,878 publications were issued on loan and 9392 were consulted in the library.
Local documentation activities were carried out as usual. The 'List of periodicals received during the week', 'List of monthly additions to the Library' and 'Current Content: Current Awareness' were prepared and circulated periodically among the specialists at the Council's headquarters.

The film Library under the ICAR Library, issued films to the members outside Delhi.

The Hindi Library of the Council offered loan to its 225 enrolled members. During the period under report 2,407 books were issued to members.

**Agricultural Research Information Service**

The ICAR started a pilot project on the maintenance of Research Project 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 the 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 projects, terminated projects-classified on the basis of discipline, subject and institution, Directory of Agricultural Personnel etc. The Unit also supplied complete list of research workers to the Commonwealth Agricultural Bureau, London, for publication in their List of Research Workers. The information compiled by the Research Project 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 File 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 & Technology) System of F.A.O. of United Nations through its Research Project Unit. About 250 inputs were sent every month to the AGRIS Data Base at Vienna (Austria) covering about 200 periodicals and other non-conventional literatures of Indian origin.
In view of the expanded activity of the Research Project File Unit, the Council decided to shift the Unit to the Indian Agricultural Statistics Research Institute, Campus, New Delhi, to utilize the new high-power computer (Burrough's 4,700) which was installed in March, 1977 and renamed the Unit as the Agricultural Research Information Centre from June, 1977. This Centre will be the nucleus of the proposed National Agricultural Research Information Service of the Indian Council of Agricultural Research.
APPENDIX I

REPRESENTATION OF SCHEDULED CASTES AND SCHEDULED TRIBES IN ICAR

In pursuance of the recommendations of the Parliamentary Committee on the Welfare of Scheduled Castes and Scheduled Tribes, a statement showing the representation of S.C. and S.T. in the service of the ICAR and its Research Institutes as on 31 March 1977 is given in the accompanying statement.

The ICAR is a scientific organisation and a majority of the posts in Class I and II are scientific in nature. So far, certain scientific posts were being exempted from the purview of reservation orders in accordance with the instructions of the Government of India, provided the posts were required for conducting research and organising, guiding and directing research.

With the introduction of the Agricultural Research Service with effect from October 1975 it has been decided that scientific posts carrying the scale up to the maximum of Rs. 2,000/- which are filled up by direct recruitment will not be exempted from the reservation orders for SC/STs. This would help in improving the representation of SCs/STs in scientific posts at the Headquarters and its Institutes.

As per another recommendation of the Parliamentary Committee, the reasons and extent of shortfalls in the prescribed percentage of appointments in the various categories of staff, if any, and possible remedial measures thereof, are being looked into by Ad-hoc Inspection Committees appointed for the purpose.

The accompanying statement relates to the persons and not posts; therefore, vacant posts have not been taken into account. Further, persons on deputation have been included in the borrowing establishment and not in the parent office. Lastly, persons permanent in one grade but officiating or holding temporary appointment in a higher grade have been shown in the latter grade.

Total number of employees in the ICAR and its Institutes, and the number of Scheduled Castes/Scheduled Tribes among them

<table>
<thead>
<tr>
<th>Class</th>
<th>Total No. of employees</th>
<th>Scheduled Castes</th>
<th>Percentage to total employees</th>
<th>Scheduled Tribes</th>
<th>Percentage to total employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>2,250</td>
<td>81</td>
<td>3.6</td>
<td>7</td>
<td>.31</td>
</tr>
<tr>
<td>Class II</td>
<td>1,307</td>
<td>89</td>
<td>6.8</td>
<td>10</td>
<td>.77</td>
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<td>Class III</td>
<td>7,431</td>
<td>1,140</td>
<td>15.34</td>
<td>207</td>
<td>2.79</td>
</tr>
<tr>
<td>Class IV (excluding sweepers)</td>
<td>7,909</td>
<td>1,887</td>
<td>23.86</td>
<td>257</td>
<td>3.25</td>
</tr>
<tr>
<td>Class IV (sweepers)</td>
<td>446</td>
<td>429</td>
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APPENDIX II

PROGRESSIVE USE OF HINDI IN THE OFFICES OF THE DARE AND ICAR

Implementation of rules for progressive use of Hindi.—A Hindi Section in the Council, consisting of one Hindi Officer, two Hindi Translators, one Hindi Assistant, one Hindi as well as one English Typist, is looking after the implementation of rules regarding progressive use of Hindi in the DARE and the ICAR. A Hindi Cell, consisting of two Hindi Typists, is also working under the supervision of Hindi Officer wherein original correspondence done in Hindi by various sections of DARE/ICAR is typed.

A gist of official Language Rules, 1976 has been circulated among all Directors of the Institutes and all officers/employees of the DARE and ICAR requesting them to comply with the said Rules.

Essential help literature published by Kendriya Sachivalaya Hindi Parishad and Commission for Scientific and Technical Terminology, Central Hindi Directorate, Ministry of Education and Social Welfare, viz. ‘Karyalaya Sahayika’ ‘Consolidated Glossary of Administrative Terms (English-Hindi) ‘Compilation of orders regarding the use of Hindi (up to May 1974) and some posters issued by the Department of Official Language, Ministry of Home Affairs have also been sent to all sections/Institutes working under the DARE and ICAR.

Official Language Implementation Committee.—The DARE and ICAR have constituted their own Joint Official Language Implementation Committee in which the orders regarding progressive use of Hindi are discussed and recommendations are made to eliminate the difficulties in its implementation.

Incentives to Hindi typists.—The Efficiency Bonus Scheme initiated by the Department of Personnel and Administration Reforms was implemented in the DARE and ICAR and its various Institutes all over India.

Incentives to Hindi stenographers.—The implementation of incentive scheme for Hindi stenographers is also applicable in the DARE and the ICAR under which an advance increment is given to those Hindi stenographers who may take dictation at a speed of 100 words per minute and two advance increments for those who can take dictation at a speed of 120 words as per minute.

Devnagri typewriters.—The DARE, being a small Department, has got one Hindi typewriter, but the Council is having 18 Devnagri typewriters at present at its Headquarters. Hindi typewriters are also available in its several institutes. The institutes who are not having it have been advised to purchase the Hindi typewriters.

Hindi Library.—The Hindi Library of the ICAR is having 2,787 Hindi books. In addition to it, two Hindi weeklies and two Hindi dailies are regularly being kept in the Library and thus 20-30 persons are being benefited from these periodicals daily.
General orders.—Effort was made with our meagre staff 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 is being done by some of the sections at present. In the Hindi Section and Hindi Editorial Unit of the ICAR, the noting is done almost in Hindi.

Reports.—Any report published by the DARE and the ICAR and which is required to be placed on the tables of the both Houses of the Parliament, are invariably published in Hindi as well as in English.

Forms.—The Joint Secretary, DARE, and Secretary, ICAR, has issued instructions to the Chief Production Officer of the ICAR that all kinds of forms used by the DARE and ICAR should be published bilingually. A request has also been made to all Officers/Section Officers that they should send the forms bilingually for printing. Consequently, all forms on behalf of ASRB are being printed bilingually.

Publication of Hindi books on agriculture.—The programme of original books on agriculture in Hindi received further impetus. About two dozen such books were being written by various experts.

Periodicals.—The Council brings out a monthly periodical entitled, 'Kheti'. The publication of Krishi Chayanika' is usually done twice in a year but it is under consideration to make it a quarterly. The scheme regarding publication of another journal 'Phal-Phal' is under consideration. It is proposed to publish the gist of the article in the Indian Journal of Agricultural Sciences and the Indian Journal of Animal Sciences in Hindi also.

Hindi addressographer.—A Hindi embossing machine was purchased to make it possible to give addresses of subscribers to 'Kheti' in Hindi. As such the addresses of subscribers to Kheti are now being given in Hindi.

Awards.—Two awards, namely 'Dr. Rajendra Puraskar, and 'Kheti Puraskar are being operated by the Council since 1974. Under these schemes two annual awards for each scheme are conferred for original writing in Hindi books on agricultural and animal science subjects. The first prize of 'Dr. Rajendra Puraskar' is of the value of Rs. 5,000 (Five thousand rupees) and the second of Rs. 2,500 (Two thousand five hundred rupees). The other one is 'Kheti Puraskar.' Two of the value of Rs 500 (Five hundred) each are given for original articles published in Kheti, the Council's Hindi Journal.

The Hindi periodical 'Kheti' got an award in the All India Exhibition of Farm publications organized in Agri-Expo-77.
APPENDIX III

AWARDS

1. Rafi Ahmed Kidwai Memorial Prizes for Agricultural Research

The ICAR had instituted in 1956 an award entitled “Rafi Ahmed Kidwai Memorial Prizes” for outstanding research work done in the fields of Agriculture, Animal Husbandry and allied sciences. Under this award 11 prizes of the value of Rs. 10,000 each are given once in two years for fundamental or applied research including inventions, discoveries etc. leading to results of practical value in the field of agricultural production. For 1974-75, 13 prizes were awarded to 32 outstanding scientists in recognition of their outstanding research in various disciplines of Agriculture, Animal Husbandry and allied sciences.

2. 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 Post-graduate Research in Agriculture”. The award comprises 5 prizes of the value of Rs. 5,000 each. In 1977 six awards, sixth in the series, were given to 7 outstanding scientists for their contributions in the disciplines of Agriculture and Animal Sciences.

3. Dr P. B. Sarkar Endowment Prize

Dr. P. B. Sarkar, former Director of the Jute Technological Research Laboratory, Calcutta, had donated a sum of Rs. 27,700 to the Council for instituting a prize of the value of Rs. 5,000 to be awarded triennially to the research workers for outstanding research work calculated to lead to enhanced food production in India. The award for the triennium 1974-77 was awarded to a distinguished scientist for his outstanding contribution in the field of Agronomy.

4. Dr R. D. Asana Endowment Prize

Dr R. D. Asana, former Head of the Division of Plant Physiology, IARI, donated a sum of Rs. 10,000 to the Council for instituting an award of Rs. 2,000 to be given triennially to the scientists in recognition of their outstanding original research on Plant Physiology, Plant Breeding, Soil Chemistry/Physics, Agricultural Physics, Agronomy and Agricultural Engineering bearing on improvement of knowledge or practice of dryland agriculture. The first award for the triennium 1974-77 was given to two scientists (jointly) for their contributions in the fields of Plant Physiology and Plant Breeding.

5. Dr Rajendra Prasad Puraskar

The Council instituted an award entitled “Dr. Rajendra Prasad Puraskar” for providing incentive to writers of original books on agriculture and Animal Sciences in Hindi. Under this award, two prizes of the value of Rs. 5,000 and Rs. 2,500 are given annually. The award for the year 1977 has been given to 2 distinguished writers.

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16—1030 Deptt. of AR & Edu./77
6. *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 annually for writing outstanding articles in Hindi in the Council's monthly journal "Kheti". Two prizes the third in the series were awarded to 4 distinguished writers jointly during 1977.

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**APPENDIX IV**

**PUBLICATIONS PRINTED DURING 1977**

2. Desertification and its Control.
3. Agricultural Research and Education—Recent Progress.
4. Myxomycetes of India (Monograph).
7. ICAR Operational Research Projects.
9. Strategy for Crop Planning in Drought and Flood Prone Areas
11. Breeding Procedures for Cross Pollinated Vegetable Crops
12. Races of Maize in India.
13. Trypanosomes and Trypanosomiases of Indian Livestock.
18. ICAR Agricultural Research Service.
19. Question Papers for the 2nd ARS Examination held in February 1977.
20. Diagnosis and Control of Helminthic Infections.
22. DARE Annual Report (1976-77)
23. ICAR Reporter (Hindi).
24. Manural Requirements of Vegetables (Hindi).
25. Bharat Main Paltu Pashu Pakshiyo kee Keet Vyadhiya.
27. Phal Vigyan (Hindi).
28. Castor.
29. Breeding Procedure of Pearl Millet.
30. Fungal Diseases of Rice.
31. Seed Borne Diseases and Their Control.
32. Vertebrate Pest Control.

PUBLICATIONS EXPECTED UP TO 31 MARCH 1978

1. Forage Pastures Insects Pest of Rajasthan.
2. Wild Edible Plants of India.

APPENDIX V

LIST OF ICAR RESEARCH INSTITUTES AS ON 14-11-1977

1. Indian Agricultural Research Institute, New Delhi 110 012.
2. Central Rice Research Institute, Cuttack 753 006.
3. Central Potato Research Institute, Simla 171 001.
4. Central Tuber Crops Research Institute, Sreekariyam, Trivandrum 695 017.
5. Sugarcane Breeding Institute, Lawley Road, Coimbatore 641 007.
7. Central Plantation Crops Research Institute, Post Kudlu, Kasaragod 670 124.
10. Cotton Technological Research Laboratory, Adenwala Road, Matunga, Bombay 400 019.
11. Jute Agricultural Research Institute, 24-Parganas P.O. Barrackpore 743 101.
12. Jute Technological Research Laboratories, 12, Regent Park, Calcutta 700 046.


15. Central Soil & Water Conservation Research and Training Institute, 218, Kaulagarh Road, Dehradun 248 195.


18. Indian Grassland & Fodder Research Institute, Gwalior Jhansi Road, Jhansi 284 001.


21. Indian Veterinary Research Institute, Izatnagar 243 122.


23. National Dairy Research Institute, Karnal 132 001.


25. Central Marine Fisheries Research Institute, PB No. 1912 Vincent Road, Cochin 682 018.


27. Central Institute of Fisheries Technology, P.O. Matesyapuri, Cochin 682 029.

28. Indian Agricultural Statistics Research Institute, Library Avenue New Delhi 110 012.

29. ICAR Research Complex for North Eastern Hills Region, Amrit Bhavan, Shillong 793 001.

30. Central Arid Zone Research Institute, Jodhpur 342 001.

31. Central Staff College of Agriculture, Rajendranagar, Hyderabad 500 030.
APPENDIX VI

LIST OF AGRICULTURAL UNIVERSITIES AS ON 29-12-77

ANDHRA PRADESH
1. Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad 500 030.

ASSAM
2. Assam Agricultural University, Jorhat 785 013.

BIHAR
3. Rajendra Agricultural University Veterinary College Campus, Patna 800 014.

GUJARAT

HARYANA
5. Haryana Agricultural University, Hisar 125 004.

HIMACHAL PRADESH
6. Himachal Pradesh University (Agricultural Complex), Summer-Hills, Simla 171 005.

KARNATAKA
7. University of Agricultural Sciences, Hebbal, Bangalore 560 024.

KERALA
8. Kerala Agricultural University, Mannuthy 680 024.

MADHYA PRADESH
9. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur 482 004.

MAHARASHTRA
12. Marathwada Agricultural University, Parbhani 431 401.
13. Punjabrao Krishi Vidyapeeth, Krish Nagar, Akola 444 001.

ODISHA
14. Orissa University of Agriculture & Technology, Bhubaneswar 751 003.
PUNJAB
15. Punjab Agricultural University, Ludhiana.

RAJASTHAN
16. University of Udaipur, Udaipur 313 001.

TAMIL NADU
17. Tamil Nadu Agricultural University, Coimbatore 641 003.

UTTAR PRADESH
18. Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208 002.
19. Govind Ballabh Pant University of Agriculture and Technology Panctnagar 263 145.
20 Narendra Dev University of Agriculture and Technology, Faizabad.

WEST BENGAL

APPENDIX VII (a)
LIST OF PROJECT-DIRECTORATES
1. Rice.
2. Wheat.
3. Pulses.
4. Oilsseeds.
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.
5. Soyabean.
6. Tobacco.
7. Cotton project assisted by World Bank.

(iii) Horticultural Crops
1. Fruits.
2. Tuber crops.
3. Potato.
4. Vegetables.
5. Medicinal and aromatic plants.
6. Floriculture.
7. Spices and cashewnut.
8. 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
    All-India Co-ordinated agronomic research project.

(vi) Agricultural Engineering
1. Research and development of farm machinery, implements production of prototypes and their evaluation.
2. Optimisation of ground water utilization through wells and pumps.
4. Post-harvest technology.

(vii) Operational Research (including national demonstrations and integrated pest-control projects).

B. Animal Sciences and Fisheries

(i) Animal Sciences
1. Cattle breeding.
2. Buffaloe 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).
9. Epidemiological studies on foot and mouth diseases.

(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. Brackish water 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 crops pests.
(2) Nematodes 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 Sugar-beet
AICRPBCCP—All-India Co-ordinated Research Project on Biological Control of Crop Pests
AICRIP—All-India Co-ordinated Rice Improvement Project
AICSIP—All-India Co-ordinated Sorghum Improvement Programme
AICWIP—All-India Co-ordinated Wheat Improvement Project
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 Maíz y Trigo, A.
CPCRI—Central Plantation Crops Research Institute
CRA—Crease recovery angle
CRRRI—Central Rice Research Institute
CSAUAT—Chandra Shekhar Azad University of Agriculture and Technology
CTRI—Central Tobacco Research Institute
CTRL—Cotton Technological Research Laboratory
CVRC—Central Variety Release Committee
DCP—Digestible crude protein
DM—Digestible matter
ESCAP—Economic and Social Commission for Asia and the Pacific, Bangkok
FAO—Food and Agriculture Organisation
FFE—Feather follicle epithelium
FSR—Foundation of Scientific Research, Iraq
FYM—Farmyard manure
HAU—Haryana Agricultural University
HPU—Himachal Pradesh University
IAEA—International Atomic Energy Agency
IARI—Indian Agricultural Research Institute
IARS—Indian Agricultural Research Statistics
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
ILRI—Indian Livestock Research Institute
IRD—Integrated Rural Development
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
MDV—Marek's disease virus
NBAFGR—National Bureau of Animal and Fish Genetic Resources
NBDIN—National Barley Diseases and Insect Nursery
NBPG—National Bureau of Plant Genetic Resources
NBSSLUP—National Bureau of Soil Survey and Land Use Planning
NDRI—National Dairy Research Institute
NHGP—National Hybridization Garden Programme
NRCD—National Research Centre for Goat Development
NSC—National Seeds Corporation
ORP—Operational Research Project
PAU—Punjab Agricultural University
RAU—Rajendra Agricultural University
SCAAP—Special Commonwealth African Assistance Programme
SRS—Sugarcane Research Station
TRS—Tobacco Research Station
UNDP—United Nations Development Programme
UNESCO—United Nations Educational, Scientific and Cultural Organisation
UNICEF—United Nations International Children’s Emergency Fund
WHO—World Health Organisation
WTRC—Water Technology Research Centre
**ANNUAL REPORT 1977-78**

**ERRATA**

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