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Indian Council of Agricultural Research

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Foreword

The year 2002–2003 was marked by one of the severest and the most wide-spread droughts in the country in the last hundred years. In this crucial period, it was at once an obligation and opportunity for the Indian Council of Agricultural Research to be of service to the nation by contributing its scientific and technological input for the preparation of eco-region specific contingency plans. Some valuable lessons were also learnt in this context. For one thing the drought brought home to us very emphatically the need for efficient water use and its *in-situ* or *ex-situ* conservation. It also highlighted the criticality of research on optimizing the mileage obtainable from every unit of water and thus produce more from less water. The need for having sufficient availability of forage and fodder was similarly highlighted.

As a corollary to the lessons learnt during the drought, research in technology for growing crops under water stress conditions has been given greater importance particularly in wheat, rice, maize, sorghum, *bajra*, pulses and minor millets. Besides this, new hybrids have been developed in rice, maize, sorghum and *bajra*. The emphasis on increasing the production of oilseeds and pulses continues in government policy, and research is paying special attention to development of hybrid varieties particularly in rapeseed–mustard. Integrated pest and disease management has been given high emphasis, and a number of new technologies have been developed in this area during the year for effective control of pest and diseases. Bio-control method is one of the components of this approach. Research in the area of cotton has resulted in the development of ready-to-use kits to differentiate Bt-cotton from non-transgenics. Among the ICAR's research projects in the frontier area of structural genomics is the project on high-quality sequencing of rice genomics taken up in collaboration with the International Rice Genome Sequencing Project (IRGSP). The first phase of this project has been completed.

To provide a viable base for the development of livestock research in animal sciences, the ICAR has paid special attention to the conservation of genetic resources, on priority particularly to those resources that need to be conserved before some of the threatened breeds become extinct. Accordingly, a DNA repository for Indian livestock and poultry breeds has been established. Since economic losses due to livestock diseases are generally seen to be enormous in scale, efforts are being made to reduce them through better diagnostic vaccines and drugs, including indigenous drugs. Livestock disease-based eco-pathozones have been established to study the epidemiology of animal diseases. Due to persistent efforts, India has been now declared free from rinderpest. A C-ELISA kit for rinderpest detection has been developed. Complete feed blocks useful in animal feeding have been developed for use during fodder scarcity, in order to insulate the livestock against the effect of drought. Programmes on value addition for milk, meat, egg and fibre have also been strengthened.

The Horticulture Revolution that has spread with uniform intensity throughout the country is expected to change grey areas into green. Hybrid technology in vegetables like tomato, brinjal, chilli, cucumber, bitter-gourd, bottle-gourd and okra is making a visible dent in accelerating the productivity of vegetable crops. Production technology of a new kind of mushroom has been developed. In addition, technology for the production and utilization of medicinal plants is getting popularity in the country. Attempts are being made to popularize under-utilized horticultural crops like *aonla*, garcinia, passion-

fruit, tamarind, *jamun*, bael, fig, custard-apple and date-palm which have particular relevance for the drought prone or arid areas of the country. INFOCROP-POTATO model to simulate potato development, growth and yield both under potential and suboptimum water conditions has been developed. In floriculture, in view of the potential of orchid a low-priced orchid-micropropagation method has been developed.

In the fishery sector, attempts have been made to diversify freshwater acquaculture by including in our programmes catfish species with promising potential. In pursuance of the strategy to strengthen prevention of disease through health management practices in preference to disease treatment, immuno-stimulant technology for brackishwater acquaculture has been developed to prevent disease in shrimps. The Central Institute of Fisheries Education, Mumbai, has developed a new chemical formulation 'cifelostress' to reduce external stress and resultant mortality of fish seed during transportation. A diagnostic kit for the detection of the White Spot Disease has been released and commercialized. Fibreglass canoes have been devised and commercialized by the Central Institute for Fisheries Technology, Kochi.

New initiatives have been taken in respect of organic farming impact and adaptation to climate change. A comprehensive soil-map of India on 1 : 1 million scale has been developed. Cost-effective bioengineering measures of soil and water conservation have been devised. Appropriate approaches for managing saline soil and coastal ecosystems using their precise estimates have been obtained with the help of GIS technology. On the basis of data obtained from agro-meteorological stations all over the country, a model has been developed for advance estimation of national foodgrains productivity.

During the year, the ICAR has made significant efforts towards providing the required fillip to conservation technologies, in collaboration with the Consultative Group on International Agricultural Research (CGIAR) system and also under the National Agricultural Technology Project (NATP). Resources conservation tillage and specially zero tillage has been extended to 0.3 million hectares during the year. This has led to a net saving of Rs 600 million annual benefit to the farming community. For the first time, scientists are working closely with the farming community in five Agro ecosystems across the country and have organized over 10,000 on-farm trials. Indigenous knowledge is also being documented under the NATP, and validated to protect indigenous intellectual right. As a new initiative, training programmes have been organized for the technological empowerment of women. Over 55,000 accessions have been collected and documented in plant, animal and fish bio-diversity.

During this year some special initiatives have been taken for the spread of technology in the North-East region by experimenting with participatory approaches. Special emphasis has been provided on horticulture and animal sciences. To provide effective support to the North-East in a concerted thrust, a special recruitment drive was undertaken for the NE, and 50 scientists have been posted there during the year.

It is a matter of satisfaction to see the effective dovetailing between national priorities in the Agriculture Sector and ICAR's programmes, particularly in the current concerns regarding conservation, optimization of resources, commercialization of technology and biotechnology. The initiatives taken during this year will doubtless bear fruit in the future.

(AJIT SINGH)
President
ICAR Society

Contents

The Mandate of the Indian Council of Agricultural Research

(i) To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.

(ii) To act as a clearing house of research and general information relating to agriculture, animal husbandry, home science and allied sciences; and fisheries through its publications and information system, and instituting and promoting transfer of technology programmes.

(iii) To provide, undertake and promote consultancy services in the fields of education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.

(iv) To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing co-operative programmes with other organizations such as the Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities.

(v) To do other things considered necessary to attain the objective of the Society.

1 Overview

Agriculture in our country provides livelihood to about 70% of the population, employs about 65% of the work-force, and contributes about 24% to national Gross Domestic Product (GDP) and nearly 16% to export earnings. The main issues which our agricultural research has to now address relate to production, profitability, efficiency and sustainability while protecting the natural resource base. We have to be adequately prepared to successfully meet the challenges and requirements of globalization, intellectual property rights, sanitary and phytosanitary measures, post-harvest technologies to ensure safe storage and transport of farm produce, processing, value-addition, agri-export, market intelligence and related issues. Need-based reorientation of agricultural research and education is thus our foremost priority.

As conservation and optimal use of plant genetic resources is a key requirement for aiming at high production on a sustainable basis, 15,243 accessions of crops and their wild relatives were collected during the year. Twelve exploration missions were specially mounted to collect plant genetic resources from Sardar Sarovar Catchment area to capture genetic resources which may disappear as the development programmes in catchment are proceed. Besides, 27,847 samples of crops from 39 countries (including 79 of transgenic crops) were introduced. During the year, the National Seed Genebank has been enriched with 27,245 accessions. It processed 138,364 crop samples including 91 transgenics for quarantine clearance, and issued 31 phytosanitary certificates for germplasm export. DNA fingerprinting of crop varieties in cereals, millets, pulses, oilseeds, citrus and banana and neem is gradually moving forward to strengthen variety information database.

Under *Crop Improvement and Management,* 21 varieties and one hybrid in rice, five varieties in wheat, one variety in barley, six hybrids/varieties in maize, three hybrids and one variety in pearl millet, and one variety each of fingermillet and little millet have been released for commercial cultivation in food crops for various agro-ecologies. Also, nine varieties of wheat and one variety of barley have been identified for release.

In oilseed crops, four varieties of groundnut, five of Indian mustard, four of soybean, three each of sesame and linseed, and one each of niger and karan rai, and three hybrids of sunflower and one of castor (first hybrid for semi-arid region of Rajasthan) have been released/identified for cultivation. Two varieties each of chickpea, pigeonpea and mungbean, and one of lentil have been identified in pulse crops for commercial cultivation.

In commercial crops, one intra-*hirsutum* and one intra-*arboreum* hybrid of cotton has been identified for release. Two new species of *Corchorus* have been recorded in jute crop. In tobacco, one Natu variety has been released; and one variety each in flue-cured virginia, Natu and Burley tobacco has been identified for cultivation in Andhra Pradesh.

Other achievements include: identification in rice of three new cytoplasmic male-sterile (CMS) lines having desirable

quality traits and introgression of bacterial blight resistance genes through marker-aided selection into BPT 5204 and Triguna rice; development of a new wheat plant type (DL 1266-5); identification of maize genotypes resistant to different biotic stresses; adding of 450 indigenous and 3 exotic germplasm of forage crops; identification of resistance donors in Indian mustard for white rust and *Alternaria* blight; development of non-spiny hybrid NARI-H 1 with tolerance to *Alternaria* and *Cercospora* leaf spot diseases and *Fusarium* wilt in safflower; development of three ready-to-use kits to differentiate Bt-cottons from non-transgenics; production of intersectional hybrids of *Nicotiana repanda* × *N. tabacum* from hormone-aided direct hybridization; standardization of mass rearing of anthocorid *Blaptostethus pallescens* on *Corcyra cephalonica;* successful rearing of *Chrysoperla carnea* larvae on artificial diet; and accomplishment of breeding of bank myna in artificial nest-boxes installed in open-wells of agricultural habitats for the first time.

In the area of *Improvement and Management of Horticultural crops,* a mango hybrid Ambika, suitable for international market, has been released. A technique for embryo rescue, and a technology for uniform ripening of mango have been developed. In banana, a natural tetraploid (ABBB) has been reported for the first time. Processing technologies of banana fruit and flower for pickle, and banana flour-based products like health-drink, baby-food and biscuits have been standardized. A software METWIN2 has been found suitable for forecasting downy mildew in grapes.

Production technology of saffron cultivation has been standardized. A technology package has been developed for mechanized sorting, waxing, washing and packing of fruits in corrugated boxes, which includes aspects of degreening and storage to improve their shelf-life.

Salient achievements in vegetable crops are: release of one variety each in bottle-gourd and bitter-gourd; development of five bitter-gourd populations with very high proportion of pistillate flowers; and identification of female sex-associated RAPD marker in pointed gourd to screen gender of plants at the seedling stage.

In potato, 77 new accessions from the International Potato Centre, Lima, and 12 indigenous samples from Kashmir and Meghalaya have been added to germplasm, and 18 transgenics from Kufri Badshah and 20 from other four cultivars of potato have been developed for field trials. A computerized management tool for identification and management of major potato pests and diseases has been developed. In tropical tuber crops, 30 tonnes of planting material was distributed among farmers.

A total of 204 wild mushroom specimens have been collected. A new species of *Lysurus* as *L. himalayanesis* sp. nov. has been reported from Himachal Pradesh, which is a new record in the world. Most-prized medicinal mushroom Reishi or Ling Zhi (*Ganoderoma lucidum*) could be successfully grown for the first time in the country and indigenous technology to organically produce Red Reishi has been developed.

In floriculture, two varieties of gladiolus have been released. A low-priced method of orchid micro-propagation has been developed, using *isabgol* as a gelling agent and polypropylene bags as culture vessels.

In plantation crops, 34 collections of coconut have been made. Fertigation has been found to reduce fertilizer requirement up to 50% NPK in arecanut palm. A cam type, pedal-operated, cashewnut sheller has been developed to overcome drudgery experienced in presently used hand-cum-pedal-operated sheller. In cashewnut 102,212 grafts

were produced and distributed to different governments, NGOs and farmers.

In spices, 234 accessions have been added for germplasm conservation. A RAPD-based molecular marker technique has been developed in black pepper for identification of true hybrids.

In the area of *Natural Resource Management*, important achievements include: preparation of soil map of India on 1 : 1 million scale for land-use planning for sustainable agricultural production; and publication of soil resource atlases of Bhopal, Guna, Betul and Ratlam districts. Soil-erosion maps for seven states were generated for formulating soil-conservation and management measures. Cost-effective bio-engineering measures could be developed integrating structural control measures with appropriate vegetation of *Erianthus munja*, *Ipomoea carnea* and/or giant napier.

Integrated nutrient management for realizing sustainability was given priority. The significant findings included: addition of lime and farmyard manure (FYM) for sustainable management of acid soils; and standardization of assessing methods for survival of inoculated microbes (*Azospirillum* and *Azotobacter*), using stable genetic markers.

Implementation of natural resource management project in the command area of RP Channel-V of Sone Canal System in Bihar and Gandak Command of eastern Uttar Pradesh demonstrated significant reduction in the cost of field preparation, weeding and labour requirement and resulted in higher yield and net income of people. Adoption of alternate raised-and-sunken bed system and consequent enhancement in the productivity owing to *in-situ* conservation of rainwater in rice fields was quite encouraging.

Soil salinity research in coastal ecosystem led to precise assessment of soil salinity using GIS technique in large areas in an irrigation command, thus providing the right approach for managing such soils. Significant reduction in soil salinity and chloride content in 0–30 cm soil depth was recorded owing to leaching through sub-surface drainage. For rehabilitation of calcareous soils, *Tamarix articulata*, *Acacia nilotica*, *Prosopis juliflora, Eucalyptus tereticornis, Acacia tortilis, Cassia siamea* and *Feronia limonia* have been found promising for plantation with furrow planting method in arid and semi-arid regions. *Salvadora persica* proved the ideal species for soil and water management in saline black soils.

Shift in rainfall pattern in the adjoining districts of Anantapur and Bijapur of Karnataka necessitated the need for recommendation of new cropping strategy. Rice varieties, viz. Karzat 4, Indryani, Panvel 2, Palgarh 1 and Palgarh 2, being shade-tolerant, have been found suitable for regions experiencing excessive clouds during the rainy season. An equation developed based on weather parameters could predict occurrence of powdery mildew two weeks in advance in *ber*. A simple model has also been developed for advance estimation of national foodgrains' productivity.

Efficient cropping systems for different agro-ecozones have been identified. Superiority of direct-seeded rice to transplanted one has been proved. A new technique for rapid decomposition of rice straw under rice–wheat system was developed.

Farming systems research indicated higher net returns by integration of rice–brinjal cropping system with mushroom and poultry, and possible incorporation of fruit wastes (nutmeg rind, parts of jackfruit and breadfruit) in livestock feeds, which are rich sources of fat and fibres.

Clonal propagation techniques were standardized for white silk cotton tree (*Ceiba pentandra*) using cuttings, grafting and air layering. Vegetative propagation showed maximum (40%) success through veneer grafting in August month and 20% through chip-budding in *chironjee* (*Buchanania lanzan*). August was found as the best month for *aonla* grafting with 85% success.

Under *Livestock and Poultry Improvement and Management*, Kankrej, Ponwar, Gangatiri and Kherigarh cattle breeds; and Jalauni, Kheri, Mandya, Hassan and Mecheri sheep breeds were surveyed in their home tract for characterization and conservation of genetic resources. Insulin-like growth factor binding protein-3 gene was studied in cattle. The dwarf and naked neck birds were found superior in antibody titres to their crosses. Molecular characterization of Indian livestock and poultry breeds is being done at different centres. The DNA repository was established for some of the Indian livestock and poultry breeds.

Twin lambing could be improved to 52% in Garole × Malpura strain. The adult clip in Magra sheep was 1.779 kg. Rabbits weaned at 28 days of age showed highest daily weight gain. Strain cross of poultry developed by the CARI produced 301.8 eggs, being higher than prominent commercial strains. Feed requirement in layer birds was reduced by 174 g to produce a dozen eggs. Synthetic broilers attained 1,101 g at five weeks of age and Caribro-Dhanraj weighed 1,595 g at seven weeks of age. Poultry germplasm developed for rural poultry could adapt well in free-range scavenging situation. Upsurge in heterologous strains of foot-and-mouth disease (FMD) has been observed as the isolates recovered were antigenically different from the vaccine strain. Indigenously developed C-ELISA kit for rinderpest was validated by the International Atomic Energy Agency, Vienna. Infectious bovine rhinotrachitis (IBR) continues to be the major herd problem, as the virus excretes through semen. Thus, complete genome sequence of IBR virus and vaccine strain was developed. Polymorphic chain reaction (PCR) for amplification of RNA gene of *Theileria annulata* was standardized. A repository of *Pasteurella multocida* isolates has been established. Vaccine against *Salmonella abortus-equi* was prepared using Outer Membrane Protein (OMP) and gave encouraging results. Zero level has been achieved in equine infectious anaemia (EIA) and rinderpest (RP) infection in India. The PCR tests were standardized for babesiosis in equine and trypanosomiasis in camel.

Feedbase-2001, a data base, provides information on feed resources and feed balance sheet, which would be a very important requirement for policy-makers, planners and researchers. Prediction of bypass protein value of feeds is possible now. Barley proved a better energy ration for ruminants than other costly ingredients. Supplementation of area-specific minerals to cows improved their fertility. Costly poultry ration could be made low priced by using foxtail millet in place of 57% maize in broiler starter ration and 67% in finisher ration. Use of propionic acid, neem leaf and neem seed-cake in feed effectively prevented mould infestation of poultry. Complete feed formulation technology is now available for commercialization.

Buffalo embryos were developed *in-vitro* using complex media. Use of this media resulted in more blastocysts per cleaved embryo. Introduction of rams after a gap of four months brought the ewes to estrous within 15 days. Pregnant mare serum gonadotropin, a hormone also used in embryo transfer technology in animals other than equines, could be isolated, purified and characterized for the first time in India.

Under the Jai Vigyan Project on Household and Nutritional Security for Tribal, Backward and Hilly Areas, migratory sheep, integrated piggery and backyard poultry were studied. The backyard poultry system provided nutritional security in one of the remotest villages near the China border.

Low-cost processed cheese has been prepared. A technology was developed for fruit *dahi* preparation. *Dahi* was also prepared from camel milk. Dehydrated instant chicken soup mix using spent hen, and egg crepe, a convenience egg-rich item, were developed. Food-borne pathogens testing methods were developed to verify quality of products. Inclusion of red chilli in chicken meat products improved its storage stability. Equine and camel hairs could be blended to develop naturally coloured furnishing fabrics.

In *Fish Production and Processing*, under the inland sector, a complete inventory and mapping of large water-bodies of more than 10 hectares in West Bengal were done through digital image-processing technique using satellite data. The management guidelines based on biogenic production potential were formulated for four reservoirs of southern Rajasthan.

Under culture fisheries, the medium carp, *Puntius gonionotus* was incorporated in culture system to diversify freshwater aquaculture. Maturity could be advanced in Indian major carps on supplementing semi-balanced diet with lysine and methionine. In north and north-eastern states, more than 100 species of ornamental fishes were identified. Captive breeding of *Carassius auratus, Puntius conchonius* and *Colisa fasciata* was standardized. In gold fish, four variants in body colouration and caudal fin formation could be recorded.

Under coldwater fisheries, the water quality of glacier and spring fed streams of Garhwal Himalayas was found quite congenial for sustaining fish and benthic food-chain, and potential sites for conservation of 'mahseer' and snow trout could be located in these streams. Significant variation was observed in size and fecundity of 'mahseer' stocks in riverine and lacustrine zones of Uttaranchal. Under brackishwater aquaculture, an immuno-stimulant technique was developed to tackle shrimp disease problems and reverse transcriptase polymerase chain reaction technique was standardized for detection of yellow head virus disease in farmed shrimp.

In mariculture, broodstock development, breeding and larval rearing of damselfish *Chrysiptera unimaculata* and grouper, *Epinephelus malabricus* have been achieved in captivity. Development of production technology of ready-to-consume fried mussel in flexible retortable pouch with shelf-life of more than one year at room temperature, and standardization of production technology of battered and breaded balls from small squids as raw material, which otherwise was not suitable for export, are the highlights of fish harvest and processing technology.

In fish genetic resources, polymorphic micro-satellite loci from nine prioritized species were identified. Sperms of wild accessions of *Horabagrus, Labeo, Catla* and *Cirrhinus* species were cryo-preserved, and six species of *Labeo* were genetically characterized. Besides, CIFELOSTRESS formulation to reduce stress and resultant mortality of fish seed during transportation and a diagnostic PCR kit for dreaded white spot syndrome virus (WSSV) have been developed.

In *Agricultural Engineering and Technology,* following implements have been developed: rotavator attachment for self-propelled reaper, power-tiller operated wetland leveler, tractor-mounted turmeric digger, tractor-mounted hydraulically-operated hoist (for harvesting mango, guava,

sapota and coconut etc.) and tractor-operated straw chopper-cum-spreader (to solve the problem of rice-straw management). A 4-row manually operated rice-seeder has been refined and was found to be 70.8% labour, 87.11% energy and 83.67% cost-effective in seeding of sprouted rice compared to mechanized transplanting of seedlings.

Prototype feasibility testing of tractor-mounted rotavator, pulverizing roller attachment and zero-till drill, ANGRAU hydrotiller, animal-drawn puddler (for NEH region), light-weight power-weeder for interculture and self-propelled vertical conveyor-reaper was carried out, and has shown promising results.

In post-harvest engineering and technology, 'okara', a by-product of soymilk has been used for preparing high-fibre nutritious soy-cereals based snacks, and a technology has also been standardized for jaggery-chocolate production.

Complete or partial substitution of conventional wet chemical process by the development of plasma treatment in preparation of grey-cotton fabric for dyeing; and 25% reduction in pollution load and 30% saving in energy with the new biochemical scouring technique, when coupled with the existing hand-processing unit, are the highlights in cotton technology. Work under jute technology led to the development of a novel method for simultaneous alkali treatment and bleaching of jute. Major finding in lac technology is the development of sustainable technology for quality brood and sticklac production on *ber*.

In energy in agriculture, major developments are: a family-size, solid state anaerobic digester for agro-residues; biogas plant of 6 m^3 capacity (floating dome-type, suitable for high water-table regions), groundnut shell-based Open Core Down Draft Gasifier, and simple electronic temperature controller for use on natural convection solar dryer.

Under irrigation and drainage, an underground irrigation grid system has been designed and installed at the CIAE Farm, Bhopal. A portable automatic multi-outlet irrigation system was designed to apply water to furrows. Surface drains at 15–20 m spacing were found sufficient to remove excess run-off water from soybean fields in Vertisols.

Under *Agricultural Human Resource Development,* financial support was given to the State Agricultural Universities (SAUs) for development of under-graduate (UG) and post-graduate (PG) programmes to expand, develop and improve quality, relevance and utility in agricultural education and training, and for instructional farm development; computerization and internet facilities were given under the capacity development programme of the ICAR.

In order to ensure quality of agricultural education and manpower development, the following initiatives were undertaken: accreditation of 16 SAUs and 3 deemed-to-be universities (DUs), completion of revision of PG curricula and syllabi, publication of accreditation-related information, provision of admission to foreign nationals in the ICAR DUs and SAUs, organization of 82 Summer/Winter Schools and Short Courses, conducting examination to provide opportunity to meritorious students for seeking education in an institution of their choice, preparation of perspective plan to strengthen agricultural education and human resource development, and awarding 201 senior research fellowships, 470 junior research fellowships and 230 national talent scholarships.

Under *Social Sciences and Policies*, progress of watershed programmes launched in rainfed areas to improve conditions of rural poor was studied. With watershed management, water run-off rate was reduced by 34%, and groundwater recharge increased by 64%.

Investment in agriculture must grow at 7.91% per annum to realize the target growth in agriculture. A study under the National Centre for Agricultural Economics and Policy (NCAP) Outreach Programme revealed that diversification in agriculture is necessary to improve farmers' conditions in the western Uttar Pradesh.

A method has been developed for the estimation of crop yield at the block level. Area of potato and ginger and their yields were estimated in north-eastern states. A methodology has been developed for forecasting fish production from ponds.

The Agricultural Technology Information Centres (ATICs) of the ICAR institutes/SAUs are providing 'Single Window' delivery system for technology products, diagnostic technology services and information available in the institutes to the farmers.

Under *Technology Assessment, Refinement and Transfer*, the Krishi Vigyan Kendras (KVKs) organized 18,461 training courses benefiting 0.43 million farmers and farm women, 3,237 vocational and skill-oriented training courses benefiting 66,000 rural youths and 1,643 training programmes benefiting 41,000 in-service personnel in various aspects of agriculture. The eight Trainers' Training Centres (TTCs) organized 188 training courses benefiting 2,893 participants, and two more TTCs in areas of vegetables and citrus have been sanctioned.

In a joint project of the Divisions of Crop Science and Agricultural Extension on multi-location trials across various crop ecologies in different parts of the country, superior yielding varieties of wheat and pigeonpea have been identified.

In the area of *Women in Agriculture,* major findings of the All-India Co-ordinated Research Project on Home Science include: identification of 36 new sources of natural dyes, enhancement in work efficiency with improved tools, and development of nine technology kits consisting of multimedia resource materials for knowledge empowerment of extension workers. The National Research Centre for Women in Agriculture (NRCWA) organized 30 training programmes benefiting 887 farm women. In addition, KVKs have imparted training to 1.10 lakh farm women in different specialised activities.

Under *Research for Tribal and Hill Regions,* salient achievements of the Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, are: the release of VL Gehun 804 of wheat and Vivek Matar 8 of pea for northern hill zone, and VL Madira 181 of barnyard millet for Bihar, Karnataka, Madhya Pradesh and Tamil Nadu; identification of Vivek Sankul Makka 11 maize composite and VLT 9531 tomato for release in Uttaranchal; two short-duration blast-resistant rice strains and a exotic capsicum line VHC 12 for release in Uttaranchal hills; development of low-cost, poly-tunnel technology for 1-month advance production of capsicum and tomato during winter; and reduction in blast score and stem-borer incidence in organically fertilized basmati rice plots compared to chemically fertilized ones.

The studies conducted at the ICAR Research Complex for NEH, Umiam, resulted in the release of four varieties of rice, collection of 1,645 germplasm, release of Megha Turmeric 1 variety of turmeric, preparation of citrus-rejuvenation package and production of tissue-cultured disease-free material for farming community, reduction in HCN content of bamboo leaves for feeding livestock, development of DNA-based rapid diagnosis techniques for salmonella and clostridial diseases, revelation of watershed-based technologies to reduce soil loss, perfection of technology for processing of soybean into soya milk, paneer and biscuits, and training of farmers of

NEH region for using and manufacturing modified agricultural implements.

The Central Agricultural Research Institute, Port Blair, recommended staggered planting at 1-month intervals for round-the-year availability of tuberose flowers; developed brinjal somaclones and herbal antimicrobial, anti-inflammatory and anti-histaminic formulation, mouth wash and vaginal contraceptive; produced on a large-scale, Quicken, a fertile intergeneric hybrid of quail; standardized for the first-time common clown (*Amphiprion percula*) culturing in India; and achieved successful larval rearing of *Macrobrachium rosenbergii* and production of juveniles.

In the organization and management (O&M) programme of *National Agricultural Technology Project,* the O&M Task Force has made several sub-committees on various aspects of reforms. In institutionalizing research priority setting, monitoring and evaluation (PME) in the National Agricultural Research System (NARS), 25 PME cells (13 in SAUs and 12 in ICAR) have been established. Two web-based networks, one among agricultural economists and the other among agricultural statisticians, have been made operational for information exchange and creating a primary-source dynamic database of economic and social information on the Indian farming situation.

In production system research, significant findings include: development of natural dye production technology from safflower petals which provides farmers additional income (60–70%), a package of practices maintaining aflatoxin level in groundnut required by importers and identification of sweet sorghum genotypes for alcohol production under rainfed agro-ecosystem; development of improved technology package for *boro* rice cultivation and fabrication of a prototype for cotton stick and bur remover to reduce farmers' drudgery under irrigated agro-ecosystem; popularization of *Oryctes rhinoceros* control by virus, standardization of technology for broodstock development and feed, and development of a vaccine for the control of duck pasteurollosis under coastal agro-ecosystem.

Development of 28 hybrids of different crops with improved quality, high yield and disease resistance; production of cabbage, tomato and chickpea using IPM and without pesticidal sprays; first time report of eight new species of fish; and development of a technology for packing ready-to-eat fish preparations are the major achievements under the mission mode research.

Under team of excellence (TOE) mode, developed a user-friendly crop-modelling framework 'Info Crop'; identified rust-resistance genes in wheat; developed an eco-friendly and value-addition method for use of slaughterhouse by-products for protein recovery (suitable for feeding pets and livestock), and the Immuno-O-Check kit for the detection of passive transfer failure in buffalo calves.

In competitive grants programme, 443 projects have been sanctioned. Significant results include: production of viral cDNA to develop transgenic papaya resistant to ring spot virus; identification of microsatellite molecular marker (RM 258) to be linked with fertility-restorer genes for use in basmati rice breeding; presence of nematicidal property in effluents of cassava-based starch factory against root-knot nematode; standardization of large-scale production protocols for medicinal plants, viz. *Chlorophytum* and *Rauvolfia*; development of technology for production of fish cakes and sausages; and standardization of protocol for isolation and purification of immuno-protective antigens.

In technology assessment and refinement through institution-village linkage programme (IVLP) accomplishments are: 50% increase in number of kids on crossing *desi* goats with improved buck (Beetal); increase

in net returns of Rs 15,992 when elephant-foot-yam intercropped with banana, and from Rs 18,000 to Rs 37,440 on introducing catla, rohu and mrigala in 20 : 70 : 10 ratio; increase in milk yield of 1.5–2.5 litres/ animal/day on licking of multinutrient block by cattle and buffaloes; fruit yield increase of 150% on adoption of integrated plant nutrient system (IPNS) in orange orchards; and significant impact of interventions like bee-keeping and button mushroom cultivation on landless villagers. Under innovations in technology dissemination, telephone helplines have been installed in eight ATICs.

The ICAR has taken a number of initiatives under *Organization and Management* to improve working environment and to make research need based, effective, efficient and relevant. For the first time, a Screening Committee was constituted for finalization of Annual Recruitment Plan of the ICAR system. The recommendations of the Sub-committee on Administrative Matters of the O&M Task Force were sent to all Subject-Matter Divisions of the Council to process them for operationalization/implementation. The constitution of eight Task Forces was recommended by the Standing Policy Planning Committee of the Governing Body under Chairmanship of Dr M S Swaminathan. During the year, 24 institutes/centres were notified in the Gazette of the Government of India under rule 10 (4) of the Official Language Rule 1976.

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan and Non-Plan) for 2001–2002 were Rs 14,045.5 million and Rs 1,325 million, respectively; and BE for 2002–2003 (Plan and Non-Plan) is Rs 14,980.5 million.

This year, 27 scientists and their 46 associates from ICAR institutes; and 18 scientists/teachers and their 13 associates from SAUs; received awards under different categories. Of the total awardees, 15% were the women scientists.

The DARE and ICAR have been operating *Partnership and Linkages* at the national and international level through the Memoranda of Understanding (MoUs)/Work Plans/ Training Courses/Exchange Visits, etc. Two agreements and a protocol were signed between ICAR/DARE and Iran, Namibia and Bulgaria. Under international linkages, five projects have been approved. Under protocol activities, foreign delegations visited India and Indian delegations visited foreign countries. Other achievements include organization of a Plan Policy Dialogue on Forward Thinking Policies for Groundwater Management – Energy Resources and Economic Approaches between ICAR and International Water Management Institute, Colombo; and a meeting of Counsellors-in-charge of Agriculture in Embassies/High Commissions/Honorary Consulates General/ Honorary Consulates to inform them about training facilities available within the NARS.

The *Directorate of Information and Publications of Agriculture* (DIPA) brought out 50 publications including *Handbook of Animal Husbandry* in English and 11 in Hindi besides regular research monthly journals/magazines, viz. *The Indian Journal of Agricultural Sciences, The Indian Journal of Animal Sciences, Indian Farming,* and *Kheti*, and quarterly semi-technical magazines/newsletters, viz. *Indian Horticulture*, *Phal-Phool*, *Krishi Chayanika, ICAR Reporter, ICAR News* and *ARIS News.* Special issues/accent numbers of periodicals were also brought out on the occasions/themes of World Food Day, International Agronomy Congress, ICAR Foundation Day, Floriculture and Environment. Of late, the DIPA has made inroads into e-publishing in a big way and has released

four CDs, viz. on-going research projects of ICAR institutes, e-book on *Handbook of Horticulture,* photographic material of the ICAR, and *ICAR Vision 2020*. The DIPA earned about Rs 4 million (up to January 2003) through sale of its publications and advertisements, and participated in various exhibitions and displayed its publications. The Agricultural Research Information Centre developed the National Agricultural Database (as a part of the ICAR-CABI Work Plan under NATP Programme), a database on 82 AICRPs, and upgraded Webpage of DIPA. About 14,000 readers visited the ICAR Library and consulted 20,000 publications.

Publicity and Public Relations Unit issued materials of current importance to various newspapers, agricultural and current affairs magazines and electronic media; and achievements of the Council in agricultural research, extension and education were covered adequately at national and regional levels. The video films prepared on the Council's activities and achievements and important issues of immediate concern to farmers were distributed to various ICAR institutes, KVKs and Extension Directorates of SAUs for wider dissemination of information. A NICNET-based Public Information and Facilitation Centre was established to bring greater transparency through better access to information.

(MANGALA RAI)
Secretary (DARE) & DG, ICAR

Salient Achievements

2. Salient Achievements
Crop Improvement and Management

PLANT GENETIC RESOURCES

Germplasm Exploration and Collection

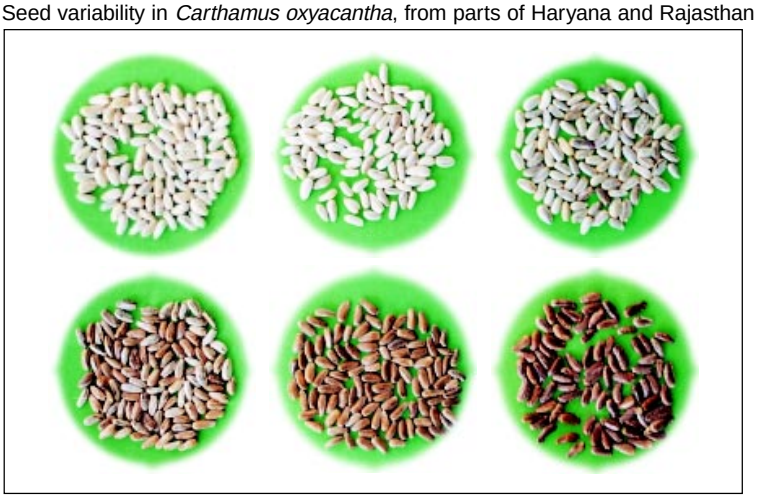
A total of 236 explorations have resulted in the collection of 15,243 accessions of different crops and their wild relatives. Important were 12 explorations undertaken in the Sardar Sarovar Catchment area; as a special mission to capture and rescue most of the existing plant genetic resources. In all, 27,847 samples of crops from 39 countries (including 79 samples of transgenic crops) and 59,745 of different international trials from the IRRI, Philippines; CIMMYT, Mexico, Nepal and Thailand and ICARDA, Syria, were introduced. A total of 3,961 samples were exported to 23 countries. Besides, 1,055 explorations were undertaken, and 64,520 accessions comprising crop landraces, local cultivars, trait-specific materials, crops' wild relatives, less-known species and wild economic plants were collected. Inland supply of germplasm comprised 6,990 samples of diverse crops.

Germplasm Conservation

In the National Seed Genebank, 27,245 accessions of the orthodox seed species have been added, making the total to 231,539 in the year. These include cereals (5,861), millets and forages (12,733), pseudo-cereals (540), grain-legumes (2,002), oilseeds (3,976), fibre crops (480), vegetables (385), fruits (41), medicinal and aromatic plants (418), narcotics (141), spices and condiments (488), genetic stocks (37) and duplicate safety samples (143). Two hundred and twelve released varieties and 32 parental lines were received and were added to the long-term conservation. In the cryobank, 733 accessions were cryopreserved as seeds, embryos, embryonic axes, making the total to 4,609 accessions. *In-vitro* cultures of 78 accessions in the *in-vitro* Genebank have resulted in 1,254 accessions in total.

Accessions conserved in long-term storage are 66, 292 and in medium storage are 36, 834.

Seed variability in *Carthamus oxyacantha*, from parts of Haryana and Rajasthan



- Undertook twelve explorations to capture and rescue the existing plant genetic resources at the Sardar Sarovar Catchment area.
- In the National Seed Genebank, the total has reached to 231,539 accessions.
- Issued 31 phytosanitary certificates for the export material.
- ARIS cell has computerized information on 4.5 lakh exotic and 2.5 lakh indigenous collections.
- Submitted to Genbank, 2 Mb of rice chromosome 11 data after sequencing.

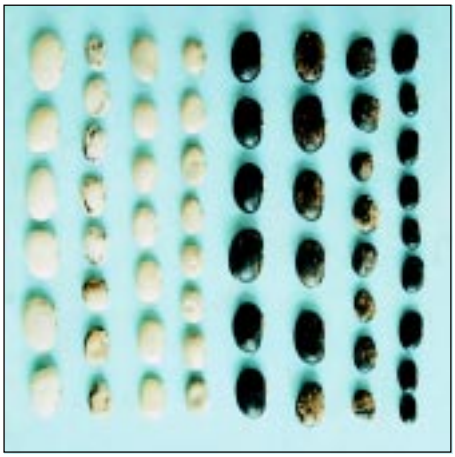
SUCCESS STORY

KIWI IN HIMACHAL PRADESH

Regional Station of the NBPGR at Shimla has been the pioneer in introduction, multiplication and early initiatives for commercial cultivation of Kiwi (*Actinidia chinensis*) in India, especially in Himachal

Kiwi fruit *Actinidia chinensis* in bearing at the NBPGR Regional Station, Shimla

Pradesh. It organizes "Kiwi Days" in February and March to impart training to farmers on various aspects of Kiwi cultivation. Till date, more than 10,000 rooted plants have been distributed all-over India, and about 500 farmers have adopted Kiwi for commercial cultivation.



Mucuna prurita seeds variability, assembled at the NBPGR Regional Station, Jodhpur

PROMISING ACCESSIONS IDENTIFIED OF DIFFERENT CROPS

Plant and characteristics	Accessions
High number of seeds/siliqua	
in *Brassica compestiris* variety yellow sarson	IC 261660
High number of seeds/pod	
in cowpea	EC 20584
in urdbean	IPU 99-89
Early maturity	
in *Brassica juncea*	IC 261646
in cowpea	IC 276938
in pea	IC 276598
Brassica	
for high oil percentage	IC 268315-1 (53.08%), IC 261672 (52.29%), IC 261666 (51.49%), IC 261647 (50.73%), IC 261658 (49.52%)
for low erucic acid	Hyola 401 (0%), EC 399915 (1.0%), EC 399918 (3.6%), EC 366271 (3.7%), EC 473769 (4.58%)
Walnut	
for oil content	GP/ANT 129 (79.4%), GP/ANT 127 (78.6%), GP/ANT 133 (78.0%)
for protein content	EC 26860 (25.7%), GP/ANT 92 (24.2%)

GERMPLASM REGISTERED

Crop	No. of genotypes
Paddy	13
Pigeonpea	6
Groundnut	4
Coffee	7
Cotton	40
Miscellaneous	22

Plant Quarantine

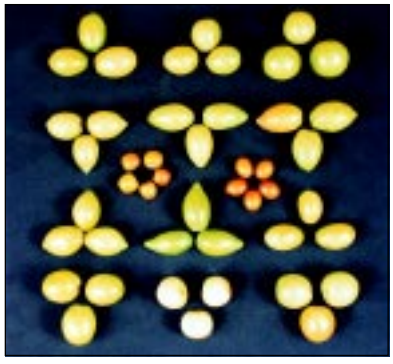
A total of 138,364 samples of crops including 91 transgenics were processed for quarantine clearance; comprising 132,271 under import and 6,093 under export. Some important interceptions, not yet reported from India, include pathogens (*Peronospora manschurica,* downy mildew in *Glycine max* from the USA) and insects (*Bruchophagus gibbus* in *Medicago sativa* from the USA; *Bruchus ervi* in *Lens culinaris* from Syria; *Sitophilus granarius* in *Triticum aestivum* from the USA). Of the export samples, 248 samples found infested/infected were salvaged before release. Thirty-one phytosanitary certificates were issued for the material under export.

ELISA testing of 30 samples, out of 91 (sunflower, *Parthenium* and other weeds), showed positive results against tobacco streak virus (TSV). TSV was also found positive in 70 advanced breeding lines of groundnut developed by the ICRISAT.

Fruit variability in citrus species, collected from the central Himalayan Region

Fruit variability in less-known vegetable of Himalayan Region, chow-chow (*Sechium edule*)

Ziziphus species fruit variability, maintained at the NBPGR Station, Jodhpur



DNA Fingerprinting

Cereals and millets. A total of 76 non-aromatic rice varieties were fingerprinted using Amplified Fragment Length Polymorphism (AFLP) markers. Sequence Tagged Microsatellite (STMS) and AFLP markers were used for fingerprinting 137 wheat varieties. Sorghum cultivars (38) were profiled using 6 fluorescently labelled STMS primer pairs.

Pulses. Pigeonpea (31) and chickpea (36) varieties were fingerprinted using RAPD, AFLP and STMS markers; in chickpea AFLP and STMS markers were highly efficient.

Oilseeds. Brassica accessions (42) belonging to *B. juncea, B. carinata, B. campestris, B. nigra, B. napus* and *Eruca sativa* were fingerprinted using AFLP-based DNA markers. Seventy-eight released cultivars of soybean were fingerprinted with 12 most informative primers. Safflower cultivars (14) were fingerprinted using 15 AFLP primer pairs. AFLP analysis of 72 Indian soybean cultivars indicated presence of moderately high genetic diversity; much of the diversity appeared to be due to 12 varieties.

Fibre crops. For AFLP analysis of 65 diploid cotton cultivars, 6 primer pairs were used. Most cultivars could be distinguished from one another using these primers.

Citrus and banana. DNA fingerprinting of citrus using 15 AFLP primer-pair combinations indicated that the rough lemon types, the oranges and the pummelos could be differentiated using molecular markers.

Molecular diversity analysis of over 34 banana accessions of 6 cultivars, collected from different banana-growing regions, has indicated the presence of considerable intra-cultivar variation.

Neem. DNA fingerprints of 8 exotic and 69 indigenous neem were obtained with AFLP markers. Exotic lines were grouped into a separate cluster; indicating that Indian neem genepool is different from exotic.

Plant Biotechnology

Till date, physical map region of the long arm of the chromosome 11 of rice between position 57.3 cM and 84.3 cM has been developed by the National Research Centre for Plant Biotechnology, and more than 2 Mb data have been submitted to the Genbank after sequencing.

Protease inhibitor and lectin genes and promoter sequences have been isolated from the indigenous legumes. These genes are being mobilized in different crops for developing transgenic plants with resistance to insect pests.

Using genetic transformation systems, more than 100 *Bt*-transgenic rice lines from 3 elite *indica* rice cultivars, IR 64, Pusa Basmati 1 and Karnal Local, have been generated using a codon optimized, synthetic and truncated *Bt*-gene, *cryIAc*.

A novel *Bt-vip* gene was cloned and sequenced from Bt Serovar tolwarthi. The deduced amino acid sequence has revealed that vegetative insecticidal protein (VIP) encoded by the novel gene (*vipto*) differs from the VIP3a with respect to 23 amino acids. The gene was cloned in a plant transformation vector, and transgenic tobacco plants were developed by *Agrobacterium* transformation. Insect bioassays using

ONE RESTORER GENE FOR 2 CMS SYSTEMS (*BRASSICA* AND *DIPLOTAXIS*)

A dominant fertility restorer gene from *Diplotaxis catholica* into *Brassica juncea* was introgressed that conferred male fertility to CMS *B. juncea* line, carrying *D. catholica* cytoplasm. This restorer was very efficient in conferring male fertility but in some cases restorer flowers lacked petals. A restorer that can bring about male fertility restoration without altering normal flower phenotype has been identified. The restorer gene of CMS (*Moricandia arvensis*) *B. juncea* has been found to restore fertility in CMS *D. catholica* as well. The restored plants produced normal flowers. This is the first instance where one restorer gene works for two different systems.

IN-VITRO CRYOPRESERVATION OF *DIOSCOREA*

Dioscorea deltoidea and *D. floribunda* are the important sources of diosgenin, an alkaloid used in steroidal drugs. Successful protocols for shoot-tips cryopreservation of these with subsequent high frequency of plant regeneration have been developed. Periodical testing of these from cryostorage has revealed that they can be maintained with unaltered regeneration frequency up to 12 and 18 months, respectively. And the regenerated plants, after cryopreservation, were found with unaltered capacity for diosgenin production.

- Standardized transformation protocol of mungbean for transfer of cowpea-protease inhibitor gene.
- The restorer gene of CMS *(Moricandia arvensis) Brassica juncea* found to restore fertility in CMS *Diplotaxis catholica* as well. This is the first instance where one restorer gene worked for 2 different systems.

International rice genome sequencing consortium shares different chromosomes of rice. (Country flag shown on each rice chromosome represents its share of sequencing)

first instar larvae of *Spodoptera litura* (tobacco caterpillar) have revealed significant *in planta* insecticidal activity of VIP.

Biochemical and physiological analyses of the second generation of osmotin potato plants in greenhouse under controlled water supply have been done. In the last crop season, third generation tubers (T3) from the previous year were sown in 65 pots (single tuber per pot) in the greenhouse to collect maximum number of tubers for subsequent field trial. All plants were screened by PCR for transgene expression and were found positive. The PCR amplified products have been further visualized and confirmed by the hybridization with digoxygenin labelled nptII primers in the Southern blots.

A transformation protocol of *Vigna radiata* (mungbean) cv Pusa Vishal and Pusa 9072 for transfer of cowpea protease inhibitor gene has been standardized.

FOOD CROPS

RICE

Crop Improvement

In rice, 21 varieties and one hybrid have been released.

Rice varieties released

Variety	Days to 50% flowering	Grain type	Ecosystem	Yield range (tonnes/ha)	Reaction to pests/diseases	Recommended and characteristics
			Central Releases			
Anjali	60–65	SB	Rainfed uplands	3.5–4.5	R–GM 1,3	Bihar, Assam, Orissa
KRH 2	95	MS	Irrigated areas	5.5–6.5	MR–Blast, BS	Andhra Pradesh, Karnataka, Tripura, Tamil Nadu, Maharashtra, Haryana, Uttaranchal, Rajasthan
			State Releases			
Rashmi	76	LS	Rainfed shallow lands	3.5–4.0	R–GM 1, SB, Blast	Madhya Pradesh, for rainfed ecosystem
Harsha	75–80	LB	Rainfed uplands	4.5–5.5	MR–Blast	Kerala, for direct-seeded uplands
SKL 8	100–105	LS	Rainfed shallow lands	5.0–5.5	R–GM, SB; MR–Blast	Maharashtra, for lowlands
ADT (R) 45	75	MS	Irrigated areas	5.5–6.1	R–GM 1; MR–SB,BPH	Tamil Nadu, for both direct sown and transplanted rices
BR 2655-9-3-1	110–115	MB	Irrigated areas	7.5–8.6	MR–Blast	Karnataka
Mugad Sugandha	95–100	LS	Irrigated areas	3.2–3.5	MR–Blast, LF, SB	Karnataka; aromatic rice, also good for parboiling
Sharavathi	140–145	MB	Rainfed shallow lands	5.0–5.5	MR–Blast	Karnataka, for normal lowlands, and also temperate hill zone of Karnataka
TRY (R) 2	80–85	LS	Coastal saline	3.5–4.0	–	Tamil Nadu, for saline and alkaline areas
Panvel 3	95–100	LB	Coastal saline	4.5–5.0	MR–Blast, SB, BPH	Maharashtra, for coastal saline soils
Kohsaar	90–95	SB	Irrigated hills	4.3–4.5	MR–Blast	Jammu and Kashmir for Irrigated, high elevation areas of Kashmir

(*continued*)

Anjali rice. It is a Central Release for rainfed uplands; recommended for Bihar, Assam, and Orissa. Its yield ranges from 3.5 to 4.5 tonnes/ha

- IR 68888 A, DRR 2A and CRMS 31A are new CMS lines of rice possessing desirable quality traits.
- Through marker-aided selection, bacterial leaf blight resistance genes *xa 5*, *xa 13*, *xa 21* are being introgressed into BPT 5204 and Triguna rice.
- Rice hybrids PHB 71 and KRH 2 found promising in nitrogen-use efficiency.

Rice varieties released (*continued*)

Variety	Days to 50% flowering	Grain type	Ecosystem	Yield range (tonnes/ha)	Reaction to pests/diseases	Recommended and characteristics
Jagtiala Sannalu	90–95	MS	Irrigated areas	5.8–6.3	R–GM1	Andhra Pradesh, for both *kharif* and *rabi*
Jagtial Mahsuri	100–105	MS	Irrigated areas	5.5–6.0	MR–BLB, BPH, Blast, GM (3, 4)	Andhra Pradesh for North Telengana
Varalu	60–65	LS	Rainfed upland irrigated	2.0–3.0 4.5–5.0	MR–GM (1,3,5)	Andhra Pradesh, for *kharif*, *rabi* and *Edagaru*
Sumati	105–110	LS	Irrigated areas	5.3	MR–Blast, GM	Andhra Pradesh; aromatic, good elongation on cooking
Bapatla Sannalu	135	MS	Rainfed shallow lands	5.6	R–BLB	Andhra Pradesh, N-responsive, can withstand submergence up to 10 days, suitable for single crop wetlands, for *kharif*
Santhi	90–95	LS	Irrigated areas	5.0	R–Blast, MR–WBPH, BS and ShR	Andhra Pradesh, for both *kharif* and *rabi;* with good cooking quality
Apurva	105	MS	Irrigated areas	7.0	R–Blast	Andhra Pradesh, for both *kharif* and *rabi*
Nandyal Sannalu	105	LS	Irrigated area	6.5	MR–BPH, LF	Andhra Pradesh, suitable for both plantings; good cooking quality, comparable to Samba Mahsuri
Tholakari	125	MS	Rainfed shallow lowlands	5.5–6.0	MR–BPH, BLB	Andhra Pradesh; three weeks dormancy
Godavari	120	MS	Rainfed shallow lowlands	5.5–6.0	MR–BLB, BPH	Andhra Pradesh, one week dormancy

R–Resistant, MR–Moderately resistant, BLB–Bacterial blight, BPH–Brown planthopper, BS–Brown spot, GM–Gall midge, LF–Leaf folder, NBL–Neck blast, SB–Stem borer, ShBl–Sheath blight, ShR–Sheath rot, RTV–Rice tungro virus, WBPH–White backed planthopper; SB–Short bold, MS–Medium slender, LS–Long slender, LB–Long bold, MB–Medium bold.

SUCCESS STORY

HYBRID RICE ENHANCES PRODUCTION AND PROFITABILITY

Five of the released hybrids KRH 2, PHB 71, Sahyadri, PA 6201 and NDRH 2 are high-yielding and are widely adapted. These are now being cultivated in Uttar Pradesh, Bihar, Maharashtra, Karnataka, Punjab, Haryana and Goa on 1.5–2.0 lakh hectares.

Impact assessment studies carried out have indicated yield advantage of 1.0 to 1.5 tonnes/ha by cultivation of hybrids over popular check varieties, grown by farmers. And the monetary profit is in the range of Rs 4,000–6,000 per hectare. Hybrid rice is also becoming popular in low to medium productivity areas of Uttar Pradesh and Bihar.

PROMISING ENTRIES OF RICE

Planthoppers	KAU 1661, KAU 9410-8-1
Different biotypes of gall midge	JGL 1738, JGL 1799, JGL 1851, JGL 2671, JGL 3828, JGL 3932, JGL 4147, INRC nos 202, 1997, 5073, 913, 1531, 1590
Potential and sporadic pests like gundhi bug	HPR 2054, INRC nos 541, 1590, 2489,
Multiple pest resistant culture	JGL 246

FIELD TESTING OF TRANSGENIC RICES FOR RESISTANCE

Field testing of transgenic IR 72, transformed with *cry1Ab* gene against yellow stem borer under artificial infestation, has showed significantly lower damage at vegetative stage during *kharif* 2001 as compared to transformed but non-expressive IR 72 and susceptible check IR 62. But during *rabi,* these differences were not seen.

Greenhouse testing of transgenic IR 72 lines transformed with *xa21* gene against BLB under artificial infestation using local (Assam) isolate of *Xoo* has showed significantly lower damage (score $\leq$ 3) as compared to the check TN 1.

Hybrid Rice Technology

In advanced variety trials, EXPH 208 (E), PAC 89001 (ME), XR 593 (ME) and PRH 122 (ME) have showed a yield advantage ranging from 12 to 24% over the highest yielding check varieties.

IR 68888A, DRR 2A and CRMS 31A are the new rice CMS lines possessing desirable quality traits.

Two cytoplasmic male sterile lines, Pusa 3A and Pusa 5A, in WA genetic background, have been registered.

With the integrated nutrient management during dry season in the hybrid rice, grain yield of PHB 71 was maximum (7.92 tonnes/ha) with 135 kg N/ha as urea + FYM at 7 tonnes/ha. Urea at 71 kg N/ha + FYM at 7 tonnes/ha + *Azolla* dual-cropping was at a par with urea alone at 135 kg N/ha, which suggests that 50% of the fertilizer-N for hybrid rice can be substituted by organic manure and biofertilizer *Azolla.*

Biotechnology

Through marker-aided selection, bacterial leaf blight resistance genes *xa5*, *xa13* and *xa21* are being introgressed into rice BPT 5204 and Triguna. The plants are currently at the BC_4F_1 stage for SS1113 × BPT 5204 and at BC_3F_1 for SS1113 × Triguna.

Crop Production

Rice hybrids PHB 71 and KRH 2 were found better than varieties in nitrogen-use efficiency (NUE) indices, like agronomic efficiency, physiological efficiency and nitrogen harvest index. Hybrids were found to maintain higher panicle water potential and also mean relative water content of primary spikelets, and the osmotic potential in spikelets decreased during grain-filling compared to varieties. These differences may be related to differences in grain-filling percentage. Continued physiological studies confirmed relatively poor grain-filling in bottom half of the hybrid panicles, lowering mean filled grain percentage. This is due to intense apical dominance in grain-filling in hybrids.

Kharif yield response to P at 60 kg P_2O_5/ha (direct effect) was equivalent to residual effect of 90 kg P_2O_5/ha applied to *rabi* rice or 30 kg P_2O_5/ha each applied to both the crops.

Crop Protection

New combination insecticides, Acephate 45% + Cypermethrin 5% (Upacy), Chlorpyriphos 50% + Cypermethrin 5% (Nurelle), Imidacloprid 50 g +

COST-EFFECTIVE INSTRUMENTS FROM CRRI

Manual rice transplanter. This costs Rs 5,000 and saves 80% in labour cost and 74% in cost of transplanting. And the output of the machine is 0.025 ha/hr

CRRI manual rice transplanter. This costs Rs 5,000 and saves 80% in labour cost and 74% in cost of transplanting, and the output of the machine is 0.025 ha/hr.

Six-row drum seeder. Its cost of operation is 90% lesser than manual transplanting i.e., Rs 250/ha as compared to Rs 3,750/ha in manual transplanting. The output of the machine is 0.125 ha/hr.

CRRI cono cum star weeder. It can be operated in paddy field with row spacing of more than 20 cm. The output of the machine is 0.012 ha/hr, and the cost of operation is Rs 650/ha, as compared to Rs 3,100/ha of manual weeding.

Betacyfluthrin 50 g/litre (Confidor Ultra) and Betacyfluthrin 12.5 g + Chlorpyriphos 250 g/litre (Bulldock Star) were on a par with the check insecticide Monocrotophos. Pyroquilon (Fongorene 50 WP) at 1.2g/litre was the most effective fungicide in the irrigated ecosystem in checking the blast infection and improving the grain yield.

WHEAT AND BARLEY

Crop Improvement

Six wheat and barley varieties have been released by the Central Variety Release Committee for commercial cultivation.

Nine varieties of wheat and one of barley have been identified for release.

Wheat and barley varieties released

	Production conditions and area of recommendation
Wheat	
VL 804	Timely sown rainfed as well as irrigated hilly areas of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, West Bengal and north-eastern states
HW 2045	Late sown irrigated areas of eastern Uttar Pradesh, Bihar, Orissa, plains of West Bengal and Assam and plains of north-eastern states
GW 322	Timely sown irrigated areas of Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan, Jhansi division of western Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Goa and plains of Tamil Nadu
HD 2781	Timely sown rainfed areas of Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
HUW 510	Late sown irrigated areas of Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
Barley	
DWR (2-row malt barley)	Timely sown irrigated areas of Punjab, Haryana, Delhi, Rajasthan, (excepting Kota and Udaipur divisions), western Uttar Pradesh (excepting Jhansi division), Uttaranchal tarai region, Jammu and Kashmir (Jammu and Kathua districts only) and parts of Himachal Pradesh (Paonta Valley and Una district)

Maintenance of Biodiversity of Wheat and Barley

Thirty-five new accessions of wheat have been added to the germplasm assembly from the hill tracts of Himachal Pradesh and Karnataka. A total of 880 accessions have been characterized for their DUS features based on the UPOV guidelines for documentation. One genetic stock DL 1266-5 of wheat for long spike with high number of seeds and thousand-grain weight has been registered.

Hybrid Wheat

Wheat hybrids HM 00504 and HM 00514 have exhibited consistently high standard heterosis for over two year; with superiority for quality parameters, protein (%), hectolitre weight, sedimentation value (ml), extraction rate (%), loaf volume (ml) and bread quality (max score 10).

A new plant type of wheat, DL 1266-5, combining 3 yield components, high grain weight, grain number per spike and tillers per plant, along with dark-green thick and broad leaves, thick stem and higher biomass, has been developed. DL 1266-5 harvested the highest grain protein per m^2, indicating its high nitrogen

- Released 5 wheat and 1 barley and identified for release 9 varieties of wheat and 1 of barley.
- Developed a new wheat-plant type, DL 1266-5, combining high grain weight, grain number per spike and tillers/ plant.
- Delayed N application at flag leaf and at flowering to wheat with addition of S enhanced its grain yield and protein content.
- Released DWR 28, 2-row malt barley variety, for timely sown irrigated areas of Punjab, Haryana, Delhi, Rajasthan, western Uttar Pradesh, Uttaranchal tarai region, Jammu and Kashmir and parts of Himachal Pradesh.

HD 2781 wheat has been released for timely sown rainfed areas of Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu

DIVERSIFICATION OF RICE-WHEAT SYSTEM

Equivalent wheat yield and economics were calculated to determine the most useful and profitable crop sequences. Highest equivalent wheat yield (12.62 tonnes/ha) and gross returns were recorded in maize (FIRB) - vegetable pea (FIRB) - wheat (FIRB) sequence and the lowest equivalent wheat yield (9.81tonnes/ ha) and gross returns were recorded in soybean (FIRB) - wheat (FIRB) sequence. Maximum cultivation cost was incurred in maize (FIRB) - vegetable pea (FIRB) - wheat (FIRB) and the minimum in pigeonpea (FIRB) - wheat (FIRB) sequence. Growing pigeonpea (FIRB) - wheat (FIRB) gave highest net returns, followed by maize (FIRB) - vegetable pea (FIRB) - wheat (FIRB) sequence.

HS 420 wheat has been identified for release for late-sown rainfed hilly areas of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, West Bengal and north-eastern states

HS 375 wheat. This variety has been identified for summer sowing of wheat in snow-bound rainfed hilly areas of Kashmir, Himachal Pradesh and Uttaranchal

BHS 352. It is an huskless naked barley variety, identified for release for timely-sown rainfed hilly areas of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, West Bengal and north-eastern states

Wheat and barley varieties identified

	Production conditions and area of recommendation
Wheat	
VL 829	Early sown rainfed hilly areas Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, West Bengal and north-eastern states
HS 420	Late sown rainfed hilly areas of Jammu and Kashmir, Himachal Pradesh Uttaranchal, Sikkim, West Bengal and north-eastern states
HS 375	Summer sowing of wheat in snow-bound rainfed hilly areas of Kashmir, Himachal Pradesh and Uttaranchal
PBW 498	Late sown irrigated plain areas of Jammu and Kathua districts, Paonta Valley and Una district of Himachal Pradesh, tarai areas of Uttaranchal, Punjab, Haryana, Delhi, Rajasthan (excepting Kota and Udaipur divisions), and western Uttar Pradesh, excluding Jhansi division
DBW 14 and NW 2036	Late sown irrigated areas of eastern Uttar Pradesh, Bihar, Orissa, plains of West Bengal and Assam, and plain areas of north-eastern states
MP 4010	Late sown irrigated areas of Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh
HI 1500	Timely sown rainfed areas of Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh
Lok 45	Late sown irrigated areas Maharashtra, Andhra Pradesh, Karnataka, Goa and plains of Tamil Nadu
Barley	
BHS 352 (Huskless-naked barley)	Timely sown rainfed hilly areas of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, West Bengal and north-eastern states

efficiency, followed by check, irrespective of the fertility levels. The superiority of this has further been proved with the activity of the enzyme nitrate reductase.

The physiological trait for translocation of stem reserves in wheat genotypes for grain development has been found promising one, as it has perceptible association with grain yield under late-sown conditions.

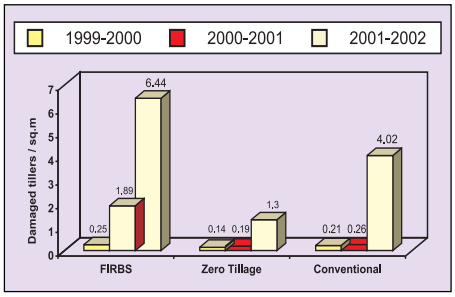
Crop Production

Various tillage options have been evaluated in a farmers' participatory approach. The data indicate that FIRB system of planting on the raised bed was not an energy saver but reduced seed rate to half. Also, the fertilizer dosage and placement improved substantially and irrigation water used for growing wheat could be reduced substantially. Rotary tillage and zero tillage reduced cost of land preparation, and saved between Rs 2,000 and 2,500/ha, compared to FIRB and conventional system. The highest net returns recorded were in rotary tillage compared to conventional broadcast sowing of wheat, followed by zero tillage.

The highest benefit: cost ratio was recorded in rotary tillage (3.37), followed by zero tillage (3.11); because of lower cost of production and higher productivity. The minimum benefit: cost ratio was recorded in the conventional broadcast sowing of wheat (2.53). The net income also followed the same trend. The specific energy required was lowest in rotary tillage (1.88 MJ/kg), and for zero tillage, it was 2.05 MJ/kg, because of higher yields.

Minimum *Phalaris minor* population in wheat was recorded under zero tillage

TILLAGE OPERATIONS AND TERMITE AND POWDERY MILDEW DAMAGES ON WHEAT



Influence of tillage practices on powdery mildew incidence in wheat

The incidence/damage due to termites and powdery mildew was more under FIRBS, and the attack of foliar aphids and pink stem borer was much less under this. In zero tillage, termite damage and powdery mildew damage was the least, whereas due to pink stem borer was the highest. The pink stem borer generally remains at a low level in wheat, but need is felt to keep a vigil on this important pest under zero-tillage system.

Influence of tillage practices on termite damage in wheat

and the maximum was under the conventional tillage system. Zero tillage seems to be a cost-effective and sustainable weed-management system.

Delayed N application, 1/3rd or 1/4th at flag leaf or at flowering stage along with the addition of sulphur at 25 kg/ha has been found to enhance grain yield and increase protein content of wheat by 7–10%.

Cotton LH 900, followed by wheat PBW 343/PBW 373 was the best option for avoiding delay in wheat-sowing in cotton-wheat system, and it produced highest wheat equivalent yield among the 4 cotton varieties tested. Use of defoliant in the 1st week of November helped in uniform opening and picking of bolls, and leaf-litter fallen had added to organic carbon (1.9–3.3 tonnes/ha) and nutrients into the soil. Intercropping of legumes for green manure in cotton-crop could add 46–52 kg nitrogen/ha.

Crop Protection

Around 17,500 samples were analyzed for Karnal bunt (KB) and over 5,000 for black point, and over 2,200 for grain discolouration were collected from all-over the country. From Gujarat, Karnal Bunt has not been detected since the last one decade. In Haryana, the south-west region had very low incidence, with Fatehabad district yielding no infected samples, and samples from Sirsa, Hisar and Bhiwani showed very low incidence.

WHEAT GENOTYPES WITH MULTIPLE RESISTANCE

Resistant to stem, leaf and stripe rusts + KB + PM	:	VL 803, TL 2908 (T), TL 2910 (T), HI 1459
+ PM + FS	:	VL 802
Resistant to leaf and stripe rusts + KB + PM + FS	:	HD 4676 (D), PDW 275 (D), DWR 2018 (D)
+ KB+ FS	:	NIDW 70 (D), COLOTANA, RAJ 6516 (D)
Resistant to KB + PM	:	MACS 2884, PBW 383, TL 2861 (T), HW 3018
Resistant to brown wheat mite	:	C 306, HI 1500, Sujata, VL 829, WH 896, GW 322, HPW 155, Sonalika, VL 832, HD 2780, HD 2781, HD 4672, MACS 1967, VL 818, VL 738 and HS 365
Resistant to root aphid and brown wheat mite +shoot fly+ three rusts+loose smut	:	LRG 101
+loose smut	:	LRG 106
+loose smut+KB+FS	:	LRG 103
+loose smut+three rusts	:	LRG 102

(KB=Karnal bunt; FS=Flag smut; PM=Powdery mildew)

SOFTWARES FOR KARNAL BUNT DETECTION DEVELOPED

GEOKB and KBRISK softwares have been developed which can indicate whether the wheat areas lie in the high, low or no risk zones for KB. This is the first PRA on KB in the country.

PATHOTYPES OF RUSTS' IDENTIFIED ON WHEAT

A new pathotype of *Puccinia striiformis* has been identified from PBW 343 leaves infected with yellow rust. This pathotype has been named as 78S84. This is the second pathotype of yellow rust, which is virulent on Yr 9. Though the new pathotype has rendered PBW 343 susceptible, but it is less virulent than pathotype 46S119, to which PBW 343 and PBW 373 are resistant. Apart from the new pathotype (78S84), 10 pathotypes of yellow rust have been observed. The pathotype 46S119 (virulent on Yr 9) has showed an increase in its proportion. Twenty pathotypes of brown rust from India and 5 from Nepal have been identified. Pathotype flora of the Himachal Pradesh was the most diverse one and yielded 15 pathotypes. In Central and Peninsular zones, stem rust spectrum showed occurrence of 4 pathotypes during the crop season and 5 during off-season at Wellington.

- Molecular profiling carried out of 15 hybrids of maize, including 10 released single-cross maize hybrids.
- Identified resistant genotypes of maize for maydis leaf blight, Turcicum leaf blight and sorghum downy mildew.

MAIZE

Crop Improvement

Two maize composites and hybrids have been released at the central level and 4 at the state level.

Simple sequence repeat profiling in maize revealed high level of polymorphism (432 SSR alleles), leading to effective discrimination of its various inbred lines. The average number of detected SSR alleles per locus was 7.45. Reconfirmation of allele designations aided in placing a high degree of confidence in dataset generated using SSRs. The study also revealed a large number of 'rare' SSR alleles (limited to 3≤ out of 69 inbreds), of which 89 alleles were found in Indian maize inbreds, and only 20 were found in the CIMMYT lines.

In maize, an early composite Narmada Moti of white semi-flint type has been released and notified for *kharif*. It is promising for Uttar Pradesh, Haryana, Delhi, Andhra Pradesh, Maharashtra, Karnataka, Kerala, Tamil Nadu, Rajasthan, Gujarat and Madhya Pradesh

Maize composites/hybrids released and notified

Variety	Yield tonnes/ha	Maturity	Season	Grain type	Area of adaptation
			Central Releases		
Composite Narmada Moti	4.0	Early	*Kharif*	White semi-flint	Uttar Pradesh, Punjab, Haryana, Delhi, Andhra Pradesh, Maharashtra, Karnataka, Kerala, Tamil Nadu, Rajasthan, Gujarat, Madhya Pradesh
Priya sweet corn	2.22	Medium	*Kharif* and *rabi*	Yellow dent, sweet	Andhra Pradesh, Maharashtra, Tamil Nadu and Karnataka
			State Releases		
DHM 2	5.4–5.6	Full season	*Kharif*	Yellow semi-flint bold grain	Karnataka
Gujarat Makka 3	5.49–7.25	Early	*Rabi*	White flint	Gujarat
NAC 6002	5.6	Early	*Kharif*	Semi-dent	Karnataka
Jawahar Makka 216	5.0–5.5 (*kharif*) 5.5–6.3 (*rabi*)	Medium	*Kharif* and *rabi*	Flint to semi-dent	Madhya Pradesh

Molecular profiling of 15 hybrids including 10 single-cross maize hybrids released was carried out. The SSR profiles showed distinct genetic nature of Almora hybrids (Vivek Hybrid 4 and Vivek Hybrid 5) from the rest. Similarly, Parkash, a single-cross hybrid, developed by the PAU, Ludhiana, was found distinct from others.

Crop Production

For hybrid seed production, nitrogen at 180 kg/ha and plant spacing of 60 cm × 20 cm were found the best. In maize-soybean intercropping, application of Alachlor at 2 kg/ha proved most effective in controlling weeds. This herbicide was very effective for baby-corn production. FYM at 10 tonnes/ha with NPK resulted in significant yield increases of maize at Kangra, Bajaura and Almora.

Crop Protection

A set of 145, set A × B RILs (recombinant inbred lines), along with their parental lines (Ki3 and CMLl, 139) were analyzed for detection of quantitative trait loci (QTL) for downy mildew (DM) resistance. The study has indicated a major QTL on chromosome 6, which appears stable across diverse environments, besides the specific QTLs controlling resistance to sorghum downy mildew and Rajasthan downy mildew.

MAIZE GENOTYPES RESISTANT TO BIOTIC STRESSES

Maydis leaf blight	F 7001, AH 918, AH 915, FH 3097, PRO 340, FH 3138, JH 068-2, KH 5991
Turcicum leaf blight	R 9601, X 520, F 7001, AH 387, PRO.340, X 3342
Sorghum downy mildew	PMZ 128, PRO 340, FH 3138, SSFX 9199, KH 5991
Browny stripe downy mildew	CMH 7, SEEDTECH 2331, AH 916, AH 387, F 7001, AH 187, AH 915, AH 918, FH 3113, SSFX 9195, JK 0682, KH 5991, JH 3795, JH 3725, KH 081, JKMH 178-14
Post-flowering stalk rot	JH 3795, JKMH 178-4

SORGHUM

Crop Improvement

CSV 17 (SPV 1489) is a new early-maturing variety (90–95 days) with 30.7% higher yield (2,709 kg/ha), and has increased resistance to grain moulds than check SPV 96. This variety will be suitable for moisture-stress areas in Rajasthan and elsewhere.

A dual-purpose hybrid, SPH 1148, developed at the National Research Centre on Sorghum, has recorded superior grain and fodder yields in multilocation trials (1998–2001). The hybrid is based on the new MS line MS 463 A{SPV 463 (IS 2947 IS 232 CO 22) 2219 B} and R line NR 486 {CS 3541 PAB 34 (IS 23521)}. This yields 4.15 tonnes of grains/ha and 11.2 tonnes of fodder/ha, which is a record 17.3% and 9.8% and 6% and 14.3% increase over checks CSH 18 and CSH 16 for grain and fodder yields.

Pyramiding genes for grain hardness in sorghum to attain moderate levels of grain hardness and incorporating genes for light glume colour could increase levels of grain-mould resistance in white-grain background.

Crop Protection

The stable sources of resistances identified are IS 18557, IS 18676, IS 18677, PJ

DHM 2 maize is a state release for Karnataka for *kharif*. It yields 5.4 tonnes of yellow semi-flint bold grains per hectare

- Released CSV 17 sorghum (suitable for moisture stress) with increased grain-mould resistance than check SPV 96.
- Sorghum cultivars developed with CS 3541 in their parentage contributed to high degree of resistance in R lines (C 43, RS 29, MR 836).

SPH 1148 sorghum hybrid is based on the new MS line MS 463 and R line NR 486. It is a dual-purpose hybrid and has recorded superior grain and fodder yields in multilocation trials

8K (Y) and Y 75. It was found that cultivars developed with CS 3541 in their parentage contributed to high degree of resistance in R lines (C 43, RS 29, MR 836).

PEARL MILLET

Crop Improvement

Three hybrids and one open-pollinated variety have been released.

GHB 558 pearl millet *kharif* hybrid. It is a late-maturing, downy-mildew resistant, high stover yielding hybrid; yields 2.83 tonnes/ha across the country

Pearl millet summer hybrid GHB 526, yielding 4 tonnes/ha, is a late-maturing, high stover giving hybrid

Pearl millet hybrids/varieties released

Hybrids/ varieties	Area of recommendation	Mean grain yield (tonnes/ha)	Salient features
Kharif			
Hybrids			
GHB 558	Across the country	2.83	Late maturity (80–82 days), downy-mildew resistant and high stover yield
HHB 146	Haryana, Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Punjab and Delhi	2.88	Medium maturity (78–80 days), downy-mildew resistant
Summer Hybrids			
GHB 526	Gujarat, Maharashtra, Tamil Nadu and parts of Rajasthan	4.00	Late maturity and high stover yield
Variety			
CZP 9802	Rajasthan, Gujarat and Haryana	1.30	Medium early maturity (75–78 days), suitable for scanty rainfall regions

- Released CZP 9802 pearl millet, an open-pollinated variety.

Crop Production and Crop Protection

Newly developed hybrid HHB 146 has been found most responsive to all levels of nitrogen. This recorded higher yield of 12.4% at 30 kg, 16.3% at 60 kg and of 15.2% at 90 kg over the best check hybrid.

Hybrids MH 1040, MH 1066 and a variety MP 403 have been identified for combined resistance to downy mildew and smut diseases. And MH 1003 has showed promise against shootfly, pyrilla and grey weevil insects.

SMALL MILLETS

Crop Improvement

Fingermillet L5, a long-duration variety, maturing in 115-120 days, with a high level of field tolerance to blast, has been released for cultivation in Karnataka.

Little millet OLM 20, an early-maturing variety of 75-80 days duration, suitable for double cropping, has been released for cultivation in Orissa, Madhya Pradesh and Chhattisgarh. Foxtail millet accession GS 1953, a unique, dwarf plant-type with erect leaves and desirable morphological frame, controlled by single recessive genes, has been registered with the NBPGR.

Crop Production and Crop Protection

Intercropping fingermillet and pigeonpea in 4:1 or 8:2 ratio is profitable in Karnataka, Andhra Pradesh, Tamil Nadu, Orissa, Jharkhand, Chhattisgarh and Bihar. This enhanced farming income as well as supply of grain-legumes.

Soaf (0.2%) was effective against fingermillet blast, and in preventing yield losses to the tune of 15-20% due to diseases. In the National Screening Nursery, kodomillet GPLM 920 and GPLM 1029, found resistant to head smut, can be donors for resistance.

Fingermillet and pigeonpea intercropping at 8: 2 ratio not only augmented farm income but also increased supply of legumes

VALUE-ADDITION OF FINGERMILLET

Whole ragi after decortication

Fingermillet is mainly used in the form of flour. A unique process for decorticating whole-grain after partly separating outer brown-coloured bran-layer has been developed. This has opened up novel ways of using whole-grain in preparing conventional and special foods for diabetic and obese population.

- Grain-amaranth Suvarna intercropped in long-duration pigeonpea CO 6 resulted in higher land-equivalent ratio, gross returns and benefit: cost ratio.
- In *Jatropha*, closer spacing (1 m × 1 m) recorded higher seed yield at lower fertilizer doses, and 2 m × 1 m spacing at higher doses.

UNDERUTILIZED CROPS

Crop Improvement

IC 35407 of grain-amaranth, Sangla B 1 of buckwheat, PRR 9402 and LRB 122 of ricebean, H 656 of Job's tear and Local check of faba-bean are found to be the highest seed yielders. In observation row trials, entries H 2216 (0.46 tonne/ha) of perilla, SMLAB 1 (1.48 tonnes/ha) of adzuki-bean and PRC 9801-1 (1.33 tonnes/ha) of chenopodium have showed promise.

Protein content of grain-amaranth ranged from 11.4 to 13.8% (SKNA 20), and the oil content was observed high in RMA 2 (12.8%), RGA 62-10-1 (12.2%) and RGA 92-6-2 (12.14%). Entry AG 114 of grain-amarnath was observed rich in oleic acid (34.3%) and Rasna 2 in linoleic acid (29.4%). Among fifteen genotypes of kalingada, protein content ranged from 27.5 to 31.8% (SKNK 158), and oil content from 30.6 to 36.4% (SKNK 16). In faba-bean, protein content in mature seeds ranged from 22.3 to 26.2% (BSH 42) and vicine-convicine content ranged from 0.76% (HB 193) to 1.3%.

Crop Production

Intercropping grain-amaranth (Suvarna) in long-duration pigeonpea (CO 6) resulted in higher land-equivalent ratio (1.26), gross returns (Rs 27,542/ha) and benefit : cost ratio (1.52). Application of Alachlor at 1.5 kg a.i./ha resulted in highest grain yield and least production of weed biomass in both common and tartary buckwheats. In *Jatropha*, closer spacing (1 m × 1 m) recorded higher seed yield at lower doses of fertilizer, and wider spacing (2 m × 1 m) in the highest seed yield at high doses of fertilizer.

- Berseem HB I released for Haryana.
- Added 450 indigenous and 3 exotic germplasms to forage crops.
- *Azospirillum* inoculation to sorghum increased green fodder yield to 19.3% and dry matter yield to 27.1%.
- In silvopasture system, trees contributed to 48% in dry matter yield in large holdings, followed by 37% in small and 35% in medium holdings.
- In hortipastoral system, pasture production was higher with *aonla*, followed by *ber* and *bael*.

FORAGE CROPS

Crop Improvement

A new variety of berseem HB I has been released for Haryana.

Total of 450 new indigenous and 3 exotic germplasms of different forage crops have been added to the collection.

Crop Production

In oats, sulphur in soil at 60 kg/ha and recommended NPK (90 : 60 : 30 kg/ha) enhanced maximum forage yield to 50.6%, compared to control (14.87 tonnes/ha). Butachlor at 2.0 kg a.i./ha (pre-emergence) to berseem produced higher forage yield (31.0%) than control (49.1 tonnes/ha) and also controlled *Cichorium intybus* and other weeds, *Chenopodium*, *Anagallis* and *Asphodelus*, effectively.

In coconut plantation, recommended NPK(150 : 50 : 50 kg/ha) + *Glyricidia* leaves at 5 tonnes/ha to Congosignal grass (*Brachiaria ruziziensis*) have been beneficial; increased forage yield (39.21 tonnes/ha) over 100% recommended dose of NPK + FYM at 5 tonnes/ha.

Paddy-cowpea (F) - oats (F) sequence has provided significantly higher (49%) net monetary returns (Rs 3,876.0/ha/yr) over paddy-sorghum (F) - oats (F). With curtailed doses of recommended fertilizers (75%) + FYM at 5 tonnes/ha to both the sequences higher rice equivalent yield (3.87 tonnes/ha) was obtained than full recommended doses of fertilizer (NPK 60 : 30 : 20 kg/ha for paddy, 60 : 30 : 0 kg/ha for sorghum forage, 20 : 40 : 0 kg/ha for cowpea forage and 40 : 20 : 20 kg/ha for oats).

To oats in saline sodic soils, 75% recommended dose of nitrogen + 25% nitrogen through FYM + 40 kg $ZnSO_4$/ha enhanced forage yield to 19.3% over full dose of NPK (90 : 50: 40 kg/ha); when the yield was 27.4 tonnes/ha.

ANIMAL FEED-BLOCK MAKING MACHINE DEVELOPED

This machine is capable of making blocks with all kinds of straws and grasses. Its overall dimensions are 3.40 m × 2.70 m × 1.81 m, and its output capacity is 30–40 blocks per hour.

The bulk density of the common roughage based feed-blocks prepared from this machine can be increased to 6–10 times. Due to higher bulk density of blocks, these require much less storage space as well as lower handling and transportation cost.

In coconut plantation, fodder cowpea provided 55% higher net monetary returns over fodder pigeonpea (Rs 8,873/ha/yr). Nitrogen 50% through vermicompost and the rest through fertilizer, realized maximum net monetary returns (Rs17,832.50/ha/yr).

The inoculation of *Azospirillum* to sorghum increased green fodder and dry matter yield to the magnitude of 19.3 and 27.1%; with *Azotobacter* inoculation, it was 6.7% and 5.6%. In maize, increases to the tune of 10 and 20% for green fodder and dry matter yield were recorded with *Azotobacter* inoculation.

Maize and cowpea in the row ratio of 2 : 2 in Central Zone, 1 : 1 and 1 : 4 in the North-east Zone, maize sole and maize + cowpea (4 : 1) in South Zone and sole maize in North-west Zone recorded higher forage yields.

Maximum fodder production from Congosignal grass could be achieved with FYM at 7.5 tonnes/ha and 50% NPK (75 kg N + 25 kg P_2O_5 + 25 kg K_2O/ha), accompanied with the irrigation at 30 mm CPE. KNO_3 spray at 4 kg/ha has been found beneficial for obtaining higher seed and forage yields from signal grass in coconut plantation in the southern zone.

In a long-term soil-fertility management experiment (5 years), maximum berseem equivalent yield (144.8 tonnes of green/ha) was recorded in guinea-grass + cowpea – berseem sequence. Organic source of manuring continued to be superior over inorganic source, in terms of yield, organic-carbon and available N, P and K status of the soil. Available S depleted by 45% and 35% in no manure and inorganic sources, respectively.

Urea and FYM in 1 : 1 ratio produced maximum biomass yield (35.4 tonnes of green/ha and 8.67 tonnes of dry/ha) of sorghum + cowpea. It was at a par with 100% FYM, 25% urea + 75% FYM and 25% urea + 50% FYM + biofertilizers. The volatilization losses of ammonia could be significantly reduced by combined use of 25% urea – N + 50% FYM-N + biofertilizers. The level of organic carbon, available N and K and microbial biomass carbon improved maximum with 100% FYM manuring.

Silvopasture in small holdings provided highest production (7.31 tonnes of dry matter yield (DMY/ha), followed by large holdings (5.68 tonnes DMY/ha) and medium holdings (4.72 tonnes DMY/ha). Trees contributed maximum (48%) in large holdings, followed by small (37%) and medium holdings (35%).

Hortipastoral system supplied highest dry matter of 5.29 tonnes/ha and, pure pasture provided 4.62 tonnes/ha. Medium basin (1.0 m) was most effective for boosting growth of *ber, bael*. And *aonla* preferred large basin size (1.5 m) for peak growth. The pasture production was higher in *aonla* (3.11 tonnes/ha), followed by *ber* (2.63 tonnes/ha) and *bael* (2.35 tonnes/ha).

Naphthalene acetic acid (NAA at 25, 50 and 100 ppm), diamonium phosphate (2, 4 and 6 kg/ha)a and muriate of potash (2, 4 and 6 kg/ha) applied to foliage at vegetative stage of *Dichanthium annulatum* improved plant stand and photosynthate assimilation. The combined response of these chemicals resulted in 50% higher seed yield over control (79.256 kg/ha).

Crop Protection

SPA 2-94022, DM 94016B and 94006B of sorghum have been found resistant to lesion nematode (*Pratylenchus zeae*) under artificial inoculation. In cowpea, IL 14 and Hy 60 were resistant to *Meloidogyne incognita* and *M. javanica*. Neem-cake at 1 tonne/ha + seed treatment with *Trichoderma harzianum* and neem-cake + seed treatment with Thiram (0.25%) + Bavistin (0.2%) gave more than 60% control of root and stem rot diseases. In lucerne, soil treatment with Carbofuran 3G at 1 g/m-row along with seed treatment with Carbendazim at 1g/kg and spray with neem-seed kernel extract at 3%, 15 days after each cut provided maximum fodder yield (38.19 tonnes/ha), but economically, seed treatment with Carbendazim at 1 g/kg has been found most viable (benefit : cost ratio is 53 : 43).

SUCCESS STORY

COMPLETE FEED-BLOCKS FOR CATTLE FEEDING

The wheat *bhusa* (40%) was mixed with berseem hay (20%), molasses (20%) and concentrate mix (19%), which included linseed-cake and ground barley at a ratio of 1 : 1, and mineral and vitamins (1%), to produce a complete feed-block (CFB). The linseed-cake was soaked overnight in water. Molasses was heated in an open pan up to a temperature of 70°C to liquidize it and then mixed it with remaining ingredients. These ingredients were thoroughly mixed manually. The added moisture was adjusted at 20%, to have a proper binding of the material.

The mixture was then processed in the IGFRI densifying machine hopper to get desired blocks. The complete feed-blocks of 31 cm × 31 cm × 50 cm were made, weighing 20 kg each, which can be easily handled by a single person. The machine had an output capacity of about 500 kg/hr with an average density of prepared bales as 400 kg/m^3. A total of five labourers were required for the operation.

The prepared blocks had 88.31% organic matter, 9.72% crude protein, 44.02% NDF, 31.11% ADF, 12.91% HC, 3.27% lignin and 11.69% ash.

On-farm feeding trials of CFB were conducted in the nearby villages of Jhansi to assess the acceptability of the product. In 2 groups of buffaloes, one was fed with CFB and the second with the traditional material (wheat *bhusa ad lib.* and 2 kg concentrate). In addition, 5 kg green berseem was also fed to each animal. After one month of feeding CFB, 7 days' digestibility trial was also conducted. Feeding trials indicated that average dry matter (DM) intake/animal and average DM intake/100-kg body weight were similar in the group fed with CFB and the one with the traditional feeding system. The DM digestibility and average milk yield were, however, 9.15% and 19% higher in the group fed with CFB. Average milk fat content (8.3%) was similar in both groups.

OILSEEDS

GROUNDNUT

Crop Improvement

Four new varieties of groundnut have been identified for release.

AK 159. An early-maturing (107 days) Spanish-bunch groundnut type, having high oil content (52%) and tolerance to thrips, has been identified for northern Maharashtra and Madhya Pradesh. The pod and kernel yields realized were 1.79 and 1.18 tonnes/ha respectively, which were 27 and 33% higher over the check variety TAG 24.

Dh 86. It is a stable variety having high pod and kernel yields and tolerance to thrips. It has been identified for summer cultivation in Gujarat, southern Rajasthan and western Maharashtra and for *rabi*/summer cultivation in West Bengal, Jharkhand and Assam.

JSP 28. It is a medium-duration, spreading genotype, having high oil content (52%). It has been identified for Rajasthan, Punjab, Uttar Pradesh and Haryana for *kharif*. It showed 16 and 28% higher pod and kernel yields over the check M 335.

TG 41. It is a large-seeded (65g/100 kernels), early- (118–120 days) and uniform-maturing (sound mature kernel = 90%), erect genotype, having desirable confectionery qualities like high oleic/linoleic acid ratio (3 : 2) and high protein content (25%). It has been identified for all-India release.

Crop Production

Compatibility of groundnut (Virginia 11, Spanish 20) with pearl millet, pigeonpea and castor indicated that its pod yield reduction was more with pigeonpea/castor (43–53%) than with pearl millet (32%). GG 20, B 95 and M 335 groundnut among Virginia types and J 11, VRI 3 and ICGS 44 among Spanish showed lesser reduction in pod yield.

Out of the 4 *in-situ* moisture-conservation techniques, inter-row water harvesting (IRWH), broad-bed furrow (BBF), flat-bed sub soiling (FBSS) and flat-bed for rainfed groundnut, IRWH resulted in the maximum pod yield (1.79 tonnes/ha) along with the highest water-use efficiency (WUE) of 5.65 kg/ha/mm. In groundnut + pigeonpea and groundnut + castor systems, yield and water-use efficiency of groundnut with pigeonpea were higher than castor, owing to better light interception in the former intercropping. Maximum water-use efficiency with added evapotranspiration was 5.45 and 3.35 kg/ha/mm in pigeonpea sole and intercrop pigeonpea at 70% water-deficit replenishment of field capacity. In castor, irrigation at 85% water-deficit replenishment of field capacity gave maximum WUE of 4.74 in sole castor and 3.12 in groundnut + castor. It was closely followed by irrigating at 70% water-deficit replenishment, giving WUE of 4.71 for sole castor and 3.11 for intercrop castor. Thus, irrigation at 70% water-deficit replenishment in groundnut + pigeonpea or groundnut+castor system would result in higher WUE and would also irrigate additional 0.40 hectare with the same amount of irrigation water.

Crop Protection

The biotic stresses in groundnut were managed more effectively with the IPM package of seed treatment with Carbendazim + trap crops (pearl millet, castor, around the field, and soybean and pigeonpea as intercrop) + insecticide mixture (neem oil 2% + Phosphamidon 0.02% or Endosulfan 0.04%) + pheromone trap (for *Helicoverpa armigera, Spodoptera litura* and *Aproaerema modicella*) + 2% neem-leaf extract spray (40 days after sowing), Mancozeb 0.25% + Carbendazim 0.05% (55 DAS), culture filtrate of *P.islandicum* (70 DAS), weedicide Fluchloralin 1.5 kg a.i./ha + one interculturing (35 DAE) + one hand weeding (30 DAE).

Seed treatment with *Trichoderma viride* at 4g/kg seed, soil application of *T. viride* at 62.5 kg/ha or castor-cake at 500 kg/ha and intercropping of pearl millet (3 : 1) have been most effective in controlling major fungal diseases of groundnut.

- Identified for release groundnut AK 159, Dh 86, JSP 28 and TG 41.
- Pod yield reduction in groundnut was found more with intercropping with pigeonpea and castor than pearl millet.

RAPESEED-MUSTARD

Crop Improvement

Six varieties of rapeseed-mustard have been released.

Rapeseed-mustard varieties released

Crop/variety	Seed yield (tonnes/ha)	Maturity (days)	Oil content (%)	Area of adoption
Indian mustard (*Brassica juncea*)				
RB 9901	1.77	129–155	41.1	Rainfed, Zone II (Haryana, Punjab, parts of Rajasthan and Delhi)
RH 9304	2.10	129–137	39.1	Irrigated, Zone III (Uttar Pradesh, Uttaranchal, Madhya Pradesh and parts of Rajasthan)
RH 9801	1.37	123–126	38.6	Late sown, Zone III
RK 9902	2.12	130–134	39.4	Irrigated, Zone III
Mahon 8 (Shivalik)	1.44	124–135	38.6	Late sown Zone II
Karan rai (*Brassica carinata*)				
IGC 01	1.42–1.56	166–175	36.8–45.1	Irrigated and rainfed areas of the country

Twelve experimental mustard hybrids have been produced. Of the 300 hybrids evaluated, promising heterotic combinations, based on the standard heterosis for seed yield over the best check, are HB 9912 × HB 9924 (80.7%) and PCR 15 × HB 9925 (42.3%).

Crop Production

In mungbean-mustard sequence, application of 75% of the recommended dose of fertilizers along with 10 tonnes of farmyard manure/ha was remunerative in north Gujarat. For the semi-arid eastern plains zone of Rajasthan, especially for the soils deficient in sulphur, boron and zinc nutrients, application of recommended dose of fertilizers along with 10 tonnes FYM/ha, 40 kg sulphur/ha, 25 kg zinc sulphate/ha and 1 kg boron/ha, was found remunerative.

Crop Protection

Seed yield losses due to *Alternaria* blight, white rust and *Sclerotinia* rot can be reduced substantially if sowing of mustard is done in the third week of October and seeds are treated with Apron 35 SD (6 g/kg). Ridomil MZ 72 WP (0.25%) may be sprayed immediately after the appearance of the white rust, followed by two sprays of Mancozeb (0.2%) at fortnightly intervals.

The genotypes Bio YSR, Bio 467-95, PWR 9541, EC 399299, EC 399301 and JMMWR 941-1-2 showed consistent resistance to white rust, and PAB 9511, EC 399303, EC 399315 and EC 41439 showed tolerance for *Alternaria* blight. These can be used as resistant donors in varietal improvement.

- Promising heterotic combinations reported in mustard for yield are HB 9912 × HB 9924 and PCR 15 × HB 9925.
- Resistant donors identified in mustard for white rust and *Alternaria* blight tolerance.

SOYBEAN

Crop Improvement

Four new varieties of soybean have been identified and released for cultivation.

- Identified soybean JS 93-05, MAUS 61-2, MAUS 71 and RAUS 5 for different agroclimates.
- At Ludhiana, soybean accessions PLSO 84 and UPSM 534 were found resistant to yellow mosaic virus.

*JS 93-05***.** It is an early-maturing variety with a duration of 90–95 days and yield potential of 2.0–2.5 tonnes/ha. The variety is recommended for Central Zone, comprising Maharashtra, Madhya Pradesh, Rajasthan, Gujarat and Bundelkhand region of Uttar Pradesh. It is a semi-determinate variety with violet flowers, lanceolate leaves and 4-seeded pods.

MAUS 61-2. This variety is also suitable for Central Zone, matures in 100–105 days, and has a yield potential of 2.0–3.0 tonnes/ha. The variety is semi-determinate with violet flowers, glabrous leaves, yellow seeds and light-brown hilum, and has moderate resistance to rust.

*MAUS 71***.** This variety is suitable for North-eastern Zone, comprising Chhattisgarh, Jharkhand, Bihar, Orissa, West Bengal, Assam, Arunachal Pradesh, Manipur, Nagaland, Meghalaya and Mizoram. It matures in 93–100 days and has a yield potential of 0.18–0.20 tonne/ha, and is semi-determinate with violet flowers, yellow seeds and black hilum.

RAUS 5. This variety is also suitable for North-eastern Zone. It matures in 96–104 days with a yield potential of 3–3.5 tonnes/ha. The plants are determinate with tawny pubescence, violet flowers and yellow seeds.

Two accessions PLSO 84 and UPSM 534 have been identified for resistance against yellow mosaic virus at Ludhiana.

Crop Production

The system efficiency of soybean-wheat was found higher than soybean-chickpea. Application of crop residue at 5 tonnes/ha + FYM at 5 tonnes/ha + Zn at 5 kg/ha along with the recommended level of fertilizers in the soybean-wheat cropping system gave highest soybean equivalent yield.

A seed-coverer with V notch on a square plate of suitable size has been developed for soybean. This device helps in covering left-over (15–20%) seeds, and has been found to support good germination and appropriate plant density.

To mitigate drought effects and conserve adequate soil moisture, a key line-seeding machine has been developed and farm validated at the NRCS. The machine facilitates planting of 5 rows at the recommended planting distance and simultaneously opens one row each on either side (fresh depth is about 20 cm which turns out to about 15 cm after settling) for facilitating removal of excess water and/or percolation of water in soil. This costs approximately Rs 12,000.

Crop Protection

Entomopathogenic fungus *Beauveria bassiana* caused 30–40% mortality of green semilooper larvae *Chrysodeixis acuta* on soybean. Chitin inhibitors Diflubenzuron and Lufenuron effectively controlled all major lepidopteran defoliating larvae, with mortality ranging from 40 to 97.5% in the laboratory conditions. *Bacillus thuringiensis* based microbial insecticide (Dipel at 1 litre/ha) alone or in tank-mix combination with Monocrotophos 36 SL (at 0.8 litre/ha) gave significant control on defoliators and stem-fly (*Melanogromyza sojae*), with yield advantage of about 30% over control.

PK 472 has been identified as a variety possessing high degree of resistance to powdery mildew.

CROSS MECHANISM FOR STRAIGHT SOWING OF SOYBEAN

To ensure straight sowing in rows of soybean and to facilitate flawless interculture/harvesting operations subsequently in the standing crop using tractor-drawn implements, a cross mechanism has been developed at the National Research Centre on Soybean. This cross mechanism practically eliminates lateral movement of implements and can be conveniently fitted on the lower links of the tractor. This device can be manufactured by the local artisans at a meagre cost of Rs 80 only.

SUNFLOWER

Crop Improvement

Three new hybrids of sunflower have been released for cultivation.

Line PS 1089 derived from *Helianthus argophyllus* × cultivated cultivar and two lines (PS 2011, PS 2032) derived from *H. petiolaris* × cultivar crosses have been found immune to rust disease.

A number of entries of sunflower Bio 82023, Krishidhan 34, JKSF 1014, PRO 001,

Sunflower hybrids released

Hybrid	Yield (tonnes/ha)	Reaction to pests/ diseases	Recommended states
KBSH 44	1.90	Resistant to major diseases and insect pests of sunflower	All India
PSFH 118	1.84	–	Punjab
HSFH 848	1.80	–	Haryana

- Identified number of sunflower entries tolerant to downy mildew.

TWCH 23298, MLSFH 89, Ajit 511, VSFH 80, NJSFH 1136, SH 357, Krishidhan 9953, Mahabeej 2001, TWC 23248, PAC 39001, MLSFH 84, MLSFH 82 and PSH 21 have been found tolerant to downy mildew.

Crop Production

In Vidarbha region (Maharashtra) in soybean + sunflower intercropping system (2 : 1), application of 100% recommended dose of fertilizers (RDF) to soybean and 50% RDF to sunflower as basal and 50% N as top dressing is recommended to get highest yield and monetary returns. Crop residue incorporation of sunflower in sorghum significantly increased grain yield of sorghum even with 50% RDF to the system. Phosphorus solubilizing bacteria provided up to 50% P requirement for sorghum, succeeding 100% RDF-grown sunflower.

Crop Protection

The pollen and thrips collected from the infected flower heads of sunflower were reported ELISA positive to sunflower necrosis virus antisera. Thrips could easily carry 30–70 pollen-grains on their body. This indicates thrips as vector of sunflower necrosis disease. Seed treatment with GAUCHO (Imidacloprid) at 5g/kg seed, followed by foliar spray of Confidor 200 SL at 0.05% at 15 and 30 DAS interval were effective in checking necrosis disease.

A number of entries PAC 1091, DRSF 109, LSH 8, LSF 1, DRSF 110, PAC 31007, ZSH 9903, PWCH 23248, SH 416, PAC 39004, SH 323, PGS 362 and 243 have been found resistant to leaf hoppers.

SAFFLOWER

Crop Improvement

A new non-spiny hybrid of safflower NARI-NH 1 (PH 6) has been developed at the Nimbkar Agricultural Research Institute, Phaltan. It is suitable for all safflower-growing regions of the country. The average yield of this hybrid is 1.93 tonnes/ha. It is tolerant to *Alternaria* and *Cercospora* leaf-spot diseases and *Fusarium* wilt, besides showing tolerance to aphids.

Safflower several germplasm accessions GMU nos. 2912, 2962, 2976 and 2720 have showed moderate resistance to leaf spot disease. And germplasm accessions GMU Nos. 2297, 2450, 2720, 2764, 2894 and 2914 have been found resistant to wilt.

Safflower genotypes SSF 593-1 and PH 4 have exhibited resistant reaction to *Alternaria* leaf spot. A number of promising genotypes such as SSF 637, NH 13, SSF 413-2, JSI 112, JSI 5-1-7, PBNS 43 and PBNS 119 have showed tolerance to aphid infestation. NSKE 5%, NSK powder 3% and neem-cake 5% are found effective and economical for aphids' management.

- Developed a non-spiny safflower hybrid NARI-NH 1, tolerant to *Alternaria* and *Cercospora* leaf-spot diseases and *Fusarium* wilt.
- At Indore and Parbhani, soybean-safflower crop sequence with 100% N and P to both recorded highest yields.
- In rainfed areas at Annigeri, *Azotobacter* treatment to safflower seeds reduced N-fertilizer needs of the crop to 50%.

Crop Production

In soybean-safflower crop sequence at Indore and Parbhani, recommended 100%

N and P to both recorded highest yields. Chickpea - safflower system gave highest yields at Solapur with 100% N + 50% P + phosphorus solubilizing bacteria to chickpea and 100% N and P to safflower.

Azotobactor seed treatment at Annigeri effectively substituted 50% of the recommended nitrogen needs of safflower in rainfed areas.

- Released RHC 1 castor for Rajasthan; the first hybrid release for arid region.
- *Trichoderma viride* strain B 16 proved effective in controlling *Fusarium* wilt of castor alone as well as in the presence of nematodes.

CASTOR

Crop Improvement

RHC 1, a new hybrid, a derivative of VP 1 × TMV 5-1, developed at the Agricultural Research Station, Mandor, has been released for Rajasthan. It is the first hybrid release for arid region, and has been reported to out-yield the other castor genotypes of the arid region.

Crop Production

At Sardar Krushinagar, application of 20 kg S/ha or 15 kg $ZnSO_4$/ha gave higher seed and oil yield of castor. Irrigating castor at 0.8 IW : CPE ratio resulted in increase in seed yield of primary and secondary order spikes.

Crop Protection

Castor accession RG 2722 has showed resistance to wilt and root rot. In artificial screening, RG 2661, 297, 941 and 1649 accessions were confirmed to be wilt resistant. The nematophagous *Trichoderma viride* (B 16) has been found effective for controlling *Fusarium* wilt alone as well as in the presence of nematodes. The shaker-culture method of mass mutliplication of *T. viride* (B 16) would enhance the shelf-life of B 16 up to 8 months. Talc is effective carrier of *T. viride* formulation. At Palem, prophylactic Carbendazim at 1g/litre or removal of affected spikes and application of 20 : 20 kg N : K/ha showed promise in managing *Botrytis* grey rot.

Nirmala sesame. It is a white-seeded mutant of B 67 variety, and is characterized by early maturity, of 86 days, tolerance to phyllody and wilt, and resistance to bacterial leaf spot and powdery mildew

SESAME

Crop Improvement

Three new varieties have been identified for release in sesame.

AKT 101 sesame is a bold, white-seeded variety for cultivation in *rabi*/ summer in Maharashtra

Nirmala (OS-Sel 164). It is a white-seeded mutant of B 67 variety, identified for release in coastal areas of West Bengal, Orissa, Andhra Pradesh and Tamil Nadu. Nirmala is characterized by early maturity, of 86 days, tolerance to phyllody, wilt and resistance to bacterial leaf spot and powdery mildew. Its average yield is 0.8–0.9 tonne/ha.

AKT 101. It is a bold, white-seeded variety, developed from a cross between N 62-10 and 12-19, and has been released for cultivation during *rabi*/summer season in Maharashtra. Average yield of AKT 101 is 0.8 tonne/ha. It matures in 87 days, contains 50% oil in its seeds and is moderately resistant to phyllody, *Macrophomina* sterm/root rot and bacterial blight.

MT 75. It is a white-seeded selection from JLT 26 × RT 12, identified for release in Uttar Pradesh, Haryana, Rajasthan,

Maharashtra and Andhra Pradesh. MT 75 matures in 88 days and gives average yield of 0.6–0.8 tonne/ha. It is resistant to phyllody, leaf curl and powdery mildew and is moderately resistant to *Phytophthora* blight and *Macrophomina* stem/root-rot.

Strains OS-Sel 2 and Sekhar have showed promise at the advanced stage of testing at the national level for *kharif* and JCS 388 and JCS 390 for *rabi*/summer season.

- Sesame + urdbean (2 : 2) in Madhya Pradesh, sesame + groundnut and sesame + mungbean (2 : 2) in Rajasthan and sesame + cotton (3 : 1) in Gujarat proved remunerative cropping systems.

Crop Production

The maximum seed yields could be obtained with 50% N through urea + 50% N through FYM + phosphorus solubilizing bacteria (PSB) + 50% P + K at Amreli; 50% N through urea + 50% N through FYM + PSB + P + K at Kayankulam; 50% N through urea + 50% N through thumba-cake + P + K at Mandore; 100% N through urea + PSB + 50% P + K at Mauranipur. Sesame + urdbean (2 : 2) in Madhya Pradesh, sesame + groundnut and sesame + mungbean (2 : 2) in Rajasthan and sesame + cotton (3 : 1) in Gujarat and sesame + soybean (3 : 3) in Maharashtra are found remunerative sesame-based intercropping systems; and increase in yield was from 28 to 75%.

Crop Protection

OS-Sel 2 and OS-Sel 24 are found resistant to *Macrophomina* stem/root rot and phyllody, and Sekhar is resistant to phyllody only. Entry OS-Sel 253 has been observed to be free from leaf curl. Endosulfan at 1.5 litre/ha at 30 and 45 DAS was effective against *Antigastra* and *Dasyneura* pests.

Resistant variety+ seed treatment with Carbendazim 50 WP (0.1%) + Thiram (0.2%) or Carbendazim 50 WP (0.2%) alone or *Trichoderma viride* (0.4%) +two sprays of Azadirachitin (0.03%) or Mancozeb (0.25%) + Endosulfan (0.07%) at 30–45 and 45–55 days after sowing + intercropping with mungbean/pigeonpea/urdbean minimized incidence of *Antigastra* and *Dasyneura* and *Macrophomina* stem/root rot, *Alternaria* leaf-spot and *Cercospora* leaf-spot.

NIGER

A high-yielding, early-maturing niger JC 1 has been released for niger-growing areas of Madhya Pradesh. JNS 14 and JNS 13 have showed promise in the advanced varietal trial. Over 0.79 tonne breeder seed of 7 varieties has been produced against the DAC indent of 0.24 tonne.

Fertilizers at 40 kgN/ha + 40 kg P/ha gave maximum seed yield when phosphorus was supplied half as DAP/SSP + half as rock-phosphate, enriched with FYM. Sulphur at 20 kg/ha with recommended dose of fertilizers gave maximum yield. Niger + Frenchbean (4 : 2) with 20-cm row spacing at Semiliguda, niger + castor (2 : 2) at Chhindwara and niger+ricebean (2 : 4) at Igatpuri were most remunerative intercropping systems.

In niger, component technology such as adoption of improved variety (34.0–57.1%), improved variety+biofertilizer (41–137%), recommended dose of fertilizers (37.7–107.6%), intercropping (37%), sowing method (47.3%) and time of sowing (246–294%) enhanced productivity on the farmers' fields.

- In niger, component technology enhanced its productivity in farmers' fields.
- Linseed lines A 95b, EC 1392, EC 1424, GS 234 and JRF 5 proved promising against bud-fly.
- In rainfed areas of Sagar, in linseed + safflower (4 : 2), 100% RDF to main crop and 50% to intercrop recorded highest linseed equivalent yield.

LINSEED

Crop Improvement

Four varieties have been identified/released for cultivation.

Out of 200 germplasm screened at hot spots, ES 1465, ES 1496, ES 1329, ES 131-10, FRW 6, GLC 1-1, GS 15, GS 53, GS 85, GS 157, GS 158, GS 234, GS 252, GS 270, GS 208 have showed resistance to powdery mildew and GS 148, GS 165 and GS 202 against rust diseases.

RLU 6 identified (*left*) and RL 914 released (*right*) linseed. The former is erect, white-flowered and is resistant to rust and bud-fly. Its oil content is 40.48%. The latter is also erect but is blue-flowered. It shows resistance to wilt and rust. Its oil content is 41%

Linseed varieties released

Variety	Released/ identified	Average seed yield (tonnes/ha)	Days to maturity	Area of adoption	Salient features
KL 210	Identified	0.85	149–158	Haryana, Punjab, Himachal Pradesh and Jammu and Kashmir	Erect, purplish-blue flowers, yellow seeds, resistant to rust and free from wilt, and moderately resistant to *Alternaria* blight. Its oil content is 40%
SLS 27	Identified	1.5	118–125	Rajasthan, Bundelkhand (Uttar Pradesh), Madhya Pradesh, Maharashtra, Chhattisgarh, Orissa, Andhra Pradesh and Karnataka	Erect, white flowers, light brown seeds, moderately resistant to all diseases and pests. Oil content is 41.43%
RLU 6	Identified	1.69 - Seed 0.86 - Fibre	136–145	Madhya Pradesh, Rajasthan and Bundelkhand (Uttar Pradesh)	Erect, white flowers, shinning brown seeds, resistant to rust and bud-fly and moderately resistant to powdery mildew and *Alternaria* blight. Oil content is 40.48%
RL 914	Released	1.67	130–137	Rajasthan (State release)	Erect, blue flowers, brown seeds, resistant to wilt and rust and moderately resistant to powdery mildew, *Alternaria* blight and linseed bud-fly. Oil content is 41%

Crop Production

At Powerkheda, sowing double-purpose linseed during last week of October, using 45 kg of seeds/ha was observed the best practice to harvest higher seed yield. At Mauranipur, double-purpose linseed sowing with 25% higher seed rate (56–57 kg/ha) during first week of November was adjudged as the best treatment for good net monetary returns. At Nagpur, broadcasting linseed at 40 kg of seed/ha at dough stage of paddy proved a superior practice for the crop sequence.

In linseed + safflower (4 : 2) intercropping, fertilizer at 100% RDF to main crop and 50% to intercrop recorded highest linseed equivalent yield at Sagar in rainfed situations.

In linseed + wheat (4 : 2) intercropping system, fertilizer at 100% RDF to both the crops and in linseed + mustard, fertilizer at 100% RDF to main crop and 50% to intercrop proved optimum in Himachal Pradesh.

Crop Protection

Linseed intercropped with chickpea (3 : 1) at recommended fertilizer and irrigation schedules, bird perches at 40–50 pegs/ha and need-based Imidacloprid 200 SL (100 m/ha) at Kanpur, Dimethoate 30 EC (0.03%) at Raipur and Oxydemeton methyl 25 EC (0.02%) at Faizabad provided maximum seed yield with higher net monetary returns as well as benefit: cost ratio.

Linseed lines A 95 b, EC 1392, EC 1424, GS 234 and JRF 5 proved promising against bud-fly.

- Noticed an extra-early genotype of chickpea; amenable for planting up to December end.
- Kabuli chickpea BG 1003 intercropped with mustard Vardan in 6 : 2 ratio found most productive and remunerative system with benefit: cost ratio of 4 : 1.
- Chickpea promising donors identified for resistance to *Fusarium* wilt.
- *Trichoderma viride* at 4 g + vitavax at 1 g/kg chickpea seeds controlled *Fusarium* wilt and root-rot.

PULSES

CHICKPEA

Crop Improvement

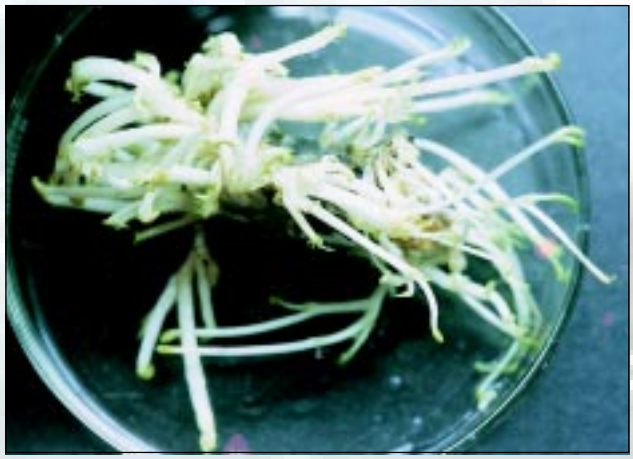
JKG 92337 is a semi-spreading kabuli chickpea variety from a three-way cross (ICCV 2 × Surutato) × ICC 7344, and has been identified for Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, southern Rajasthan and Bundelkhand area of

JKG 92337 kabuli chickpea possesses moderate resistance against collar rot and *Fusarium* wilt. Its average seed yield is 1.7 tonnes/ha (*inset* : its seeds)

TRANSGENICS IN CHICKPEA

A simple regeneration and genetic transformation system has been perfected for developing transgenics in chickpea. The system involves multiple shoot induction from apical shoot meristem, followed by transformation by *Agrobacterium tumefaciens,* carrying plasmids with different selectable markers.

Chickpea genotypes K 85, BG 256, K 850 and C 235 have been transformed, carrying various plasmids having *Cry 1Ab* (*Bt* gene), with ppt and kanamycin resistance marker genes. A simple system of micro-grafting has also been developed to establish transformed shoots.



Multiple shoot induction from embryonic chickpea axis after transformation with a marker gene

Uttar Pradesh. Besides being early-maturing, this variety possesses moderate resistance against collar rot and *Fusarium* wilt. Its average seed yield is about 1.7 tonnes/ha.

And Phule G 9531, a bold-seeded (35g/100 seeds) kabuli selection, from the cross (ICCC 32 × ICCL 8004) × (ICCC 49 × FLIP 82-8C) × ICCV 3), has been identified for Orissa, Karnataka, Andhra Pradesh and Tamil Nadu. It is an early-maturing (90 days), *Fusarium*-wilt resistant variety with an average yield of 1.8 tonnes/ha.

Five elite lines, IPC 98-12, IPC 97-67, IPC 98-53, IPC 97-7 (*desi*) and IPCK 98-18 (*kabuli*), have showed promise in the advanced trials, and IPC 94-94 has been found an extra-early genotype, amenable for planting up to December end.

Crop Production

In rainfed areas, two sprays of 2% urea or DAP one at flower initiation and 10 days thereafter proved effective in increasing grain yield of chickpea significantly. For bold-seeded kabuli chickpea in soils having less than 15 kg available P/ha, 60 kg P_2O_5/ha proved beneficial.

IPC 99-10 chickpea exhibits stable resistance to *Fusarium* wilt (Race 2)

Kabuli chickpea BG 1003 intercropped with mustard Vardan in 6 : 2 row ratio was most productive (2.09 tonnes chickpea equivalent/ha) and remunerative system, with benefit : cost ratio of 4 : 1. Chickpea after rice responded to higher 30 : 60 : 30 kg NPK/ha and deep ploughing. In rainfed areas, grain yield showed significant correlation with total biomass, number of pods and branches. Branch number was one of the principal components determining yield variation.

Crop Protection

IPC 99-13, IPC 99-34 and IPCK 96-3 have been identified as promising donors for resistant to *Fusarium* wilt. PBG 34, PBG 127, IPC 95-2, IPC 97-1 and IPC 99-10 exhibited stable resistance to race 2 (Kanpur) of *Fusarium* wilt.

Three variants of *Rhizoctonia bataticola* causing dry-root rot have been identified. *Trichoderma viride* (4 g) + vitavax (1 g) effectiveness per kg of seed in controlling *Fusarium* wilt and root rot has been confirmed.

Chickpea intercropping with mustard or linseed or coriander combined with alternate spray of NSKE (5%) –NPV (250 LE) or Endosulfan was highly effective in managing *Helicoverpa armigera*.

- Pigeonpea T 21, Bahar and UPAS 120 transformed, carrying various plasmids, having number of gene constructs, including *Cry 1Ab.*
- Pigeonpea GT 288A and 67A confirmed as stable cytoplasmic male sterile lines; identified a few fertility restorers also for GT 288 A.
- On alluvial soils, 60 kg P_2O_5/ha to pigeonpea + sorghum system yielded highest seed yields.

PIGEONPEA

Crop Improvement

Two varieties of pigeonpea have been identified.

IPA 04 pigeonpea with multiple resistance to *Fusarium udum, Alternaria* blight, *Meloidogyne incognita* and *Heterodera cajani,* and IPA 2000-1 with resistance to *F. udum* and sterility mosaic have been identified.

Pigeonpea varieties identified

Variety	Adoption region	Yield (tonnes/ha)	Duration (days)	Other salient features
Pusa 992	Punjab, Haryana, western Uttar Pradesh, Rajasthan	2.4	149–162	Medium bold seeds, 6 days earlier than UPAS 120
MA 6	Eastern Uttar Pradesh, Bihar, Assam, West Bengal, and north-eastern states	2.28	248–267	Resistant to pod-fly and pod-borer

Pigeonpea genotypes T 21, Bahar and UPAS 120 have been transformed carrying various plasmids having number of gene constructs, including *Cry 1Ab* (*Bt* gene).

GT 288A and 67A have been confirmed as stable cytoplasmic male steriliy (CMS) lines. A few fertility restorers have also been identified for GT 288A.

Crop Production

Short-duration pigeonpea with wheat adds to 30 kg N/ha in the soil. In north-eastern plains comprising eastern Uttar Pradesh, Bihar, West Bengal and Assam, where excess moisture/water stagnation often causes mortality of plants during early stage, ridge planting of pigeonpea proved superior to flat-seed beds. This also minimized incidence of *Phytophthora* stem blight.

A positive response was observed in the crop when 15 kg $ZnSO_4$ was applied per hectare across the locations; making it a component of recommended fertilizer schedule in pigeonpea. Seed treatment with sodium molybdate at 4 g/kg seeds was promising in high P soils. FYM at 5 tonnes/ha significantly increased pigeonpea seed yield by 210 kg/ha, besides positive residual effect on the succeeding wheat. At 60 kg P_2O_5/ha, in pigeonpea + sorghum system on alluvial soils, seed yield of both the crops was highest.

Crop Protection

BSMR 842 and BSMR 736 have showed resistance to wilt and sterility mosaic across the locations and IPA 38, KPL 43, KPL 44, BSMR 52, BSMR 23, BSMR 889 and BSMR 539 have promised resistance against wilt and sterility mosaic at Kanpur. Pusa 2001-1, H 82-1 and MAL 19 are found tolerant to pod-borer and ICPL 98014 performed better against *Maruca vitrata*. MAL 13 identified, possesses resistance against *Meloidogyne incognita* and *Heterodera cajani*.

MA 6 pigeonpea yields 2.28 tonnes/ha and is resistant to pod-fly and pod-borer

- Wide crosses between mugbean and urdbean resulted in IPM 99-125 and IPM 02-1 lines that combined early maturity with determinate growth and bold seeds.
- Identified promising donors of urdbean for photo-insensitivity.
- In mungbean, *Rhizobium* strain CRM 6 proved most effective, followed by PMR 2001.

Intercropping of pigeonpea with sorghum reduces wilt incidence and nematode population

Pigeonpea intercropped with sorghum and seed treatment with *Trichoderma harzianum* reduced *Fusarium udum* as well as parasitic nematodes significantly.

Orymyrus and *Bracon* spp. are found potential larval/pupal parasites of pod-fly. Pigeonpea + sesame reduced plant parasitic nematodes and pigeonpea + urdbean cropping system increased them. Seed treatment with *Calotropis* latex at 1% proved effective against root-knot nematode.

MUNGBEAN AND URDBEAN

Crop Improvement

OUM 11-5 mungbean has resistance to mungbean yellow mosaic virus (MYMV) and tolerance to *Cercospora* and powdery mildew. It has been identified for Andhra Pradesh, Karnataka, Orissa and Tamil Nadu (*kharif*).

Another mungbean HUM 12 possesses tolerance to mungbean yellow mosaic virus and has been identified for eastern Uttar Pradesh, Bihar, West Bengal and Assam (summer season).

NUTRIENT AVAILABILITY IN PULSE-GROWING SOILS

Soil samples representing alfisols (Raipur, Hyderabad, Bangalore and Ranchi), inceptisols (Delhi, Kanpur, Faizabad and Varanasi) and vertisols (Sehore and Gulbarga) were collected and were analysed for various fertility parameters.

Distribution and availability of nutrients. All 10 soil profiles were low in organic-carbon content and in available N. Excepting Bangalore, rest of the profiles were medium in available P. Alluvial soils (inceptisols) were low in available K and black soils (vertisols) were found relatively high in available K status. Available S status of pulse-growing soils was low. All profiles, excepting Varanasi, were deficient in available Zn. Available Fe was sufficient in all profiles, excepting Delhi, and Cu and Mn were sufficient in all profiles.

Distribution of sulphur fractions. S ranged from 240 to 376 mg/kg for total S, from 191 to 362 mg/kg for organic S, from 12.9 to 59.0 mg/kg for adsorbed S, from 3.47 to 9.22 mg/kg for available S. Larger organic and total sulphur was observed in vertisols, followed by inceptisols and alfisols, and adsorbed S was higher in alfisols. Organic sulphur constituted 81–95% in the total S.

Distribution of forms of potassium. Vertisols showed higher water-soluble K and 0.01 M $CaCl_2$ extractable K as compared to inceptisols and alfisols. Among 10 profiles, Sehore and Gulbarga soils showed available K (NH_4OAC-K) in higher range; Delhi, Raipur, Hyderabad and Bangalore were medium; and Kanpur, Faizabad, Varanasi and Ranchi were low in available K. In reserve K (HNO_3 K), alfisols at Hyderabad, Ranchi and Bangalore profiles showed less than 400 mg/kg and rest of the profiles showed above 600 mg/kg.

Wide crosses between mungbean and urdbean have resulted in promising lines IPM 99-125 and IPM 02-1, which combine early maturity with determinate growth habit and bold seeds.

Some of the promising donors of urdbean for photo-insensitivity are NDU 94-10, IPU 96-1, PDU 103, UH 82-51, STY 2593, Sel 2, DUS 29, PLU 704, No. 4812 and UH 82-35.

Crop Production

Nitrogen at 20 kg/ha as basal and 10 kg/ha as foliar spray proved beneficial in late sown (August) mungbean with higher yield at high plant density (4–5 lakh/ha).

Mungbean PDM 2000-88, TM 99-37, HUM 15 and PDM 139 are found resistant to MYMV disease. Urdbean DPU 88-31 has been confirmed as having stable resistance to MYMV. Mungbean lines Pusa 105, Pusa 9871 and UPM 78-1 are identified as resistant to root-knot nematode.

Rhizobium strain CRM 6 proved as most effective, followed by PMR 2001 in mungbean. And in urdbean, PUR 34 and PUR 16 performed better.

LENTIL AND FIELDPEA

A new lentil variety NDL 94, a pedigree selection from DLG 105 × PL 406, has been identified for eastern Uttar Pradesh, Bihar, West Bengal and Orissa. It has small seeds with an average yield of 1.52 tonnes/ha. The variety possesses resistance to rust. Seed rate of 75 kg/ha resulted in higher grain yield of bold-seeded varieties in northern states. In *utera* cultivation, 2 hr of seed soaking in 2% KH_2PO_4 was effective with 9% higher yield.

In fieldpea, 2 sprays of Mancozeb (0.25%) were effective in controlling rust and 2 sprays of wettable sulphur (0.3%) in controlling powdery mildew. Fieldpea HUP 15, HUD 16, KSP 22, KPMR 144-1, KPMR 557, DPFPD 8, DPFPD 62 and JP 181 have showed tolerance to rust in Uttar Pradesh.

ARID LEGUMES

Crop Improvement

Cowpea GC 9714 has yielded 10.50% (1 tonne/ha) higher over the better check GC 3 (0.79 tonne/ha) in the multilocation trial. It flowers in 47 days and takes 72 days to mature. Mothbean CZM 45 has yielded 32.2% (0.59 tonne/ha) higher over the corresponding check CAZRI Moth 1 (0.45 tonne/ha) in the all-India co-ordinated trials. This flowers in 40 days and yields 26.13% crude protein.

In guar genotypes HGS 365, GG 1 and HGS 880, maximum galactomannan gum (31.2%) and endosperm (38.45%) contents, and means viscosity profile (3726 Cp), respectively, were observed.

Crop Production

At Hisar and Bawal, 0.5% $ZnSO_4$ spray at 25 and 45days after sowing (DAS) gave 69% yield (1.7 tonnes/ha) increment in guar yield over control (1.05 tonnes/ha). Spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ on cowpea at 45 DAS proved quite effective at Pattambi, wherein grain yield increased by about 44.9% over control (0.42 tonne/ha).

Crop Protection

Guar entry HGS 870 was found resistant (less than 10% infection) to bacterial leaf blight (BLB), and GAUG 12 and HGS 885 showed less than 3% infection against *Alternaria* leaf blight. Seven cowpea entries TC 101, TC 102, TCM 77-4, DCP 3, DCP 4, V 649 and HC 98-50 are found free free from YMV.

- Fieldpea genotypes HUP 15, HUD 16, KSP 22 showed tolerance to rust in Uttar Pradesh.
- Mothbean CZM 45 yielded 32.2% higher over CAZRI Moth 1, the check.

- Identified cotton intra-*hirsutum* hybrid NCHH 207 for irrigated areas of South Zone and intra-*arboreum* ADCH 1 for rainfed areas of Central Zone.
- Ridge-and-furrow on flat-bed increased seed-cotton yield by about 0.4 tonne, broad-bed and sunken-bed by 0.5 and raised-and-sunken bed by 0.65 tonne over control.
- The CICR has developed 3 ready-to-use kits to differentiate *Bt*-cottons from non-transgenics.

SUCCESS STORY

IPM FOR COTTON IN CHINNAPUTHUR (TAMIL NADU)

By adopting IPM/IRM farmers of the Chinnaputhur village were able to manage efficiently resistant pest population of *Helicoverpa armigera*, and reduced pesticide application by 50%. The bollworm damage was brought down to 10%. The farmers of the project village obtained a mean seed-cotton yield of 1.874 tonnes/ha, against 1.50 tonnes/ha in the control village. The farmers gained additional returns of Rs 12,000/ha compared to farmers from the control village.

COMMERCIAL CROPS

COTTON

Crop Improvement

Intra-*hirsutum* cotton hybrid NCHH 207 for irrigated areas of South Zone and intra- *arboreum* hybrid ADCH 1 for rainfed areas of Central Zone have been identified for release.

Genotypes of upland cotton (*Gossypium hirsutum*) GJHV 370, LH 1948, PH 348, NH 545 and H 1252 for irrigated areas and LH 1948, NH 545, Khd.122, CNH 155 and KH 11 for rainfed areas have showed promise. LH 1948 and NH 545 are found suitable for rainfed and irrigated areas.

Genotypes identified for salt tolerance are LRK 516, PKV 081, Khandwa 3, Badnawar (*G. hirsutum*) and G. 27 (*G. arboreum*). Tolerant genotypes are found to have higher osmotic potential, K/Na ratio and have high proline accumulation, up to 10 EC.

In zonal trials in South Zone, *G. hirsutum* genotypes GJHV 337 (1.56 tonnes/ha) and CCH-In 526612 (1.7 tonnes/ha) showed significant superiority over zonal check LRA 5166. In the intra-*hirsutum* hybrids, conventional hybrid PSCH 504 (1.72 tonnes/ha) and male-sterility-based hybrid PSCH 809 (1.54 tonnes/ha) showed superiority over NHH 44 (zonal check).

Crop Production

Reduced tillage helps in improving soil-organic carbon and so the crop productivity in cotton.

Cotton-crop suffers mostly due to low moisture, and sometimes due to excess moisture. Ridge-and-furrow on flat-bed increased seed-cotton yield by about 0.4 tonne, broad-bed and sunken-bed by about 0.5 tonne and raised- and- sunken bed by about 0.65 tonne over control.

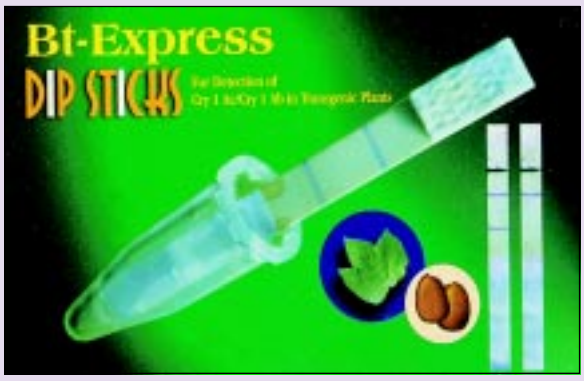
Irrigation at 1 evapotranspiration (ET) through drip resulted in highest water-use efficiency of 16.1 kg seed-cotton/ha/cm water with a saving of 31.1% water compared with flood irrigation. NPK at 75% in 6 splits and irrigation at 1 ET through drip resulted in the highest water- and fertilizer-use efficiency.

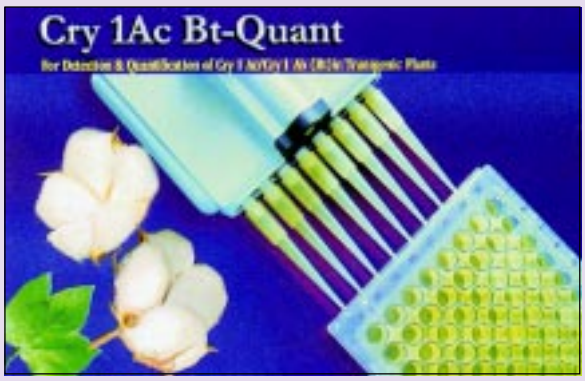
Cotton on raised bed and mugbean on furrows

READY-TO-USE KITS TO DIFFERENTIATE BT-COTTONS AND COTTONS

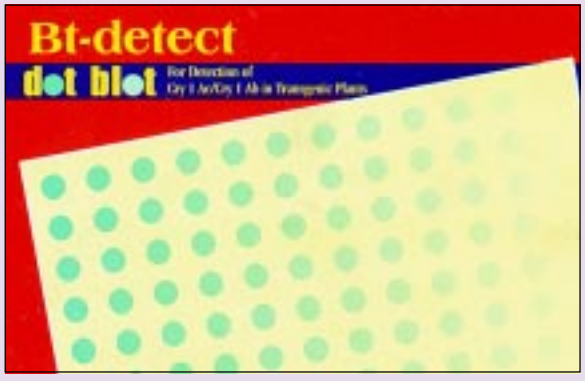
(a)

(b)





(c)



(d)

Bt cotton-testing kits.
(a) Transgenic cotton LRA 5166;
(b) Bt-express;
(c) Cry 1 AC Bt-Quant;
(d) Bt-detect

Cotton hybrids MECH 12, MECH 162 and MECh 184 have incorporated *Cry I Ac* as the toxin-producing gene. It has become important to differentiate Bt-cottons from non-transgenics to monitor gene introgression, to detect spurious material and also to maintain seed quality. The CICR, Nagpur, has developed 3 'ready-to-use' kits to cater to the needs of the farmers, researchers and administrators.

Cry 1 Ac Bt express. This is a dip-stick format and can be used by even a layman for instantaneous detection of Bt toxin in either seeds or in plant tissues. It takes 10 minutes for the test. This test can be used in the field and does not require any additional facilities. The kit is rapid, reliable and ready-to-use.

The Cry 1 Ac Bt-quant. It is an ELISA kit, which facilitates precise quantification of *Cry 1 Ab* or *Cry 1 Ac*, expressed in transgenic plants. The kit is simple, cost-effective and very reliable. Each ELISA plate can be used for 96 samples. It takes 4 hours for completion of one set of ELISA assay.

The Cry 1 Ac Bt-detect. This is a dot-blot assay and enables user to detect Bt toxin presence in seeds or in plant tissues. Each kit can be used for 100 samples. The kit is fairly simple and can be used by persons with minimum technical capabilities and with a little training. It takes 2–3 hours for completion of one set of test assay.

- Sugarcane selections 93-A-21 and COLk 9216 showed promise for planting after wheat harvest.
- Cane maturants Dinitrocifrol (8 kg/ha) and Triacontanol (5 litres/ha) through irrigation water in the first fortnight of September improved sugarcane juice attributes.
- Stain B of sugarcane mosaic virus reduced cane yield significantly in Co Pant 90223, CoS 767 and CoLK 8102.

Sulphur at 60 kg/ha improved seed-cotton yield by 28.9% at Khandwa and 18.2% at Nanded.

Crop Protection

Thiamethoxam 35 F.S and Poncho 600 F.S as seed dressers effectively controlled sucking pests of cotton up to 45 days. In Sriganganagar, effectiveness remained up to 60 days. Cotton-seed treated with Imidacloprid (Gaucho) 70 WS at 5 g/kg seed protected plants from early attack of cotton leaf curl virus disease through whitefly.

Talc-powder formulations of *Pseudomonas fluorescens* (Pf 1 and CHAO strains) as seed treatment at 10 g/kg seed, followed by foliar spray at 0.2%, have been effective in managing bacterial blight, *Alternaria* leaf spot and grey mildew at Dharwad.

SUGARCANE

Crop Improvement

From the National Hybridization Garden (Coimbatore), 41.35 kg of hybrid fluff of sugarcane was obtained, and has been supplied to different co-ordinating centres for raising seedlings and selection of clones suitable for different agroclimatic zones. Out of 38 clones evaluated, early genotypes CoSi 88033, CoSi 91012, CoC 97061, 91 V 83, CoS 96258 and CoLk 9411 and midlate Co 92020, Co 94019, Co 95012, CoS 94270 and CoLk 9606 have possessed potential for high sugar yield per hectare.

Sugarcane CoLk 97169 (early-maturing) and CoLk 9710 (mid-late maturing), have been accepted for Zonal Varietal Trial of the North-west Zone. Sugarcane selections viz., 93-A-21 and CoLk 9216 have been found promising for planting after wheat harvest.

Crop Production

Sugarcane planting in overlapping cropping system with wheat and berseem in February gave significantly higher cane equivalent yield of 89.8 and 115.6 tonnes/ha

SUGARCANE MECHANIZATION

An improved model of tractor-operated multipurpose sugarcane farming equipment has been developed.

It is used for sugarcane planting, intercultural operations, earthing-up, puddling, seed-drilling and land preparation.

Basically the equipment is a three-row sugarcane cutter-planter. Any tractor (35-hp or more) can be used to operate it. It has following improved features: (i) the operator need not hold the cane while planting; (ii) power transmission system has been drastically simplified; (iii) it needs minimum head land; (iv) furrowers (not ridgers) open the furrows; (v) curved blades cut the cane by shear action; (vi) canes are cut at 65° for smooth cutting; (vii) length of the setts remains uniform, (viii) setts placement pattern remains same, irrespective of the tractor and the gear in operation, and (ix) best weight distribution.

All sub-operations of cane planting are performed simultaneously, without any loss of time and soil moisture. An area of one hectare can be planted in 3.5–4.0 hr with the help of six persons, including tractor-driver. This equipment is able to meter optimum seed rate of cane.

Multipurpose equipment planting sugarcane

over cane planting after harvest of wheat and berseem (81.1 and 108.9 tonnes/ha). Urdbean-*toria*-sugarcane-ratoon-wheat and rice-berseem-sugarcane-ratoon-wheat systems have revealed that inclusion of berseem in crop sequence has ameliorative effect on the soil physical properties, leading to higher cane yield (73.7 tonnes/ha) and water-use (0.84 tonnes/ha/cm).

To characterize indigenous *Acetobacter diazotrophicus* isolates, 16s r-RNA probe was used. IS 100, 107, 111, 112, 113, 120 and 121 were confirmed positive, and were designated as *A. diazotrophicus*. Isolate IS 100 has been found the best. These isolates can be exploited as biofertilizers in fields.

Cane maturants Dinitrocifrol (8 kg/ha) and Triacontanol (5 litre/ha) through irrigation water in the first fortnight of September improved sugarcane juice quality attributes. Spraying freshly harvested canes with 10 ppm Dithiocarbamate + 1% sodium metasilicate and mixing 10 ppm of Benzalkonium chloride in the primary juice, suppressed acid invertase, dextran-sucrase activity and dextran formation *per se*.

Crop Protection

Non-conventional plant-based insecticides neem (10,000 ppm at 0.3%) and annona 20 EC (0.2 and 0.1%) were effective against black-bug and whitefly. Insecticides, Acephate (0.05%) and Karate (0.03%) showed highest toxicity against black-bug, followed by Endosulfan (0.05%), Polytrin (0.03%) and Carina (0.05%).

Strain B of sugarcane mosaic virus (SCMV) significantly reduced cane yield by 13.6, 10.7 and 11.2% of CoPant 90223, CoS 767 and CoLK 8102.

- Identified an induced mutant of *Corchorus capsularis* (var. JRC 212) for understanding lignification process of secondary phloem fibre cells of jute.
- Jute phloem lignin-dificient mutant dphl, showed potential for utilization to genetically engineer low lignin, fine and soft quality jute.

JUTE AND ALLIED FIBRES

Crop Improvement

For understanding the lignification process of secondary phloem fibre cells of jute, an induced (50 kR) mutant of *Corchorus capsularis* (var. JRC 212) has been

TWO NEW SPECIES OF *CORCHORUS* FOUND IN INDIA

Wild jute *Corchorus pseudo-olitorius*

Only 8 species of jute (*Corchorus*) were reported from India. In January 2002, in the southern parts of Kerala and Tamil Nadu, one more species *Corchorus pseudo-olitorius* was found distributed in the Tirunelvelli district (Tamil Nadu). This has been growing as weed in the sugarcane field and in the raised boundary wall of the paddy field. This species showed remarkable tolerance to diseases and pests compared to other wild jute species.

Another species, *Corchorus depressus* has been reported from western provinces of India, and has showed tolerance to drought. This species was collected for the first time from Jaisalmer and other districts of Rajasthan.

Corchorus depressus, wild jute

With the incorporation of drought-tolerant genes in the cultivated species, like *C. olitorius*, jute cultivation may be more remunerative.

Beauveria bassiana, a biogent. This fungus has been isolated from the mesta-flea beetle *Nisotra orbiculata* and has proved active for controlling insect-pests of jute and mesta

identified and characterized for histological, biochemical and chemical traits. A clear distinction is visible in wall thickening of secondary phloem fibre cells in the mutant compared to normal plant. The extracted fibre strands from the mutant run almost parallel and do not show typical meshy nature of jute fibres.

The lignin content of the mature fibre of the mutant was only 8–9% as compared to 17–21% in JRC 212. This phloem lignin-deficient mutant, designated as dphl, has a potential for utilization to genetically engineer low lignin, fine and soft quality jute.

Crop Production

At Bahraich, Nagaon and Aduthurai, substitution of 25% NPK either through compost or green manure enhanced jute fibre productivity significantly. Compost prepared from *Sesbania rostrata* proved most promising at Nagaon and green manuring with *dhaincha* at Bahraich and Aduthurai showed best performance.

Crop Protection

The bioagent, *Beauveria bassiana* (Balls.) Vuill., an entomogenous fungus, has been isolated from mesta-flea beetle *Nisotra orbiculata* (Mots.), and has proved active microbe for controlling insect pests of jute and mesta. Some other bioagents isolated either from diseased insects or from soil are *Metarrhizium anisopliae*, *Gliocladium* sp. and *Paecilomyces lilacinus.*

The mass culture of the fungus is possible on the natural, semi-synthetic and synthetic media. Metabolites were extracted from *Beauveria bassiana* using ethyl acetate as solvent in the laboratory. These proved toxic when sprayed on the insect larvae. This fungus has got the antagonistic effect on the jute stem-rot, caused by *Macrophomina phaseolina*, and on *Fusarium* spp.

B. bassiana spores could remain viable for 240 days, and after 8 months, no colony was recorded, as viability was lost.

TOBACCO

Crop Improvement

A Natu tobacco variety Pyruvithanam has been released by the SVRC, Orissa, for cultivation in pikka-tobacco growing areas of Orissa. This variety has yield potential of 1,250 kg/ha. And a chewing tobacco variety Lichchavi has been released for cultivation in the north Bihar.

Tobacco varieties recommended for identification

Variety	Yield potential (kg/ha)	Recommended for identification
Hemadri	2,500	FCV tobacco for traditional black soils in rainfed areas of Andhra Pradesh
Bhairavi (NG 73)	2,600	Natu tobacco for rainfed areas of Andhra Pradesh
BSRB 2 (Sweta)	2,000	Burley tobacco for light soils of Agency area in Andhra Pradesh under monsoonic conditions

- Produced intersectional hybrids of *Nicotiana repanda* × *N. tabacum* from hormonal-aided direct hybridization.
- *Helicoverpa armigera* damage to FCV tobacco was more when high N was applied, but K reduced its incidence and damage.

Advanced breeding lines Cy 135, Cy 136, Cy 137 and Cy 139 performed well in bulk observation trials, yielding 2,250 to 2,450 kg of cured leaf/ha; an increase of 24 to 36% (1,240 to 1,590 kg/ha), and 37 to 53% increase in bright leaf over the check in the northern black soils.

Intersectional hybrids of cross *Nicotiana repanda* × *N. tabacum* have been

Burley tobacco variety Sweta has been recommended for identification for light soils of Andhra Pradesh in monsoonic conditions. It has a yield potential of 2,000 kg/ha

FCV tobacco variety Hemadri has been recommended for identification for traditional black soils in rainfed areas of Andhra Pradesh. It has showed a yield potential of 2,500 kg/ha

produced from hormonal-aided direct hybridization. The hybrid is very important because ovule-parent is reported to be resistant to eleven diseases and two insect pests of tobacco.

Crop Production

Nitrogen at 120 kg/ha to Banket A1 variety of burley tobacco of light soil in organic (FYM) and inorganic forms in 25 : 75 ratio recorded 18.4% more leaf yield to normal practice. This variety recorded maximum cured leaf yield of 2,062 kg at 120 kg N/ha along with 10 tonnes FYM.

High-grade phosphate rock of Jhamarkotra mines (Rajasthan) with 34% total P_2O_5 and 74 micron size (PR 34/74) was found promising for FCV tobacco on neutral soils, low in available P. PR (34/74) at 80 kg P_2O_5/ha in combination with FYM at 3.5 tonnes/ha or PR at 90 kg P_2O_5/ha along with green manuring can be profitably used for the southern light-soil crop, replacing SSP and diammonium phosphate.

Cowhage, *Aswagandha* or *Coleus*, medicinal plants, are promising alternatives to FCV tobacco, and they may be considered for soils unsuitable for quality tobacco production.

At Bihar, maximum total cured leaf and first-grade leaf yields of chewing tobacco have been recorded when 50% of N as ammonium sulphate and 50% as castor-cake were applied.

Crop Protection

Three alley crops, *jowar*, maize and *bajra*, grown as border to tobacco, were significantly superior to when they were grown as strips in reducing stem-borer, tobacco caterpillar, tobacco budworm, tobacco leaf-curl vector and tobacco aphid in tobacco.

Budworm *Helicoverpa armigera* damage to FCV tobacco was more when high N was applied, but K application reduced the incidence and damage.

Tracer 48 SC, Avaunt 14.5 SC, Cascade 10 DC, Rampage 10 SC at 100 g a.i./ha and Larvin 75 WP at 750 g a.i./ha are found effective against tobacco budworm.

Entomopathogenic nematode *Steinernema carpocapsae* talc-based formulation was found effective at 1×10^5 IJ/m^2, in succession with NPV at 1.5×10^{12} PIBs/ha to contain seedling damage caused by *Spodoptera litura* (15.33 seedlings). EPN alone

- Hybrid seed production was economical of castor and sorghum at Hyderabad and of sunflower at Bangalore.
- Suitable seed treatments developed for enhancing storability of wheat, maize, sorghum and *bajra*.
- Identification manuals are being prepared to help quality seed production and DUS testing.
- Recommended packaging of soybean seeds in jute canvas bags with inside lining of bubbled-polyster, for their safe transport.
- Cotton-seed lots with 55% germination could be upgraded to standard germination by the use of specific gravity separation.

was effective at 4×10^5 IJ/m^2 with seedlings damaged totalling to 22/m^2 compared to control (121.66 seedlings).

Five accessions MD 40, 872, 201, Coker 129 and Speight G 41 have been graded as resistant to TMV; 9, Coker 129, 297, 371, MD 10, 872, NC 73, 2326, DB 10 and Va 310 resistant to black shank and 5, MD 609, NC 2326, HV 92 2, 92 4 and VR 2 showed resistance to root-knot nematode (RKI <1).

In FCV tobacco nursery, bordeaux mixture at 0.5% up to 35 DAS, followed by 2 foliar sprays with Propiconazole (Tilt 25% EC) at 0.05% have been recommended for controlling leaf and stem infection phases of anthracnose.

SEED PRODUCTION AND TECHNOLOGY

BREEDER SEED PRODUCTION

During 2001–2002, a total of 3,064.36 tonnes of breeder seed have been produced; major quantities belonged to oilseeds (1,335.72 tonnes) and cereals (1,101.13 tonnes), followed by pulses (562.53 tonnes), forages (45.82 tonnes) and fibres (19.16 tonnes). Besides, additional breeder seed was also produced against indent of state-level varieties.

Seed Technology

Diagnostic characterization. A massive programme on variety characterization major field crops has been taken up for morphological characters, chemical tests and electrophoretic banding pattern. The work is being harmonized with the National Test Guidelines for DUS.

Economics of hybrid seed production. In cotton, the cost:benefit ratio is economical in Hyderabad (1 : 2.22), Dharwad (1 : 1.95) and Akola (1 : 1.8) for hybrid seed production. Hyderabad is also beneficial for castor and sorghum, and Bangalore is ideal for sunflower hybrid seed production.

Seed coating. Seed coating using natural or synthetic adhesive (starch gruel or carboxy methyl cellulose), natural filler, (Arappu leaf powder/neem kernel powder/ vermicompost) and Thiram 0.3% or $ZnSO_4$ (0.3 g/kg) has shown enhancement in field emergence and crop growth in soybean; the storability was satisfactorily up to 3 months.

SEED TREATMENTS FOR ENHANCING STORABILITY

Crop	Treatment	Moisture content (%)	Period (months)	Container
Wheat	Vitavax + Thiram (1 : 1)	8	18	Poly-lined gunny bags
Maize	Thiram	8	12	Poly-lined gunny bags
Sorghum	Thiram+Carbendazim (1 : 1)	9	18	Poly-lined gunny bags
Bajra	Thiram	8	18	Poly-lined gunny bags

GROWING-ON TEST OF SEEDS TO ASSESS TRANSMISSION OF VIRUSES

Based on the growing-on test of seeds collected from diverse sources, the seed transmission of viruses was 1–16% and 2–27% of black-eye cowpea mosaic potyvirus in cowpea and urdbean; 2–6% and 3–33% of urdbean leaf crinkle disease in mungbean and urdbean; 0.3–49% and 4–67% of bean common mosaic potyvirus in mungbean and urdbean; 0.5–5% of pea seed-borne mosaic potyvirus in pea and 2–52% of soybean mosaic potyvirus in soybean.

PLANT PROTECTION

BIOLOGICAL CONTROL

Biosystematic Studies on Indian Predatory Coccinellidae

Five apparently new species belonging to *Protoplotina* Miyatake, *Microserangium* Miyatake, *Synonychimorpha* Miyatake, *Ghanius* Ahmad and *Ortalia* Mulsant have been recorded from different parts of India.

Rearing/Culturing Techniques and Studies on Natural Enemies

Mass multiplying method for *Eriborus argenteopilosus* has been evaluated; wherein a parasitoid-host ratio of 1 : 5 was found optimum. Parasitism ranged 18–45% on cotton and 9–40% on chickpea.

Mass rearing of the anthocorid *Blaptostethus pallescens* (from maize ecosystem) has been standardized on *Corcyra cephalonica* using bean pods as oviposition substrate. A single nymph could feed on a mean number of 87 eggs, an adult male on 373 eggs and an adult female on 408 eggs.

Cage studies for interaction between *Campoletis chlorideae* and *E. argenteopilosus* revealed that *C. chlorideae* provided higher percentage of parasitism alone than when there was interference by *E. argenteopilosus*. Irrespective of the parasitization sequence, *C. chlorideae* appeared superior to *E. argenteopilosus E. argenteopilosus* performance was adversely affected in *C. chlorideae* presence.

Behavioural Studies on Natural Enemies

L-tryptophan (0.66%)-treated plants attracted higher oviposition by *Chrysoperla carnea* in fields and in laboratory. *Corcyra* scale extracts fortified with tricosane and pentacosane at 0.1% and 0.2% and sprayed on egg cards of *Corcyra cephalonica* increased parasitization by *Trichogramma chilonis* in the fields. Highest parasitization of *Helicoverpa armigera* eggs by *T. chilonis* was recorded on cotton G-Cot 10 (48.88%), followed by CPD 428 (39.99%).

Artificial Diets for Host Insects and Natural Enemies

Chrysoperla carnea larvae could be successfully reared on artificial diet for 15 generations with a mean adult emergence of 85.7%; similar to when reared on *Corcyra cephalonica* eggs (86%). The diet could be stored for 200 days in a refrigerator at 5°C without any deleterious effect on rearing.

Toddy palm-leaf powder-based diet has been found promising for rearing *Opisina arenosella*, providing high percentage of pupation and female-adult emergence.

Improved Strains of Natural Enemies

Attempts to develop a heat-tolerant strain of *Trichogramma chilonis* have succeeded after 55 generations of constant rearing at 36 ± 1.5°C, with adaptation to parasitism of 90% and survival > 4 days. *Telenomus remus* after 30 generations of constant rearing at 34°C gave 72.2% parasitization with longevity of 7.8 days. 'Endogram' strain of *T. chilonis* has now been made tolerant to 0.09% Endosulfan, 0.05% Monocrotophos and 0.002% Fenvalerate. A strain of *T. chilonis* with high host-searching ability has been selected after 30 generations of selective rearing; it has good host searching ability with 50.6–77% parasitization.

Entomopathogenic Nematodes

Heterorhabditis bacteriophora, *H. indica*, *Steinernema carpocapsae* and *S. bicornutum* isolates were effective against *Spodoptera litura*, *Agrotis ipsilon*, *Phthorimaea opercaulella*, *Plutella xylostella* and *Opisina arenosella*. Progeny production was maximum in *Galleria mellonella* with *H. bacteriophora*, recording highest yield. Among *Steinernema* isolates, *S. bicornutum* gave maximum yield. Wouts medium was found suitable for mass production in solid medium. Talc- based formulations of *S. carpocapsae* and *H. indica* have showed effectiveness in tobacco nurseries against *S. litura*.

Biological Control of Plant-Parasitic Nematodes

Two strains of *Paecilomyces lilacinus*, and one each of *Verticillium chlamydosporium* and *Pasteuria penetrans* have been isolated and found effective against root-knot nematode *Meloidogyne incognita* and reniform nematode

- Mass rearing of anthocorid *Blaptostethus pallescens* on *Corcyra cephalonica* standardized.
- Recorded highest parasitization of *Helicoverpa armigera* eggs by *Trichogramma chilonis* on cotton G-Cot 10, followed by CPD 428.
- Successfully reared *Chrysoperla carnea* larvae on the artificial diet, which could be stored for 200 days in refrigerator at 5°C without any deleterious effects on rearing.
- Selected a strain of *Trichogramma chilonis* with high host-searching ability.
- *Beauveria bassiana* and *Metarrhizium anisopliae* sporulated maximum on pongamia and castor oil-cakes.
- Talc-based formulations of *Steinernema carpocapsae* and *Heterorhabditis indica* proved effective against *Spodoptera litura* in tobacco nurseries.
- In sugarcane at Coimbatore, *Trichogramma chilonis* showed higher parasitization on shoot-borer eggs, followed by internode borer and on *Corcyra cephalonica* eggs.

ENTOMOPATHOGENIC VIRUSES AND FUNGI ISOLATED

Nucleopolyhedrosis viruses from coconut skipper *Gangara thyrsis*, paddy leaf roller *Cnaphalocrocis medinalis*, coconut black-headed caterpillar *Opisina arenosella* and mottled emigrant white butterfly *Catopsilia pyranthae*, a granulosis virus from castor semilooper *Achaea janata* and a poxvirus from maize stem borer *Chilo partellus* have been isolated.

SMAY medium incorporated with chloramphenicol (50 ppm) and rose bengal (100 ppm) could be used for isolation of *Nomuraea rileyi* from field-infected larvae of *Helicoverpa armigera* and *Spodoptera litura.* Several isolates of *N. rileyi* against *H. armigera* and *S. litura* showed 100% mortality of 3rd instar larvae when a spore suspension of 8.5×10^8 conidia/ml was used. Maximum sporulation of *Beauveria bassiana*, *Metarrhizium anisopliae* and *Verticellium lecanii* was observed with pongamia and castor oil-cakes. A talc-based formulation of *V. lecanii* has been developed.

SUCCESSFUL IPM MODULE FOR COTTON

Location-specific IPM for eco-friendly and sustainable cotton production has been evaluated at 15 locations (villages) in north, central and south cotton-growing zones, covering an area of 600 ha approximately. The proven IPM technologies being transferred to farmers include cotton leaf-curl resistant varieties/ hybrids, use of cover/trap crops and of critical eco-friendly inputs such as release of *Trichogramma chilonis*, HaNPV and neem-seed-kernel powder extract. The pesticide load in irrigated cotton-crop reduced to 8–10 sprays in Punjab and Haryana compared to 18–20 sprays in the non-IPM farmers' fields, and in rainfed cotton pesticide application was restricted to 3 sprays in IPM plots compared to 6–8 sprays in non-IPM plots.

Rotylenchulus reniformis on cowpea and chickpea. *P. lilacinus* and *V. chlamydosporium* integration with air-dried FYM/oil-cake, followed by light irrigation favoured fungal establishment and parasitization on egg masses of *M. incognita*. *Paecilomyces lilacinus* reduced root-knot nematode population in chrysanthemum at 4–6 kg/acre along with neem-cake at 150–200 kg, and enhanced flower yield by 18–24%.

Biological Suppression of Crop Pests

Commercial crops. In Punjab, *Trichogramma chilonis* 8 releases in sugarcane at 10 days interval during April-June at 50,000/ha reduced early shoot borer by 51.7% and *T. japonicum* 4 releases, coinciding with availability of egg masses of top borer, at 50,000/ha during May–July, reduced top borer by 50.7%. At Coimbatore, *Trichogramma chilonis* showed higher parasitization on shoot borer eggs, followed by internode borer and C. *cephalonica* eggs.

The BIPM module with *Chrysoperla carnea* and *Trichogramma chilonis* releases and NPV sprays has been effective in suppressing sucking pests and bollworm complex of cotton in Pune, Hyderabad, Ludhiana and Anand.

Pulse crops. In Andhra Pradesh, sequential application of HaNPV-NSKE-HaNPV-NSKE in pigeonpea, starting from flower initiation stage at 10 days interval, reduced damage by *Helicoverpa armigera*, pod wasp and pod-fly. Bt-HaNPV-Bt-HaNPV sequential application resulted in decrease in *H. armigera* larval population and pod damage in pigeonpea in Gujarat.

Cereal crops. Releases of egg parasitoids *Trichogramma japonicum* and *T.chilonis*, each at 100,000 adults/ha/release/week, 3 times have been found effective in reducing rice leaf folder and stem borer infestations during *kharif* and *rabi*, and recorded maximum yields in Maharashtra, Assam and Punjab.

Horticultural and plantation crops. In Solan, *Chrysoperla carnea* larvae for management of woolly apple aphids could be released safely after 10 days of treatment with Malathion (0.05%), 15 days with Endosulfan (0.05%) and 30 days with Profenophos (0.05%).

Five sprays of HaNPV at 1.5×10^{12} POBs/ha at weekly interval, and 5 weekly releases of *Trichogramma pretiosum* at 50,000 adults/ha/release + 3 sprays of HaNPV at 1.5×10^{12} POBs/ha, when the first spray started 5 days after first release of parasitoid were most effective against tomato fruit borer in Maharashtra. In Punjab, releases of *T. pretiosum* (5 releases at weekly interval at 50,000/ha) + 3 sprays of HaNPV (1.5×10^{12} POBs/ha) + 3 sprays of Endosulfan (at 2.5 1itres/ha, at 15 days interval) proved most effective for managing fruit borer on tomato.

In Bangalore, diamondback moth on cabbage could be managed either through release of *T. bactrae* at 50,000 adults/ha/release, 5 times at weekly interval, commencing 25 days after planting or spraying Delfin WG at 1 kg/ha 5 times at 10 days interval, starting from initiation of flowering.

IPM VALIDATION IN PIGEONPEA

During 2001–02, an area of 53 acres in IPM and 35 acres in Non-IPM were taken for pigeonpea validation. Interventions in IPM were: 5 pheromone traps, 2 sprays of NSKE, 1 spray of HaNPV and in Non-IPM: 3 sprays of Endosulfan, Monocrotophos, Ashotop (Acephate), Lanate/Dunate, Chlorpyriphos, Rogor and Cypermethrin, along with three times shaking of plants was done in IPM and once in non-IPM. The yield was 1.52 tonnes/ha in IPM and 0.92 tonne/ha in non-IPM.

HONEY BEE RESEARCH

Honey Bee Pollination

In litchi, bees were predominant (75–95%) among the insects visiting the inflorescence. And among bees, *Apis mellifera* dominated (46%), followed by wild bees *Apis dorsata* (36.8%) and *Apis florea* (17.2%). Little bees *Trigona iridipennis* were found as occasional visitor. Peak activity of bees was observed in the forenoon. Little bees, Italian bees and rock bees had spent on an average 4.0, 2.9 and 2.6 seconds/flower. Fruit-setting in covered branch was 26.5/branch and in uncovered it was 64.4/branch.

Bee visits were 17.03 bees/min./panicle in orchards where 45 bee-colonies were placed and were lowest (4.26 bee/min/panicle) in orchards without bee-colonies (control). Maximum fruit-set (2.1%) and fruit weight (22.35 g) were recorded where

45 bee-colonies were placed and lowest (0.38%) fruit-set and fruit weight (16.85 g) were recorded in control. Overcrowding of bees had no adverse effect on fruit-set in litchi.

Bee Diseases and Enemies

In Kerala, incidence of Thai Sac Brood Virus disease was noticed with varying intensities in different districts. Percentage infestation was more in Thiruvananthapuram (20.80) and least in Kannur.

In Punjab, incidence of European Foul Brood on *Apis mellifera* ranged between 0 and 0.97% in summer, 0 and 9.52% in spring, 0 and 4.0% in winter, 0 and 13.63% in autumn and 0 and 19.23% in monsoon. Incidence of sac brood during different seasons in the state ranged between 0 and 6.81%. Besides, negligible incidence of chalk brood was also noticed.

Varroa jacobsoni infected *Apis mellifera* colonies in Kerala. To control this mite, 60% formic acid proved effective.

Bee Management and Hive Products

A. mellifera colonies establishment in the Eastern Ghat highland zone of Orissa has been achieved, and attempts are in progress to spread bees in the tribal belts of southern Orissa also.

Karl-Jenter method and Dolittle method, using plastic (PVC) queen cell cups and bee-wax queen cell cups, and the effect of position of top and bottom bars of the queen-rearing frames were compared with respect to acceptance of 24-hr larvae grafted for mass-queen rearing. Position of the bar of queen-rearing frame did not affect larval grafting. Maximum larval acceptance of 58.33% was obtained with larval grafting in PVC wax cells.

In *A. mellifera*, brood-rearing activity (2,611.7 cm^2) and pollen stores (383.5 cm^2) were high in ferocious colonies compared to moderate and mild bee-colonies.

During dearth period (monsoon) at Pant Nagar, brood development pattern in 6-frame colony was as good as in 10-frame colony, if timely feeding was given.

Among variable quantities of nectar and pollen substitutes, 1,000 g sugar syrup with 5 g sattu would be optimum for proper development of colony to be fed during dearth period at Pusa, Bihar.

Pollen trapping at 25% could be safely made without any adverse affect on the colony, but it was adversely affected when trapping was 50% and above.

- In *Apis mellifera*, brood-rearing activity and pollen stores were higher in ferocious bee-colonies than moderate and mild colonies.
- Arecanut white-grub could be effectively managed by Chlorpyriphos 10G or Phorate 10G or Carbofuran 10G.
- Hisar Latit, a tomato variety showing resistance against root-knot nematode, when transplanted in solarized field reduced root-knot index.
- In Kerala, crow-pheasant (*Centropus sinensis*) proved potential biocontrol agent against stem-borer of cardamom.
- Accomplished for the first time breeding of bank myna in artificial nest-boxes at open-wells of agricultural habitats.

RODENT MANAGEMENT

Use of parasites. Infector of *Trypanosoma ivansi*, a highly pathogenic protozoan,

Placement of poison bait in wheat-crop fields

INTEGRATED RODENT MANAGEMENT

- Two crown baitings with Bromadiolone cakes in coconut, one in January and the other after 30 days, have been recommended for managing rodents in coconut (success rate 82.5%).
- A collar of GI sheet when put on mango stems yields fairly good success in protecting fruits from squirrel's damage.
- Two applications of Bromadiolone (wax block) at 10 g/burrow (i) at flowering and (ii) at pod maturity stage gave significant rodent control in groundnut.
- Regular trappings, fumigation, weeding and burrow baiting with Bromadiolone (0.005%) may be integrated for management of pest-rodents in tomato in Himachal Pradesh.

JOJOBA SEED-CAKE REPELS *TATERA INDICA*

Jojoba (*Simmondsia chinensis*) seed-cake powder possessed repellent/deterrent effect on *Tatera indica*. Laboratory trials indicated that Indian gerbils avoided jojoba seed-cakes at 50, 75 and 100% concentrations in baits, and under no choice died of hunger. At 10–15%, gerbils recorded some consumption of treated baits (as forced feeding) but lost 12.0–28.2% body weight within a week of exposure. *T. indica* showed almost negligible intake of treated bait when exposed in the presence of plain baits (choice test). The consumption of treated bait was 0.54–1.21 g/100 g body weight, which was significantly lower than that of plain bait (5.64–9.13 g/100 body weight).

proved lethal to *Bandicota bengalensis and Rattus rattus*. The parasite showed two peaks of parasitaemia, and no test rodent survived after second peak. Infected rodents showed weakness, sluggishness, depression and posterior paralysis.

Laboratory evaluation of rodenticides. Coumatetralyl (Racumin paste), a new, multiple dose anticoagulant rodenticide, yielded 70 and 90% mortality of test rodents when exposed for 8 and 10 days. The formulatioin was less palatable. The lethal feeding period (LFP_{50}) and lethal feeding dose (LFD_{50}) of anticoagulant was 5.5 days and 2.41 g/100 g body weight.

In no-choice test, freshly prepared *bajra*-based bait of Difethialone, resulted in cent percent mortality of *Tatera indica* (gerbil) and *Funambulus pennanti* (squirrels) in one-day exposure. However, in choice tests, one-day exposure yielded 80% mortality in gerbils and 50% in squirrels. The death period ranged between 6 and 11 days for *T. indica* and 4 and 9 days for *F. pennanti*. On increasing exposure period to 2 days, the mortality rate of squirrels increased to 80% but in *T. indica* 2 days exposure showed no change in mortality rate, however, the duration of mortality was brought down to 4–8 days.

AGRICULTURAL ACAROLOGY

Mite infestation in rice. Mite infestation on popular hill rice, Jaya, Mandya Vijaya, Rasi, IR 30864, Mukthi, Tellahamsa, and a hybrid KRH 2 ranged from 12% (Tellahamsa) to 60% (KRH 2). Similar damage was observed in Kothamadi, Eru, Unn, Navasari and Mohanpura areas in Gujarat.

Screening of available rice lines to spidermite (*Oligonychus oryzae*) during September–October in Coimbatore showed IR 64616H, IR 76715 H, PSBRC 2, IR 69612H, IR 65622-151-1-2-2R free from mite damage and entries IR 71625H, IR 69701-CP-138-C1-304-1-12 highly susceptible.

Mite infestation on chilli. In Gujarat, yellow mite *Polyphagotarsonemus latus*, a serious pest of chilli crop, showed 2 distinct peaks in last week of October and beginning of December, with no activity of any predators. Leaf curling in 38% plants inflicted 28% green chillies yield loss. Jwala, RHRC Erect, ACG 77 and ACS 92-2 were fairly tolerant with minimum leaf curling (4-9 mites/15 leaves), and varieties G 4 and PBS 86-1 (with 39 mites/15 leaves) were susceptible. In Kalyani, hybrid chilli Line 86235 was relatively tolerant and varieties Jhulan, Bullet and Suryamukhi were highly susceptible.

PESTICIDE RESIDUES

Out of 796 samples of different vegetables, 61% were contaminated with DDT, HCH, Endosulfan, Chlorpyriphos, and out of which 12% exceeded their maximum residual limit (MRL) values. In fruits, out of 378 samples, 48% were contaminated with different pesticides but none of them contained residues above MRL value. About 40% of 92 samples of spices from the market were contaminated. Residues of DDT, HCH, Endosulfan and Chlorpyriphos were detected in 264 vegetarian and 243 non-vegetarian human diet samples, 11% vegetarian and 15% non-vegetarian samples exceeded their MRL values. Out of 468 bovine-milk samples, 65% samples were contaminated with HCH and DDT; out of which 15% were above MRL value. In 98 animal feed and fodder samples, 52% were contaminated with HCH, DDT, Dicofol, Malathion and Endosulfan. Besides 59% groundwater and 65% surface water samples were found containing DDT and HCH. Out of 67 rain-water samples, 20% were contaminated with HCH, DDT, Endosulfan and Chlorpyriphos. And out of 82 honey samples analysed, residues of HCH, Endosulfan, DDT, Chlorthalonil and Cypermethrin were detected in 51% samples. Out of 47 samples of processed food, 29% samples were contaminated with HCH, Malathion, Chlorpyriphos, Cypermethrin and DDT.

NEWER MOLECULES OF ACARICIDES

In Coimbatore, newer molecules of acaricides like fenpyroximate, bifenthrin, diafenthiuron and buprofezin offered better protection (76–93% reduction) against rose spidermites. These and fenazaquin were able to control chilli mite up to 92% in 15 days period and thus better fruit yields of chilli were obtained in Bangalore, Kalyani (also on commercial jute), Navasari and Coimbatore. These acaricides are also found effective against spidermites on brinjal and okra, and resulted in 80% reduction in mite population in 9–12 days in Ludhiana.

WHITE-GRUB MANAGEMENT

Groundnut

Among the new seed dressers for groundnut protection from white-grubs, Imidacloprid 200 SL (0.6 g a.i./kg seed) and Chlorpyriphos+Cypermethrin (5 g a.i./kg seed) have been found as effective as the presently recommended Chlorpyriphos for the last 3 years. Fipronil 5 FS (100 g a.i./ha) tested for the first time has also showed promise. On 3 years data, B : C ratio of Imidacloprid was 15.74 and of Chlorpyriphos + Cypermethrin was 19.45 as compared to about 22.00 of Chlorpyriphos and Quinalphos.

Imidacloprid 200 SL at 60 g a.i./ha and Fipronil 5 FS at 150 g a.i./ha were found better than existing Chlorpyriphos 20 EC (at 800 g a.i./ha) and were at a par with Quinalphos 20 AF (at 800 g a.i./ha), when applied 21 days after mass emergence of beetles in the standing crop of groundnut. On 3 years data, highest B : C ratio of 13.68 was with Imidacloprid 200 SL, as compared to 9.8 by Chlorpyriphos and 9.06 by Quinalphos.

Arecanut

Arecanut white-grub *Leucopholis lepidophora*, with a two-year life-cycle and overlapping generations, can be effectively managed by each of Chlorpyriphos 10G or Phorate 10G or Carbofuran 10G or Chlorpyriphos 10G (25 g/palm) and Chlorpyriphos 20 EC at 6 ml/palm.

NEMATODE MANAGEMENT

Rice. White-tip disease intensity, caused by white-tip nematode (*Aphelenchoides besseyi*), reduced significantly by soaking paddy seeds in Carbosulfan (0.1%) for 6 hours, followed by foliar spray of Carbosulfan (0.2%) at 40 DAT.

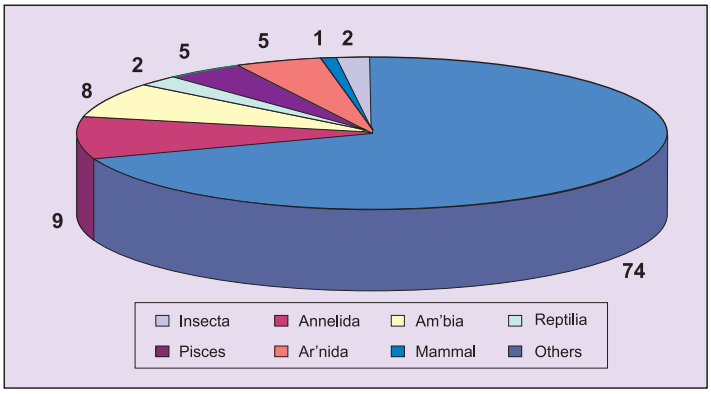
Pulses. In pigeonpea, when *Pseudomonas fluorescens* was combined with *Trichoderma viride* at 2.5 kg/ha for managing pigeonpea-cyst nematode wilt complex, the nematode population reduced and yield of the crop increased up to 43.8%. Root-knot nematode (*Meloidogyne incognita*) management in chickpea with Carbosulfan 25 EC at 0.1% a.i. led to an increase of 23% in yield over control with a cost: benefit ratio of 1 : 3.

Vegetables. Hisar Lalit, a tomato-variety resistant against root-knot nematode when transplanted in solarized field showed reduced root-knot index. Sweet-potato Sree Bhadra when intercropped with brinjal or okra reduced root-knot nematode population and generated cost : benefit ratio of 1 : 1.27. Nursery treatment with Carbofuran 3G at 0.3 g/m^2 and seedling root-dip treatment with Carbosulfan 25 EC at 0.05% for 6 hours for brinjal and seed treatment with Carbosulfan 25 ST at 3% w/w for bittergourd significantly reduced various nematodes.

Fibre crops. In cotton, seed treatment with *Pseudomonas fluorescens* at 20g/kg seed and soil application at 10 g/pot proved best in controlling reniform nematode (*Rotylenchulus reniformis*). Neem-cake at 1,000 kg/ha and soil drench with Mancozeb 80% WP at 0.4% against *Meloidogyne incognita* and *Macrophomina phaseolina* complex reduced effectively plant mortality, gall index, nematode population and spore load and increased fibre yield.

Fruit crops. Meloidogyne incognita Race 1 population was reduced in banana treated with *Pasteuria penetrans* and *Trichoderma viride*. Application of *Pseudomonas fluorescens* at 10 g/pit at planting and 45 DAT was found to reduce *M. incognita* population and increased banana yield. Paring of banana rhizomes before planting + neem-cake at 1 kg/plant + Carbofuran 3G at 16.6 g/plant effectively minimized *Radopholus similis, Helicotylenchus multicinctus* and *Meloidogyne incognita* complex.

Bank myna feeds on 1,061 g of insects, which equals to 3,810 insects during nestling period of a brood



Diet composition of cattle egret nestlings in Andhra Pradesh

Sprouting groundnut is being damaged by rose-ringed parakeet at the roosting site

Screen crop, a potential device for saving grains from birds' damage

AGRICULTURAL ORNITHOLOGY

The BBR$^+$ at 10 ml/litre of water concentration and reflective ribbon showed higher yield in sorghum in *kharif* (845.7 kg/ha) and *rabi* (1,013 kg/ha). Similarly wrapping and ribbon on maize-crop during *kharif* showed higher yield (1,369 kg/ha) in treated plot compared to control (1,197.25 kg/ha).

In *kharif*, spray of BBR$^+$ at 10 ml/litre of water concentration reduced avian damage in field in Punjab. In BBR$^+$ sprayed field, mean damage estimation was 0.08 ± 0.87 as compared to control value of 7.50 ± 0.80.

BBR$^+$ at 5 ml/litre of water concentration was effective in controlling bird damage during grain-filling stage of rice at Kerala. At Andhra Pradesh on sorghum BBR$^+$ at 10 ml/litre of water concentration showed significant yield increase (1,005 kg/ha) compared to control (833 kg/ha); with 17.1% reduction in damage among treatments.

Reproductive success of rose-ringed parakeet in different areas of Andhra Pradesh varied between 48% (Scarce Rainfall Zone) and 63% (Southern Telengana Zone).

The dietary preference and diet composition of cattle egret in different heronries of Andhra Pradesh showed high preference to insects (75%), followed by non-insect matter (25%). This indicates, cattle egret as an important potential depredatory bird in agricultural ecosystem.

In Kerala, crow-pheasant or coucal (*Centropus sinensis*) has been found a potential biocontrol agent against stem-borer of cardamom.

Accomplished for the first time breeding of bank myna an important depredatory bird of Orthopteran and Lepidopteran pests, in artificial nest-boxes installed in open wells of agricultural habitats.

Improvement and Management of Horticultural Crops

FRUIT CROPS

MANGO

A total of 633 accessions were maintained in the National Repository of Mango Germplasm at Central Institute for Subtropical Horticulture, Lucknow. Of them, 252 were catalogued as per the IPGRI descriptors. A high-yielding, regular-bearing mango hybrid Ambika having medium-sized fruits with yellow and firm flesh, suited to international market, has been released. Mango Pusa Arunima and Pusa Surya having medium-sized fruits with a self-life of 10–12 days at room temperature have been recommended for commercial cultivation.

Embryo-rescue technique has been developed successfully for the first time in the world. The hybrids of intervarietal cross Alphonso × Kerala Dwarf have been developed successfully using excised hybrid embryo culture coupled with *ex-vitro* shoot-tip grafting. Varietal evaluation revealed that superior clones of Dashehari clone 51 and clone 32 at Sangareddy; Bangalora and Mallika at Sabour; Asaugia Devband, Langra Rampur and Zafrani Gola at Pantnagar, and Bangalora and Dashehari Chottee at Rewa were promising. Among released mango hybrids Neeleshan produced maximum yield at Sangareddy, and Mallika at Sabour and Rewa.

A promising mango hybrid Ambika

Among different methods of propagation, maximum fruit yield (262.07 kg/tree) was recorded in veneer grafted trees. Rootstock Kalapaddy gave maximum yield with Bombai scion. Application of 250 gN/tree/year resulted in best tree growth, canopy development and fruit quality with maximum fruit yield (170 kg/tree) in Totapuri. In planting system-cum high-density, double hedge-row system of planting produced higher yield than square system.

The experiment on rejuvenation of over crowded orchard, maximum number of fruits and yield per tree were recorded in the control (thinning of branches and centre opening without paclobutrazol application), whereas at other centres, paclobutrazol applied either as a foliar or soil application gave higher yield than the control.

Spraying of extract of Nettle leaf + cow urine was found to reduce about 75% mango hopper population up to 7 days after spraying under field conditions. Three sprays of monocrotophos (0.05%) starting from panicle emergence to subsequent 15 days interval resulted in reducing the hopper population at Vengurla, Sabour, Mohanpur and Paria.

Cowdung paste was found very effective in controlling gummosis and die back diseases in mango compared to application of biodynamic tree paste or copper oxychloride. Laboratory studies have shown presence of anti-pathogenic microorganisms in cowdung.

For pre-harvest treatments of mango by tricyclozole (Beam 0.1%) followed by Prochloraz (0.1%) and for post-harvest treatment by Prochloraz (0.1%) alone was found most effective to control anthracnose.

- Ambika, a mango hybrid, has been released.
- An embryo-rescue technique in mango has been developed.

BANANA

Three new species, *M. rosacea*, *M. aurantiaca* and *Ensete glaucum*, have been identified. The occurrence of a natural (ABBB) tetraploid, a potential gene source

- Three new *Musa* species have been identified.

for biotic stresses, has been reported for the first time. A single plant selection of Pisang Awak with a yield potential of 15–20% more yield than local, having field resistance to nematodes and Sigatoka leaf spot diseases has been identified. This is a dual purpose variety with excellent dessert and cooking quality. Banana Gold Finger was highly resistant to Sigatoka leaf spot. A promising triploid hybrid, H 212 (ABB) (Karpooravalli × Pisang Lilin) was found superior to Ney Poovan (AB) in yield, quality and tolerance to nematodes.

Application of distillery sludge 2.5 kg + 1 kg vermicompost + 1 kg neem cake + 2.5 kg poultry manure per plant showed maximum growth in Rasthali and Karpooravalli. It has significantly suppressed the population of root-lesion nematode, root-knot nematode and spiral nematode besides checking the Sigatoka leaf spot disease. Application of gypsum (2 kg/plant) + FYM (15 kg/plant) + 120% K is recommended for optimum yield of banana in saline sodic soil. Additional profit of Rs 34,250/ha in Poovan banana may be taken by application of 15 kg rice husk ash or 15 kg poultry manure per plant, thereby saving 20% inorganic fertilizers.

Application of N and K_2O in 4–7 split doses recorded highest bunch weight and yield/ha in banana. Plant spacing of 1.2 m × 1.2 m × 2 m for Rasthali was found ideal to get highest yield. Application of 300 : 90 : 300 g, N : P_2O_5 : K_2O/plant/year for Gandevi selection recorded highest bunch weight (27.66 kg) and yield (85.35 tonnes/ha). Application of 200 and 150 g N/plant/year in vegetative and reproductive phase respectively was found ideal for Rasthali. Intercropping cowpea was found effective to control weeds in Palayankodan banana under Kannara conditions. Fertigation of 25 litres/day with 200 : 30 : 300 g/plant/year N : P : K recorded higher yield in first ratoon crop. Foliar application of CCC (1000 ppm) 4 and 6 months after planting in Robusta recorded higher bunch weight (24.1 kg) and number of fingers (1,245) under Coimbatore conditions.

DISEASE MANAGEMENT IN BANANA

Dipping paired suckers in monocrotophos (0.75%) before planting followed by drenching with Bordeaux mixture (1%) twice at fortnightly intervals gave effective control to Rhizome rot at Kannara. Dipping the suckers in chlorpyriphos (0.5%) followed by two sprays of chlorpyriphos (0.5) was effective in controlling pseudostem weevil.

Sucker treatment by Monocrotophos (14 ml/litre) followed by soil application of Carbofuran (60 g) 4 and 7 months after planting protected the plants from corm weevil infestation. Swabbing of Chlorpyrifos (0.06%) over pseudostem 5 months after planting provides effective control of banana stem weevil infestation.

Entomopathogenic nematode was effective in killing the stem weevil grub. Endophytic fungi, *Fusarium* spp., is recommended as an effective biocontrol agent for controlling nematodes. Prophylactic spraying of 0.1% Carbendazim or 0.1% Propiconazole on peduncle immediately after shoot emergence and covering it with dried banana leaves to avoid exposure to sun completely controls the occurrence of peduncle rot of banana. Application of *Trichoderma viride* @10 g/plant 4 times (at the time of planting and 3, 5 and 6 months after planting) controlled *Fusarium* wilt in banana. *Trichoderma* spp. could be multiplied on mass scale in the dried banana leaves within 4 days.

CITRUS

Under the clonal selection programme, 20 plants of Nagpur mandarin, 2 clones of acid lime from Aurangabad and 2 clones of sweet orange 'Mosambi' from Jalna were selected. Citrus rootstock hybrids, CRH 12, CRH 57 and CH 47, were resistant to *Phytophthora* and citrus nematodes and CRH 57 and CRH 12 were tolerant to drought. In acid lime, hybrid Rasraj was tolerant to bacterial canker disease. Sweet orange, Selection 2 and Selection 4, at Rahuri, Nadimpalle at Tirupati, Nagpur mandarin and Kagzi lime local at Akola and nucellar mosambi at Rahuri were promising. At Tinsukia, rootstock Volkamariana was superior for Khasi mandarin.

Plant spacing at 6 m × 3 m (555 plants/ha) was found ideal for higher yield of Nagpur mandarin in 13 years old trees at Akola and 12 years old trees of acid lime at Rahuri. Application of glyphosphata (2 kg/ha) followed by Gramaxone (1.8 litre/ha) recorded higher weed control efficiency of 66.7% under Periyakulam conditions. Application of copper oxychloride (0.3%) or carbendazim (0.1%) in combination with 2, 4-D (10 ppm) or NAA (30 ppm) was effective in retaining 70–75% fruits in Kinnow at Ludhiana.

Efforts were initiated to work out various causal factors responsible for better orchard efficiency. Mycorrhizae were observed to be highly effective in low fertility and coarse-textured soils. Mycorrhizal trees had better plant growth, and uptake of nutrients. Inoculation of soil with mycorrhiza also helped in regulating the water relations and carbohydrate metabolism of citrus trees. Phosphorus nutrition of mycorrhized citrus trees improved using rockphosphate as a source of P than any other source. Technique has been standardized of *in-vitro* shoot tip grafting in Nagpur mandarins to eliminate virus and virus like diseases. Technique of double grafting was also standardized for transfer of *in vitro* STG plants.

For integrated management of insect pests and diseases, a mass-multiplication technique of polyphagous predator of citrus blackfly and other soft-bodied insect pests has been standardized and successfully tested in the field. Spraying of monocrotophos (0.05%) or fenvalerate (0.01%) or neem oil (1%) or acephate (0.05%) or ethion (0.1%) or chlorpyriphos (0.1%) effectively controlled black fly, leaf miner, mealybug, leaf folder and lemon butterfly in citrus. Soil drenching and spraying of metalaxyal (0.2%) followed by Bordeaux pasting was effective in checking the spread of *Phytophthora* root rot in Kinnow mandarins. Dry root rot in sweet orange was effectively controlled with two applications of hexaconazole (0.4%) and carbendazim (0.2%) at monthly interval. Pruning followed by spraying of streptocycline (100 ppm) and 4 sprays of copper oxychloride (0.3%) at monthly intervals recommended for the control of canker in acid lime. Gummosis and fruit rot in sweet orange was effectively controlled by phosetyl (0.2%).

Management of Nagpur mandarin decline in central India has been taken seriously. More invincible response of various treatments on growth and yield performance of treated declining orchard became visibly apparent and plants started looking healthier and productive to preceding years. The management of causal factors to citrus decline appeared to be purely site-specific.

INTEGRATED NUTRIENT MANAGEMENT

Integrated management of nutrients and water through fertigation has shown consistently good response to yield and quality. Rootstocks showed a significant influence on leaf nutrient composition of scion and various fruit quality indices like fruit weight, firmness, peel thickness, juice content, acidity, total soluble solids and their ratio. Optimum stress at 3.3–3.7 MPa was observed to be critical from the point of veiw of induction of flowering in Nagpur mandarins.Growth retardants such as CCC (double spray at 2000 ppm) and paclobutrazol (18 g/plant) were found highly efficient in induction of *hasta* bahar (September bloom) in acid lime. Black polyethylene (100 µ) was extremely effective in reducing evaporation loss and weed growth which in turn imparted a favourable response to growth of plants.

GUAVA

Micropropagation through shoot bud culture has been standardized and September–October being the best responsive period. Guava Allahabad Safeda at Sabour, Allahabad Surkha at Udaipur and Surkhee, Anakapalli, Chakaiya, Mahmoodnagar and G 27 at Rewa were promising. Chittidar produced maximum fruit yield (171.93 kg/plant) which was superior to most of the cultivars.

In planting system-cum high-density trial, maximum yield was recorded in double-hedge row system as compared to minimum in square system at Sabour, Rewa and Udaipur. Similarly, maximum winter season yield may be obtained through pruning of top three-fourths current shoots in guava Sardar.

Maximum yield of 40.41 kg/plant was achieved in a plant spacing of 3 m × 6 m (3 years) after planting. Control of guava wilt was achieved with biocontrol agents, viz. *Aspergillus niger, Trichoderma* sp. and *Penicillium citrinum. Aspergillus niger* was found more aggressive pathogen and its spread was very fast. Application of *Aspergillus niger* enriched FYM @ 0.01% and incubated for 10 days were applied in pits before planting was found to save newly-planted plants.Its application (FYM enriched with *A. niger*) @ 10 kg/plant in established plantation before rain during July is recommended to control the disease as a regular practice.

- Micropropagation through shoot bud culture in guava has been standardized.
- Seventeen new grape accessions have been added to germplasm.

GRAPE

Seventeen new accessions were added to grape germplasm making to a total 363 accessions including indigenous as well as exotic cultivars. A 17-3, a white seedless accession, was found promising.

Use of rootstock for sustainable grape production under adverse situation has been initiated. The decline in yield due to the problems associated with soil and water salinity, chlorides in irrigation water and excess levels of sodium and free lime in soil and drought in and around Maharashtra state alerted the situation.

METWIN 2 SOFTWARE

Software, METWIN 2, was found to be good gadget for forecasting downy mildew in grape. Four sprays of fungicides could be saved in the season as compared to total 18 fungicidal sprays given in the control block. The software was found to be useful in disease management to decide an appropriate spray time.

ROOTSTOCK IN GRAPES

The rootstock Bangalore Blue performed better for Thompson Seedless scion, producing highest number of bunches and yield/vine (8.5 kg). For Arkavati salinity and drought tolerant rootstock Dogridge produced highest number of bunches (95) and yield/vine (12.5 kg/vine), whereas in Arka Kanchan, Thompson Seedless when used as a rootstock improved the bunch number (142) and yield (24 kg). None of the rootstocks used appreciably altered the quality of berries. On comparing productivity of Thompson Seedless and Arkavati on Bower and other training systems, Thompson Seedless produced highest yield (18 kg/vine) on Tatura system followed by Bower system (11 kg/vine).

Rootstocks can be used under the conditions of saline soil, alkali soils, drought, poor nutrient uptake and improving quality and quantity of produce.

In India, most commonly used rootstock in grape is popularly known as Dogridge. Based on different sources of this rootstock, i.e. one from University of California, Davis, and the second type from collection at IIHR, Bangalore, these two types of Dogridge rootstocks were named as American Dogridge (Dogridge A) and Bangalore Dogridge (Dogridge B) respectively. The variation has been noticed with regard to morphological characters and performance of this rootstock. At Pune, variation in performance of Tas-A-Ganesh grafted on two types of rootstock revealed that Dogridge B rootstock imparted more vigour to Tas-A-Ganesh in terms of total shoot length, pruning weight and leaf size as compared to Dogridge A. As a result, new vineyards are being established on rootstocks and there is a great demand for the genuine rootstock material. A rootstock nursery has been developed for a large-scale multiplication of rootstocks with an annual capacity of producing one lakh rooted plants of Dogridge B in polybags to supply to growers.

The fertilizer application could be reduced to 40% of the recommended dose without affecting yield and quality by application of NPK through fertigation. Water stress at bud differentiation and berry setting and at shattering stage did not have adverse effect on yield and quality. Water-use efficiency could be increased up to 53% by newer water scheduling technique. At Bangalore, fertigation trials with Anab-e-Shahi and Thompson Seedless grapes showed that fertigation with 75% of the recommended dose of fertilizer recorded higher bunch number and yield which was at par with 100% of the recommended dose of fertilizer.

The GA application in pH range of 6.5–7.0 increased berry diameter and crispness as compared to its application at pH 7.5. Bio-formulations like biopower and bioforce when applied to partially substitute bio-regulators, improved significantly vine traits like shoot length, yield/vine and berry characters, whereas another bio-formulation 'Combine' affected only berry characteristics.

Spraying of anti-stress, a poly carbon acrylic formulation, before or after spraying of fungicides significantly reduced the disease incidence and sporulation of the pathogens, increasing the efficacy of fungicide. Yield in *Botryodiplodia* infected vines could be improved by treatment with fungicides or *Trichoderma*. Cent per cent recovery was obtained by treating *Botryodiplodia* infected cuttings with hot water at 60°C for 45 minutes. Thompson Seedless clone 2A, which was introduced from the USA in 2000, was found free from *Botryodiplodia* infection, while H5, introduced as an improved clone of Thompson Seedless, had few infected canes.

PAPAYA

At IIHR, Bangalore, Pusa Nanha and Pusa Dwarf were found to be dwarf. The hybrid, Surya, was found to be superior in quality having smaller cavity, dark pink in colour and higher TSS content compared to its parents. Papaya Coorg Honey Dew and Pink Flesh Sweet were promising with regard to yield as well as quality. At Coimbatore, 4 gynodioecious accessions recorded higher fruit yield with better fruit qualities. Application of 10 litres of water per day with 6 g each N and K_2O per week through fertigation and soil application of 45 g P_2O_5/plant in bimonthly interval improved growth, yield and quality characters of CO2 papaya. Application of neem oil (1.0%) and dimethoate (1.5%) in combination increased fruit yield and recorded low incidence of PRSC.

SAPOTA

- Thirty-one accessions of sapota have been maintained at IIHR, Bangalore.
- Forty-two accessions of litchi were maintained at NRC for Litchi.

At IIHR, Bangalore, 31 accessions of sapota are being maintained. Sapota PKM 1 having resistance to various insect pests and diseases was superior in growth and yield at Periyakulam. An open-pollinated seedling selection having 92 g fruits with a few (2–3) seeds has been released as PKM 4 from Periyakulam.

Under AICRP on Tropical Fruits a total of 20 varieties at Gandevi, 20 at Arabhavi,

27 at Kovvur and 14 at Periyakulam were maintained and evaluated. The variety PKM 1 was found superior in terms of growth and yield. Among 31 hybrids evaluated at Periyakulam, hybrid progenies of Guthi × Badami was found promising. Planting density of 312 plants/ha (8 m × 4 m spacing) recorded higher yield for PKM 1. Application of 600 g N, 200 g K_2O/plant/year in PKM 1 under Periyakulam conditions was found ideal. It was also observed that at Gandevi, application of 25 kg FYM, 400 g N, 60 g P_2O_5 and 300 g K_2O/plant/year recorded higher yield of Kalipatti sapota. Application of 150 : 40 : 150 g N : P_2O_5 : K_2O_5/plant/year with 25 kg FYM or 200 : 40 : 150 g N : P_2O_5 : K_2O/plant/year with 5 kg vermicompost recoded higher yields of Kalipatti under Arabhavi conditions.

LITCHI

Forty-two accessions of litchi collected from Bihar, West Bengala and Jharkhand are maintained in the field gene bank at NRC for Litchi, Muzaffarpur. Under AICRP on Subtropical Fruits a total of 48 germplasm accessions and 13 superior seedlings were maintained at different centres, viz. 13 each germplasm accessions and superior seedlings at BCKV, Mohanpur; 21 at GBPUA&T, Pantnagar and 15 at RAU, Pusa including hybrid Sabour Madhu (Purbi × Bedana). In evaluation of germplasm at BCKV, Mohanpur, maximum fruit weight in selection SG-JAL-6, minimum seed weight in SG-JAL-10 and maximum TSS and minimum acidity in selection SG-JAL-2 were recorded. Similarly, Rose Scented recorded maximum fruit weight at Pantnagar.

IDEAL CULTIVATION SYSTEM

In planting system, maximum yield per plot was recorded in double-hedge row system. In training, modified leader system of training was best for getting maximum yield at Sabour and Pantnagar.

JACKFRUIT

At Mohanpur, 8 superior genotypes of jackfruit have been identified while at Kannara 156 trees were characterized for growth and yield as per the IPGRI descriptors. Wide variation was observed for all the characters. Among them, 5 each were identified for table and culinary purposes and 2 for chips making. Softwood grafting tried at Kannara revealed that rootstocks of 6 months old were ideal for good graft success. Survey studies for the incidence of pests and diseases indicated that there was an incidence of leaf-eating caterpillar, spittlebug, leaf folder, bark-eating caterpillar and grey weevil in jackfruit-growing regions. Major diseases of jackfruit were Rhizopus fruit rot and leaf spot.

TEMPERATE FRUITS

In walnut, selections AAS/AHP/BP/DS-2 and LG 5 having smooth shell texture, light shell colour and nut weight 20.45 and 27.16 g respectively; selections AAS/AHP/BP-GG-7 and BBW-8 having 57.25 and 58.38% kernel recovery and kernel weight of 6.87 and 8.63 g respectively were identified for cultivation. The latter selections have extra light kernels and potential to fetch better foreign exchange in the international market with better returns to the growers. In vegetative propagation, 63% success has been achieved by bench grafting under ordinary double-walled polyhouse. Pre-soaking and use of GA_3 + thiourea in walnut increased germination rate from 55 to 83.3%.

In almond, two late-blooming selections which can escape early spring frost and having medium-large-sized nuts with soft-shell were identified.

In apricot, a sweetest selection Suka having average fruit weight 22 g, length 36.1 mm and diameter at suture and cheek 36.4 and 32.1 mm respectively and average pulp and stone weight 11.5 and 1.5 g respectively has been identified from Ladakh.

Three genotypes of saffron CITH-B-54, S_{21} and B-64 having average stigma length 36.70, 33.41 and 33.14 mm with excellent quality (Newal grade) were selected. The production technology of saffron cultivation has been standardized.

LG 5 is a new walnut selection

New saffron genotype

ARID ZONE FRUITS

At Central Institute for Arid Horticulture, Bikaner, 322 genotypes of ber, 22 each of boradi and aonla, 152 of pomegranate, 105 of cactus pear, 47 of date palm, 32 each of ker and gonda, 4 of phalsa, 5 varieties of Kinnow mandarin, 558 of *kachari*, 192 of *mateera* (watermelon), 90 of snapmelon, 132 of chilli and 64 of muskmelon were maintained. Besides, from the exploration in the parts of Rajasthan and Gujarat, 18 promising genetypes of ber were identified.

For rapid multiplication of propagules in aonla, patch budding during mid-July on 6 months old rootstocks raised in polybags and in lasoda, budding during mid-September gave 90.6 and 95.5% success respectively.

The water-stress studies in *mateera* reveals that reduction in number of irrigation has no effect on dry-mater contents as well as photosynthetic rate.

For arid ecosystem, datepalm Halawy was identified as best variety in respect of photosynthetic rate, water-use efficiency and carboxylation efficiency.

The effect of vermicompost, inorganic fertilizer and FYM in pomegranate revealed that maximum plant height and spread were observed under vermicompost and inorganic fertilizer in a 1 : 1 ratio. The maximum photosynthetic rate and water-use efficiency were recorded in vermicompost and sheep manure with best water retention in soil.

In pomegranate, best plant growth and yield were achieved with 0.75 CPE irrigation along with 75% recommended dose of nitrogen through drip. In pomegranate hybrid, Ruby, higher multiplication rate has been achieved by manipulating the growth medium. Methodology for saving hardening space has also been standardized.

Planting material of ber, aonla, pomegranate and Indian aloe were raised for distribution to farmers. Seed production of *mateera*, *kachari*, snapmelon and *salad kakdi* were undertaken. About 300 kg foundation seed was produced.

Bottle gourd DVBG 1

Bitter gourd DVBTG 1

VEGETABLE CROPS

Bottle gourd, DVBG 1 and bitter gourd DVBTG 1 have been released for cultivation in Uttar Pradesh. Okra, IIVR 11, a tall variety has been developed. Besides, 8 open-pollinated and 8 hybrids have been identified under AICRP for release. These include PMR 57/88 K in chilli, NDBG 104 in bottle gourd, CM 20 and PCUC 28 in cucumber, NDVP 250 (resistant to powdery mildew) in mid-season pea, DMDR 2 in muskmelon, VRO 4 (resistant to YVMV) in okra and CHES 309 (resistant to BW) in brinjal. Hybrid BH 1 in brinjal (round), DTH 8 and CHTH 1 in tomato (determinate), ARTH 128 in tomato (indeterminate), Sungro 86-235 in chilli, Lario in capsicum, MHY 5 in muskmelon and DVR 4 in okra were identified for release.

Female sex associated RAPD marker in pointed gourd has been identified. The marker could be used in breeding programme to screen the gender of plants at seedling stage. Five bitter gourd populations with very high proportion of pistilate flowers (>90%) have been developed from gynoecious lines. Development of such populations will be useful in hybrid seed production. Raising of hybrid seedlings of tomato, viz. Apoorva in potting plugs at Kanpur, ARTH 3 in polybags at Coimbatore and Avinash 2 in polybags at Varanansi has been recommended. Planting of tomato hybrid ARTH 4 at 80 cm × 45 cm along with staking and pinching of side branches at 30 cm from ground gave highest yield (372.4 q/ha) and maximum C : B ratio (1 : 2.8) at Sabour. However, the same hybrid at the above spacing and without pinching gave highest yield (470.8 q/ha) and C : B ratio of 1 : 2.9 at Ambajogai. Hybrid Avinash 2 at 50 cm × 30 cm spacing along with staking and maintaining single shoot per plant gave 1,227.0 q/ha yield under low-cost polyhouse at Pantnagar.

Application of 20 tonnes FYM + half recommended dose of NPK (150 : 80 : 100 kg/ha) in tomato hybrid Avinash 2 gave maximum yield (773.0 q/ha) and C : B ratio (1 : 4.0), at Varanasi. At Faizabad, maximum yield (332.05 q/ha) and C : B

ratio (1 : 3.45) of tomato Narendra Tamato 2 was recorded with green manuring + recommended dose of NPK (60 : 30 : 30 kg/ha) when seedlings were transplanted at 60 cm × 45 cm. The highest yield (346.87 q/ha) and C : B ratio (1 : 2.35) were obtained with the application of FYM @ 20 tonnes/ha + recommended dose of NPK (150 : 60 : 60 kg/ha) in tomato S 7 at Sabour. Highest dry yield of 16.4 q/ha of chilli G 2 was obtained under fertilizer dose of 240 kg N + 60 kg P_2O_5 + 60 kg K_2O at Hybderabad. Application of 75% of recommended N dose (150 kg/ha) + *Azospirillum* as seed treatment, seedling dip and soil incorporation at Varanasi gave maximum yield of green chilli LCA 235 (117.52 q/ha) along with maximum C : B ratio (1 : 1.77) followed by application of 50% recommended dose of N + *Azospirillum*. Application of *Azotobactor* as seed treatment, seedling dip and soil application of 75% recommended dose of N (140 kg/ha) in cabbage Pride of India gave maximum yield (379.0 q/ha) and C : B ratio (1 : 3.4) at Pantnagar. Similar results were also obtained at Hyderabad.

Maximum seed yield of okra Hisar Unnat was obtained by sowing on 15 June at 60 cm × 30 cm spacing at Hisar. Arka Anamika produced maximum seed when sown on 15 May at 45 cm × 45 cm spacing at Vellanikara. It is recommended that for higher recovery of good quality seeds in tomato the seeds of first 3 pickings should be extracted. Application of 20 ppm NAA along with apical pinching at 60 cm × 45 cm spacing is recommended for obtaining maximum seed yield in bell pepper California Wonder.

The results of 3 years' trials at Varanasi, Rahuri, Sabour and Hyderabad showed that clipping of infested shoots at weekly intervals followed by spraying of Cypermethrin thrice @ 50 g a.i./ha at 15 days interval was effective in the management of brinjal shoot- and fruit-borer. Five sprays of Lambda cyhalothrin @ 0.0015% or NSKE 4% starting from flower initiation at 15 days interval were recommended for the management of shoot-and fruit-borer in brinjal at Rahuri. Planting one row of marigold after every 16 rows of tomato and 2 sprays of Endosulfan (0.07%) 28 and 35 days after planting were recommended for the management of tomato fruit-borer under Hyderabad conditions. For the management of cabbage pests, sowing of mustard after 25 rows of cabbage at planting times and spraying on mustard crop with dichlorovos @ 0.1% (2 sprays) at weekly intervals and NSKE 4% were recommended under Rahuri conditions.

Muskmelon DMDR 2

TRANSGENICS OF POTATO

Eighteen transgenics of Kufri Badshah encoding fused *cry1 AB + cry1B* gene and 20 transgenics from 4 cultivars with *AmA1* gene providing better resistance to insects/ pests and nutritional qualities respectively, were developed. The *osmotin* gene from wild potato species, *Solanum chacoense,* was cloned and a part of the gene was also sequenced.

TUBER CROPS

POTATO

The germplasm was enriched by adding 77 new accessions from CIP, Lima, and 12 indigenous samples from interiors of Kashmir and Meghalaya. JEX/A-680-6, an *Andigena* parental line, was registered with NBPGR, New Delhi, as an elite germplasm.

Red-skinned, high-yielding hybrid, MS/92-2105, having field resistance to late blight was proposed for release for cultivation in the plains of Bihar, West Bengal and Orissa. The hybrid yields 35.38 tonnes/ha, nearly 2% more dry-matter yield than Kufri Lalima and Kufri Sindhuri in the northern plains. Heat tolerant, white-skinned hybrid, HT/92-621, was identified performing very well in warmer parts of the country. Besides higher yields, this hybrid produces high dry-matter recovery right from 75 days onwards and produces excellent chips and French fries. The hybrid is under pre-release trials. A new hybrid TPS population, 92-PT-27, was recommended for release in the plains of India particularly for the warmer plateau areas where good quality potatoes cannot be produced for use as healthy seed. Besides higher yields over the existing population, TPS-C-3 and HPS-1/13, new TPS population has an added advantage of its parents flowering under short-day conditions of the plains.

Red-skinned potato hybrid MS/92-2105

The use of satellite WiFS data was found satisfactory to estimate the potato

- The potato germplasm has been enriched by 77 new accessions.
- MS/92-2105, a new potato hybrid is likely to be released.
- About 18 transgenics of potato varieties have been developed
- A computerized Management Tool for management of potato pests and diseases has been developed.

acreage in Punjab, Haryana, Uttar Pradesh and West Bengal using remote sensing and GIS. WiFS was found unsuitable in Bihar where it could not capture a large tract of potato area, which was being cultivated in small fields. An INFOCROP-POTATO model was developed following extensive sensitivity analysis and validation, which could satisfactorily simulate potato development, growth and yield both under potential (no stress of N and water) and sub-optimum (N and water) conditions. A computerized 'management tool for identification and management of major potato pests and diseases' was also developed.

Varieties of potato, wheat and rice identified and recommended for cultivation in rice–potato–wheat system at Jallandhar (Punjab), Hisar (Haryana), Modipuram (western Uttar Pradesh), Faizabad (Eastern Uttar Pradesh) and Patna (Bihar) are as follows:

Varieties of potato, wheat and rice suitable for rice–potato–wheat system

Location/region	Potato	Wheat	Rice
Jalandhar (Punjab)	Kufri Pukhraj	PB 373	PR 106
Hisar (Haryana)	Kufri Ashoka	PB 373	Gobind
Modipuram (Western Uttar Pradesh)	Kufri Pukhraj	PBW 226	Saket
Faizabad (Eastern Uttar Pradesh)	Kufri Ashoka	Malviya 234	Narendra 97
Patna (Bihar)	Kufri Ashoka	PBW 226	Proagro 6107

POTATO BREEDERS' SEED

The CPRI, Shimla, supplied a total of 17,746.1 q and 14,28.20 q breeders' seed from the plains and hills, respectively. Nearly 50,000 disease-free micro-tubers of 11 Indian varieties and 2 parental lines were produced *in vitro* at Shimla and supplied to regional stations at Jallandhar, Gwalior, Patna and Modipuram for net house multiplication. The emergence of micro-tubers was found to be between 25.4 and 54.1% depending upon the size of micro-tubers and variety and resulted in production of nearly 64,065 mini-tubers.

Studies on economizing the use of fertilizer in succeeding crops in different crop sequences has revealed the application of recommended doses of NPK fertilizers both to potato and *bajra* followed by 50% in sesame to be effective in potato–groundnut–sesame sequence at Deesa in north Gujarat. In potato–onion–groundnut and potato–wheat–cowpea cropping systems at Jallandhar, *in-situ* incorporation of each crop residue to succeeding crops was found economizing on NPK by 50%. In potato–onion–groundnut system, both potato and onion need to be fertilized with optimum NPK while groundnut with half the required dose of NPK. In potato–wheat–cowpea system, potato needs to be fertilized with optimum NPK while the succeeding crops of wheat required full N and cowpea only half of NPK.

Potato + garlic intercropping was found effective in reducing cutworm damage by 40% at Shimla in the initial stages of crop growth and resulted in higher average yield (31 q/ha). Electron microscopic studies established the association of a gemini virus with potato apical leaf curl in the North-western plains of India. It is for the first time that a Gemini virus was detected in potato from India causing leaf curl disease in potato crop.

TROPICAL TUBER CROPS

- About 173 new accessions of various tubers have been added to germplasm
- Four triploid cassava hybrids have been identified.
- Sree Arun and Sree Varun, new sweet potato varieties, have been released.
- About 30 tonnes of planting material of tuber crops was distributed to farmers.

A total of 173 new accessions have been added to the germplasm of various tuber crops at different centres of AICRP on Tuber Crops. At present, a total of 4,213 accessions are being maintained at various centres. Coimbatore centre maintains the largest number of cassava germplasm (410).

In cassava, breeding line, MNGA 1, received from CIAT found to be resistant to CMD for the past 8 years. It gives an average tuber yield of 29 tonnes/ha with good cooking quality and very low cyanogens. Four superior triploid hybrids of cassava were identified from advanced yield trials. Since triploids cassava have higher starch yield, they were planted in the premises of a starch factory at Salem, Tamil Nadu, for location-specific testing. Two sweet potato genotypes, RS-III-3 and CIP-490056-2, have been released as Sree Arun and Sree Varun respectively. Both the varieties are spreading types with fusiform short/spherical tubers, maturing in 90–100 days,

with tuber yield of 20–28 tonnes/ha. Sweet potato Sree Bhadra has now been under cultivation in an area of around 10,000 ha in a span of 5 years in north Bihar.

Occurrence of natural polyploidy among the seedlings of *D. alata* (sexual polyploidy) is reported for the first time. Two hexaploids (2n=60) were obtained from the seedlings of crosses between tetraploids (2n=40). Four superior accessions of *D. alata* were selected from advanced yield trials. Five high-yielding hybrids of taro, identified from advanced yield trials, were laid out in on-farm trials in 4 locations. They recorded significantly higher tuber yield than Sree Reshmi and are also tolerant to taro leaf blight. Five high-yielding hybrids of elephant-foot yam were identified. Three hybrids gave a tuber yield of above 40 tonnes/ha, during 3 consecutive years.

The NPK fertilizer dose of 75 : 37.5 : 75 kg/ha is sufficient for cassava in continuously fertilized ultisols. Indigenous rockphosphate can be used as an alternate source of phosphorus in place of superphosphate. Zinc @ 1 g/plant enabled recovery from deficiency symptoms and helped an increase in yield. Application of wood ash to soil @ 3 tonnes/ha is beneficial to reduce the cyanogenic glucosides as well as to increase the starch content in cassava. Cassava genotypes, CE 111, CE 534 and CE 273, gave higher extractable starch (200–250 g/plant) under drought conditions. On-farm trials on arrowroot showed that planting at a spacing of 30 cm ×15 cm on raised beds, mulching with locally available plant material and application of NPK @ 50 : 25 : 75 kg/ha increased the yield by 40% over the existing farmers' practice. Growing of intercrops such as maize, sorghum and red gram either by normal planting or paired row planting of *Dioscorea* increased the yield of *Dioscorea* significantly compared to its sole crop. Among intercrops, maize was best both under normal as well as paired-row system.

Technique for production of antiserum of Indian Cassava Virus (ICMV) was refined with sucrose density gradient method and dialysis techniques. The method yielded higher titre values of purified preparations and high virus concentrations. Nucleic acid spot hybridization results showed strong signals with susceptible varieties, while meristem derived plants had no signals. Replicative forms of ICMV DNA isolated and replicase gene (1.1 kb) was amplified and cloned in pGEM-T vector and confirmed by sequencing. The pathogen causing tuber rot in cassava was identified on *Phytophthora palmivora*. The incidence ranged from 20 to 38% causing crop losses up to 47.4%. Two biotypes of whitefly, cassava biotype and sweet potato biotype, were identified. Both had distinctly different electrophoretic patterns of esterase isozymes. Cassava biotype only transmitted ICMV. A rapid screening method using cell-wall glucan elicitors isolated from *Phytophthora colocasiae* was developed for *in-vitro* screening of taro genotypes for leaf blight. Use of disease-free seed tubers and 2 sprayings with Mancozeb (0.2%) and Monocrotophos (0.05%) 30 and 60 days after planting effectively controlled mosaic, collar rot and leaf blight diseases of *Amorphophallus*.

Electroantennogram response of *Araecerus fasciculatus* (cassava chips borer) to whole body washes and certain HPLC fractions showed the evidence of aggregation pheromone. Extract of seeds, leaves and rinds of cassava and seeds of yam bean, in organic solvents were highly toxic to many storage and fields pests. The mortality of *Sitophilus oryzae* was 100% when exposed to cassava tuber rind extract at 50% concentration. High mortality was also noticed due to the fumigant action of cassava seed extract on storage pests. Extract prepared in organic solvents further diluted with water was highly effective to control field pests such as *Spilarctia oblique*, *Aphis craccivora* etc. Yam bean seed extract (3%) caused high mortality of *S. oryzae*, *Tribolium castaneum*, *Araecerus fasciculatus* and *Lasioderma serricorne*.

Installation and functional evaluation of pilot plant for the manufacture of liquid adhesive from cassava starch has been carried out. The plant has a capacity of 100 litres and applications of the product include carton sealing, laminated/corrugated board making, bottle and container sealing etc. The gum produced has good flow characteristics and is ready to use. A drum type feed granulator operated manually or by motor was developed with a capacity of 20 kg/hr for making granulated feed

Sweet potato variety Sree Arun

QUALITY PLANTING MATERIAL

More than 30 tonnes of planting material of elephant-foot yam (Gajendra), taro, greater yam and sweet potato was supplied to State Departments, NGOs, farmers and private agencies of Karnataka, Rajasthan, Tamil Nadu, Pondicherry, West Bengal, Uttar Pradesh, Chattisgarh, Madhya Pradesh and Orissa.

Sree Varun sweet potato is high-yielding

Leaf blight resistant taro Muktakeshi

for poultry/cattle. Marked variations in the major biochemical constituents were found in Colocasia under water-stress condition. Significant increases in the levels of free amino acids, free proline and soluble proteins were observed in water-stressed Colocasia leaves. Studies on the anthocyanin content of young purple coloured leaves of sweet potato at different stages of growth showed that its content and colour intensity of extracts were maximum 20 days after planting. The stability of sweet potato leaf anthocyanins in a model beverage was fairly good, with a pigment retention of 90% in the samples stored at 4°C for 20 days.

Surveys conducted on demand assessment of cassava indicated that tapioca starch finds applications in a wide range of industries namely textile, corrugation box industries, paper conversion industry, liquid gums for domestic sector, paper industry etc. besides food industry especially the sago production industries. The IVLP was implemented with 616 farm families covering 6 production systems. The technology assessment and refinement showed that Uma, a paddy variety, was suited to both the seasons of *kharif* and *rabi*. This variety is getting popularity in the adopted villages. The other technological interventions namely improved paddy sickle, amaranthus as intercrop in banana, Sree Priya a white yam variety in banana plantations, vermicompost as organic manure in banana, tissue-cultured banana, ginger as intercrop in coconut, etc. have been accepted by the farmers.

MUSHROOM

- About 204 wild mushroom specimens were collected.
- A most-prized medicinal mushroom, Red Reishi, was produced organically.
- An indigenous technology for producing medicinal mushroom has also been standardized.

A total of 204 wild mushroom specimens were collected from hilly areas of Himachal Pradesh in rainy season. A new species of *Lysurus* (Gasteromycete) was reported from Himachal Pradesh, namely *Lysurus himalayansis* sp., which is a new record in the world. In the continued experiment on long-term preservation, 11 test fungi were preserved (as mycelial discs and mycelium grown on wheat grain) in cryovials containing glycerol as cryoprotectant. These were stored in liquid nitrogen at –196°C following the principle of slow cooling and rapid thawing. Forty-two *Agaricus bisporus* germplasm lines comprising commercial strains, wild collections from India and exotic strains were characterized for mycelial growth and colony type on different media. More than 800 SSIs were characterized for colony morphology and growth rate. The SSIs showing slow mycelial growth were screened for future hybrid developmental programme. About 18 SSIs of *P. sajor-caju* and 36 hybrids were developed by pairing SSIs in all possible combinations. Amongst hybrids developed, PSCH 19, was found to be the fastest growing and fruited in 12 days time only.

Improved method of compost preparation using indoor bunker was standardized. The compost was prepared in 13 days, with improved output and reduced shrinkage of base materials. An average of 17.3 kg of mushroom from 100 kg compost in 6 weeks of cropping was harvested under environment-controlled conditions. Effect of different temperature regimes on pinhead initiation in *A. bisporus* showed higher number of pinhead initiation at 14±2°C. For fruit body development, it was observed that raising the room temperature by 4–5°C in the treatment at 14±2°C hastened the growth of pinheads to mature fruit bodies. Development of fruit bodies studied in *Agaricus bitorquis* strain NCB-13, produced 58.83% of medium-sized fruit bodies of 3-5 cm *pileus* diameter. Different agro-byproducts/industrial byproducts were evaluated as casing materials in cultivation of *A.bisporus*. Biozyme (a biofertilizer) application as a spray @ 0.2 ml/kg dry substrate in 1 and 2 spray schedules gave significantly higher mushroom yield in *P. flabellatus*. Three biofertilizers namely, *Azotobacter, Azospirillum* and *Microphos* @ 0.5 and 0.75% of wet weight of substrate were applied at the time of spawning and spawned with *P. sapidus*. *Azospirillum* at both the concentrations and *Azotobacter* at 0.5% gave significantly higher mushroom yields over untreated control.

Button mushroom grown in an environment-controlled room

Volvariella strain, OVV 01, obtained from Orissa Agricultural University, showed highest level of enzyme production on wheat straw substrate, while OE 29 and OVV 03 on paddy straw, and strain OVV 01 and OVV 03 on wild grass. Laccase

SUCCESS STORY

MEDICINAL MUSHROOM PRODUCTION

The NRC for Mushroom, Solan, has made a breakthrough by successfully growing the medicinal mushroom called Reishi or Ling Zhi (*Ganoderma lucidum*). Most-prized Red Reishi was produced organically to the desired maturity level and yield obtained was equal to the international standards. The Reishi mushroom costs about 1 billion dollar international and Rs 100 crores current domestic market. The technology is being scaled up at pilot plant level and concurrently various exotic as well as local collections of mushrooms are being evaluated for yield and pharmacological properties. Only a few countries have the technology of Reishi production. China controls 60% of the world trade of 5,000 tonnes/annum. Medicinal products of *Ganoderma lucidum* are very popular in the American and European countries and foreign companies have started trading the products in Indian market also.With an eye on the export market as well as import substitution, the NRC for Mushroom, Solan, has come out with a totally indigenous technology to produce Red Reishi completely organically as demanded by the pharma industry.

Vigorously-growing Red Reishi mushroom

activity was quite significant in these two strains followed by OE 55 (*V.diplasia*) on paddy straw substrate. Paddy straw mushroom could be stored under ambient condition (22–28°C) for 3–4 months and up to 6 months under lower temperature conditions (15–20°C). Similarly, mushroom spawn can also be stored for about 45 days under ambient temperature conditions. Most important medicinal mushroom, Reishi or Ling Zhi (*Ganoderma lucidum*), was successfully grown for the first time in the country. The Red Reishi, a Korean strain, was cultivated on wheat bran supplemented sawdust (organically) and 20% biological efficiency obtained which is equal to the international level of yield obtained.

Survey of different mushroom farms revealed widespread incidence of wet bubble in Dharmpur and adjoining areas of Solan District. However, in Chambaghat area, severe incidence of sciarid flies was observed in 2 farms. Germination studies revealed that only 3 months old chlamydospores of *Mycogones perniciosa* germinated in glucose and sucrose solutions. In sucrose solution germination began 24 and 96 hr after incubation at 25°C, and 15 and 12% germination was recorded at pH 6.0 and 7.0 respectively. Germination of conidia occurred in all the media and at both the temperatures and pH levels. Maximum (96%) germination occurred in young mushroom extract. Conidial germination of *Cladobotryum dendroides* in different media showed 100% germination in mushroom extract followed by compost extract after 8 hr.

In-vitro studies on diflubenzuron against *A. bisporus* and mushrooms sciarid showed that 0.3% diflubenzuron caused 11.11% inhibition of *A. bisporus*. However, in all the treatments larvae failed to moult. Different concentrations of Neemjeevan were tested against sciarid larvae by dipping method. At 60, 90 and 120 ppm concentration, 100% mortality of larvae was recorded. The NRC for Mushroom, Solan, organized 6 training programmes, and one each of Kisan Goshti and Kisan Mela.

FLORICULTURE

ROSE

Maximum plant height, number of flowers and stem length of cut flowers were obtained with the application of NPK @ 400 : 200 : 200 ppm. Diafancanazole @ 0.05% was effective in controlling powdery mildew followed by Hexaconazole @ 0.05% at Pune. Bavistin @ 0.1% controlled black spot at Ludhiana. Vase-life of rose cut stems was enhanced by pulsing treatment with a solution of sucrose (2%) + aluminium sulphate (300 ppm) at Ludhiana. Maximum vase-life was recorded in 1.5% sucrose + 300 ppm citric acid solution at Pune.

GLADIOLUS

Gladiolus, Phule Prerana and Phule Neelrekha, have been released by MPKV, Pune. The NBRI, Lucknow, has developed mini chrysanthemum varieties, viz. NBRI Little Darling, NBRI Kusum, NBRI Indiana and NBRI Mini Jessie through conventional breeding. Benomyl 0.2% + Captan 0.3% was effective against *Fusarium* wilt and *Fusarium* corm rot in storage at Pune. Dithane M 45 (0.2%), Kavach (0.2%) and Rovral (0.2%) were found effective in controlling *Botrytis* blight along with improvement in cormel yield. At Pune, sucrose (4%) + aluminium sulphate (300 ppm) + sodium hypochlorite (25 ppm) increased vase-life of cut spikes. Holding solution containing 8-HQC (250 ppm) and sucrose (1.0%) was effective in opening of flower buds, increasing vase-life, floret size and longevity of flowers of Eurovision and White Prosperity at Lucknow. Packaging with polythene sleeves for 24 hr was best for floret opening, floret size and vase-life.

- Phule Prerana and Phule Neelrekha, new gladiolus varieties, have been released.

CHRYSANTHEMUM

Six sprays of chlorothlonil 0.2% or Mancozeb 0.02% at 15 days interval starting the first spray immediately at the disease appearance was found effective in controlling leaf blight disease, increasing flower yield and monetary returns. Application of Dithane M 45 (0.2%) at 15 days interval has been recommended for the control of leaf spot at Ludhiana. At Pune, chlorothlonil (0.2%) proved most effective in controlling leaf blight disease. Wrapping with butter paper was better than other materials in spray chrysanthemums at Lucknow.

ORCHID

A cheap method of micropropagation of orchids has been developed using isabgol as gelling agent and polypropylene bags as culture vessels at Barapani. Work has been initiated on the performance and cost : benefit ratio of low-cost polytunnels for providing suitable growing conditions to orchids. Crosses have been attempted to develop superior hybrids of cymbidium. Potting mixture with equal proportion of leaf-mould, FYM and sawdust has been found suitable for development of new shoots.

ANTHURIUM

Anthurium plants grown under 80% shade level with closed sides produced highest number of leaves and good quality of flowers with highest spike, spathe and spadix length. Spray of NPK @ 5% or BA 250 ppm produced highest number of flowers, longest flower stalks and spathe at Yarcaud. Leaf-mould and cocopeat proved best as a growing media. Application of NPK @ 0.2% + GA 100 ppm in White Queen showed healthy plant growth and early flower initiation.

TUBEROSE

Carbendazin 0.1% + Captan 0.24% was effective in controlling stem rot. At Lucknow, Iprodine 0.25% was effective against leaf blight followed by Benomyl 1.0% + Mancozeb 0.2%.

GERBERA

The *Trichoderma viridae* was effective in controlling foot rot disease. Benomyl 0.1% + Mancozeb 0.2% was effective against leaf spot and Diafancanazole 0.05% against powdery mildew at Pune. At Barapani, cultivar Alesmera showed maximum

vase-life of 13 days in the solution, containing 20 ppm A_gNO_3 + 4% sucrose. Maximum vase-life of gerbera flowers was recorded in 25 ppm A_gNO_3 solution at Yercaud.

PLANTATION CROPS

COCONUT

Thirty-four collections of coconut from Goa, Maharashtra, Assam, Sri Lanka and Bangladesh were made. Fingerprints of 181 palms of coconut using RAPD indicated the phylogenetic relationship among 58 indigenous and exotic accessions.

Intercropping coconut with maize, sorghum, banana, red gram and betelvine were found to be technically feasible at Lakshadweep and in the North-eastern regions with vegetables and ornamental plants. Fertigation studies in coconut in red sandy loam soil indicated that the yield was at par in the treatments consisting of 50 and 100% of NPK fertilizers supplied through drip irrigation system. To assess the allelopathic potential of coconut root and leaf leachates on germination and growth of cowpea seeds (a test crop for dicotyledons), the leaf leachate from younger WCT coconut palm stimulated cowpea seedling growth at 1 : 10 concentration. In coconut-based mixed farming unit at Kasaragod an annual net return of Rs 73,140/ha was obtained. Management practices adopted in root (wilt) affected gardens increased the productivity of coconut with a net return of Rs 45,410/ha. Experiments on soil and water conservation at Kidu indicated that on 28% sloppy land, growing of vegetables and grass could reduce the soil loss up to 0.1 tonne/ha/day as compared to one tonne/ha/day in a plot without any soil conservation measures. A fuzzy neural network system with independent variables as temperature, relative humidity, sunshine, soil-moisture deficit and alternate bearing was developed to predict coconut yield. This model could simulate the impact of different factors like climate and irrigation management on coconut yield. Highest compost recovery of 86.5% was achieved when coir pith and coffee husk were mixed in a 1 : 3 ratio. Biofertilizers, *Azoarcus*, *Arthobacter* and *Azosprillium* were found to be effective bacterial inoculants for production of vigorous and healthy seedlings.

The leaf rot affected coconut palms which received *Bacillus coagulans* culture in the leaf axil showed significant improvement. The newly emerging spindle leaves were completely free from disease in most of the treated palms. Drought tolerant palms had higher net photosynthetic rates, instantaneous water-use efficiency, apart from having more number of leaves in crown, number of bunches and nuts/bunch compared to other palms. The protocols for AFLP, DAF and microsatellite of coconut DNA for tagging resistance for root (wilt) disease were standardized.

- The Bioinformatics centre has compiled coconut literature on biotechnology in full text form in CD-ROM.
- The Snow Ball Tender Nut machine was modified for easy operation, low-cost and easy for transportation.
- Coconut chips could be stored in vacuum packaging in aluminium foil laminated with LDPE for more than 6 months.
- Two CD-ROM on coconut descriptors and IPM of coconut pests were released.

ARECANUT AND COCOA

Twelve distinct accessions of arecanut were added to the germplasm pool making the total strength to 140. Nine cocoa exotic accessions collected were added to the germplasm at Vittal. In young arecanut palms a saving of 50% NPK fertilizers was realized through fertigation. In high-density multispecies cropping systems, 7 tonnes of organic matter could be recycled within the system.

- Thirty-four collections of coconut were made.
- A mini, hand-pressed oil detraction machine for oil palm has been designed.
- The National Cashew Gene Bank (NCGB) has been enriched by germplasm collections.
- *High-Density Planting of Cashew*, a bulletin on package of practices has been published for cashew growers.

OIL PALM

A mini hand-pressed oil extraction machine has been designed and fabricated for extracting the oil at the laboratory scale. Three isolates of *Ganoderma lucidium* were collected from basal stem rot disease-affected coconut palms from Coimbatore, Thambikottai and Vepankulam in Tamil nadu. All the three isolates produced white mycelia and brown spores in PDA media but spores turned blackish at later stage in Vepankulam isolate. Oil palm and coconut stem as well as root tissues were inoculated to

record the biomass reduction. Genetic diversity of these isolates was estimated through DNA fingerprinting by RAPD and AFLP. Cluster analysis of RAPD data showed that Coimbatore isolate is similar to that of Vepankulam.

A new pest, slug caterpillar *(Thosea andamanica),* was recorded in a 6-year-old oil palm plantation in West Godavari district of Andhra Pradesh. The caterpillars appeared with blue spots on dorsal side of body. The larval stages of the pest feed on older leaves caused heavy defoliation.

CASHEW

District-wise collection maps for 125 cashew accessions conserved in National Cashew Gene Bank (NCGB) and 8 in RCGBs at AICRP on Cashew Centres were prepared. A technical bulletin entitled, "*Status of Cashew Germplasm Collection in India*" was published. Total number of cashew accessions conserved in NCGB is raised to 473 and 1,188 in regional cashew gene bank (RCGB). The correlation analysis of flowering and fruiting characters vis-a-vis yield/tree over the last 4 years showed that fruiting intensity and nut yield/m^2 of canopy are most important yield characters and hence these characters can be used for evaluating breeding material for improvement of nut yield/tree.

The performance of S 15/14 (1/3 Ceylon self) and H 24/4 (BLA 139-1 × A 18/4) were found better for cumulative yield and annual yield respectively. BLA 139-1 and V 4 had higher carbohydrate content, and BPP 5 and V 1 had more sugar and fibre content. Auxillary shoot bud proliferation (1-12 buds/explant) was induced on MS medium containing thidiazuron from shoot explants of matured tree origin. Micrografting was successful even with microscions of less than 5 cm length. A low-frequency somatic embryogenesis was observed on callus from nucellus induced on medium containing 2, 4-D and kinetin. Suspension culture from embryogenic calli resulted in high frequency regeneration of somatic embryos. Isozyme extraction from leaves was standardized. Staining prototcol for 6 isozymes were worked out. Recyclable biomass from cashew garden after mixing with cowdung slurry could be converted into vermicompost rich in N, P, K and micronutrients by earthworm *Eudrilus* sp. within 3 months. Sesbania grown as green manure crop in one-year-old cashew orchard contributed maximum green biomass which is equal to 48 kg N, 7.2 kg P_2O_5 and 9.8 kg K_2O/ha. Under high-density trial, at 4 m × 4 m spacing gave 1.3 tonnes/ha yield at CRS, Bapatla. V 4 gave

CASHEW NUT SHELLER

A cam type, pedal-operated, cashew nut sheller has been developed to overcome the drudgery experienced in presently used hand-cum-pedal-operated sheller.

- Forecasting models have been worked out for India as well for different cashew-growing states in the country.
- A total of 102,212 grafts were produced and distributed to different governments, NGOs and farmers by NRCC, Puttur.

Cashew grown in high-density planting

SUCCESS STORY

REMUNERATIVE CASHEW PRODUCTION

In cashew, a net profit of Rs 77,054, 73,735, 70,050 and 58,790/ha was obtained in high-density planting, accommodating 625, 500, 400 and 384 trees/ha respectively, for the initial 12 years, compared to Rs 31,278/ha in normal planting density (156 trees/ha). The biomass of dried branches in high-density planting was 10 times more than widely spaced trees. Weed biomass collected from high-density planting was significantly lesser than low-density planting. Total biomass per hectare-basis was higher in high-density planting compared to low-density planting. Organic-matter content available in soil up to 1 m depth and soil moisture level at the top 0–30 cm were higher in high-density planting. Heavy deposit of cashew leaves under high-density planting system when incorporated in soil will be a good source of nutrients for better plant growth and yield.

Thus a package of practices for high-density planting has been developed for farmers, and a technical bulletin, *High-Density Planting of Cashew,* has been published. To popularize this technology, farmers' participatory research-cum-demonstration plots were laid out at farmers' fields. So far 11 such plots were laid out under high-density planting system with a spacing of 6 m × 4 m and 5 m × 5 m. High-yielding varieties, viz. Ullal 4, Vengurle 4, NDR 2-1, Goa 11/6 and H 3/4 were distributed for this purpose. The plots are being monitored regularly. At present the plots are under second and third years of maintenance.

an yield of 1.6 tonnes/ha at a spacing of 5 m × 5 m with 75% thinning at RFRS, Vengurla.

Unmated males and virgin females of CSRB showed higher response to extracts and volatiles collected from cashew bark, frass and exuded gum. Evaluation of efficacy of new insecticides against TMB showed that Cartap hydrochloride (0.075%) was effective and comparable with carbaryl (0.1%). It was found that cashew kernel baby bits coated with sugar and different flavours could be stored without any quality deterioration up to 8 months. Cashew apple pomace could be blended with cereals and pulses up to 10% without affecting quality in terms of *in-vitro* digestibility of protein and starch.

SPICES

About 153 accessions of *Piper* spp., 26 of *Elettaria* spp., 21 of *Zingiber* spp., 19 of *Garcinia* spp., 9 of *Myristica* spp., 2 of *Cinnamomum* spp., 1 of *Syzygium* sp. and 3 of *Vanilla* spp., were added to germplasm conservatories. A database of black pepper germplasm was brought out in a CD. RAPD profiles were developed in 13 species of *Piper*, 4 of *Zingiber* and 12 cultivars and 6 species of *Curcuma*. A RAPD based molecular marker technique was developed in black pepper for identification of true hybrids.

The Acc. 239 was identified as a promising line in black pepper. In cardamom, high-yielding (Acc. 8-4 D 11 and Acc. 7-24 D 11) and drought tolerant (CL 668, P 6, D 237, 2-2 D 11) accessions were identified. V_3S_1-8 in ginger and PTS 59 and PTS 55 in turmeric were identified as promising lines. These are in an advanced stage of release. Ginger V_1E_8-2 and turmeric PTS 43, TCP 1 and TCP 2 were proposed for release. Turmeric Alleppey and BDJR 1260 were selected for high curcumin content and yield. The exotic line of coriander, EC 2-32666, was identified as the best for leaf type. The highest volatile oil content (4.4%) in cumin EC 232684 was recorded.

Promising variability in *Garcinia* species

Acc. 5302 of pepper was found to be promising with 8.0% oil, 19.0% oleoresin and 3.7% piperine. Ginger, Acc. 197, was promising with 2.5% oil, 7.0% oleoresin and 2.8% fibre. Nutmeg, Acc. A9/18, had maximum oil in nut (16.5%) and mace (26.1%). Acc. 828 of pepper was tolerant. *M. malabarica* was found to be superior in evaluation as rootstock for grafting nutmeg to overcome drought. The promising black pepper lines, Coll.1041, OPKM, HP 780, HP 1411 and HP 813, continued to maintain their superiority in yielding 2–3 kg fresh berries/vine during the fourth year of planting. The elite cassia line, D 1, yielded highest with a mean fresh bark yield of 462.7 g/plant.

Foliar application of Zn (0.25%) twice resulted in high rhizome yield in ginger compared to soil application. Application of neem cake increased availability of N significantly and highest available N was recorded in beds applied with half the dose of N as urea along with neem cake @ 2 tonnes/ha. A fertilizer schedule of 100 : 100 : 175 kg NPK/ha was recommended along with organic and inorganic manure in cardamom. Application of micronutrients increased the yield in coriander and fennel.

Blanching of mace in 75°C hot water for 2 minutes before drying, gave 23% more colour and its stability, than hot air-dried mace. Biochemical characterization of *P. capsici* from black pepper using isozyme analysis revealed the existence of two subpopulations in the species. Thirty-one promising hybrids (based on preliminary screening) were further tested for their reaction to *P. capsici* and 6 hybrids (HP 293, HP 400, HP 674, HP 1372, HP 1375 and HP 1389) showed a tolerant reaction. Trials with *Phytophthora* resistant rootstocks of *Piper colubrinum* at farmers' fields indicated that there was no deterioration in growth of grafts up to 5 years after grafting and an average yield of 11 kg (green berries) per standard was obtained from these grafts.

A simple screening technique for resistance directly inoculating the bacterial wilt pathogen, *R. solanacearum*, in tissue-cultured ginger somaclones was developed. Six accessions each of ginger and turmeric were screened for their reaction to *Meloidogyne incognita* and 2 turmeric accessions (Acc. 1 and Acc. 8) gave a resistant reaction. Evaluation

PLANT GROWTH PROMOTER

Evaluation of Plant Growth Promoting Rhizobacteria (PGPR) obtained from Silent Valley (Kerala) indicated that strain, IISR 331, could increase the growth of black pepper cuttings by 228% and showed 82.7% inhibition of *P. capsici in-vitro*. A RFLP-PCR technique was standardized for identifying strains of *R. solanacearum* causing bacterial wilt of crop plants.

of 11 promising antagonistic fungi and 1 bacterial isolate (*Pasteuria penetrans*) in black pepper, turmeric and ginger fields for suppression of *M. incognita* indicated that all of them caused significant suppression of nematodes. *Verticillium chlamydosporium*, *Fusarium* sp. and *Scopulariopsis* sp. also significantly increased the yield of black pepper and ginger besides controlling nematodes. Evaluation of extracts of various plants indicated that methanol and hexane extracts of *Annona squamosa* seeds were the most promising resulting in complete deterrence of feeding activity of *pollu* beetle at 1% concentration. The management of root mealybug *Planococcus* sp. on black pepper at Wynad (Kerala) indicated that drenching of affected vines with chlorpyriphos (0.075%) was effective.

HP 1411 is a promising black pepper hybrid

A low-cost technology for mass multiplication of *Trichoderma* sp. for field application was developed. Rhizome rot of ginger under storage could be managed by storing seed rhizomes of ginger in sand layered pits mixed with Dithane M 45 and Bavistin. Coriander, RCr 441, RCr 435, RCr 436, UD 446 and UD 684, were resistant to root-knot nematode. Sowing cumin on 10 November was ideal to minimize wilt incidence and to obtain a high yield. Guj. Cum.3, Acc. 1136, Acc. 1145 and Acc. 1165 were moderately resistant to *Fusarium* wilt.

Surveys conducted in traders' godowns at Calicut and Kochi indicated that *Lasioderma serricorne*, *Rhizopertha dominica*, *Tribolium castaneum*, *Araecerus fasciculatus* and *Tenebroides mauritanicus* were major species of insects associated with stored dry rhizomes of ginger and turmeric.

BETELVINE

Vasani Kapoori at Bapatla, Shirpurkata at Sangli and Dindugal at Sirugamani yielded highest leaf compared to local checks. Yield increase was in the tune of 54.0, 30.8, and 45.0% respectively at Bapatla, Sangli and Sirugamani centres. About 100% replenishment of pan evaporation rate through drip irrigation produced highest leaf yield (25.55 lakh/ha) at Jabalpur. However at Sangli centre, 125% evaporation replenishment produced highest yield (42.32 lakh/ha) with a water saving of 34.26%. At Jabalpur centre, 1.5 lakh plants/ha population was found to be the best with increased leaf yield (15.80 lakh/ha).

At Bhubaneswar, 2.00 lakh plants/ha gave highest leaf yield. At Pusa center, 1.50 lakh plants/ha yielded maximum number of leaves (37.51 lakh/ha). Disease incidence increased with increase in population. Under open system of cultivation, 1.0 lakh plants/ha produced maximum leaf yield at Bapatla (57.17 lakh/ha), 50,000 at Sangli (71.11 lakh/ha) and 75,000 at Sirugamani (41.83 lakh/ha). At Kalyani, *Azotobacter* 5 kg + 100 kg P_2O_5 + 100 kg K_2O treatment produced highest leaf yield (41.56 lakh/ha). At Sirugamani, *Azospirillum* 5 kg + 100 kg P_2O_5 + 100 kg K_2O + *Azotobacter* treatment was the second highest yielder (70.22 lakh/ha) after recommended fertilizer dose. In integrated crop management, integration of following treatments such as best plant population/ha, 200 kg N + 100 kg P_2O_5 + 100 kg K_2O, watering 100% replenishment of PER and application of Bordeaux mixture (4 drenches + 8 sprays) produced highest leaf yield at Bapatla, Kalyani, Jabalpur and Bhubaneswar centres.

- For betelvine, a package of practices has been developed for getting higher yield.

Four applications of *Trichoderma* spp. was found to increase higher leaf yield. It was found statistically at par with Bordeaux mixture (4D + 8S) treatment in increasing leaf yield and in reducing the disease incidence at all the centres except Sangli where 4 applications of *Trichoderma* at quarterly interval produced highest leaf yield (54.18 lakh/ha).

Application of oil cakes + carbofuran + 3 inoculations of *Phytophthora lilacinus* inoculated oil cakes showed best control of root-knot nematode and increased leaf yield compared to other treatments at Jorhat, Jabalpur and Pusa centres. Incidence of tobacco caterpillar was observed at Bapatla from October to December with a maximum leaf damage of 15.8% during the first fortnight of November. On *Sesbania*, higher incidence of leaf-eating caterpillars was recorded with a maximum plant damage of 31.4% during the first fortnight of September, resulting in total death of newly-planted seed vine cuttings. Lady bird beetles (*Verania vincta*) was observed to be the most common predator in betelvine crop ecosystem followed by spiders. The beetles are found to feed on the early instar larvae of tobacco caterpillar and eggs of mites. At Kalyani, Homopteran fly complex

white fly (*Dialeurodes pallida*) and black fly (*Aleurocanthus rugosa*) was most dominating one.

At Sangli, black fly and scale insect mites and betelvine fly were most dominating insects. At Jorhat and Pusa, 60 g of inoculum was found to be best in producing highest spore concentration and colony-forming units when 10 kg MOC was inoculated and incubated for 60 days. At Kalyani, oat or barley used as substrate for the production of mass culture of *T.harzianum*, were best and 40 g of unit inoculum of both the low-cost cereals could be used and can be distributed to farmers for mass culturing in oil cake. At Sirugamani, spraying of NSKE (5%) or neem oil (2%) after initial drenching with the same had significant effect in reducing the pest population, drenching NSKE (5%) or neem oil 2% followed by spraying suppressed the stem-borer on *Sesbania*.

MEDICINAL AND AROMATIC PLANTS

Aswagandha WS 90-100 (8.0q/ha), WS 90-104 (7.3 q/ha) and WS 90-134 (7.3 q/ha) produced higher root yield at Indore. At Udaipur, WS 90-127 gave highest root yield (8.03 q/ha). Significantly higher root yield (8.58 q/ha) and best weed control were recorded in Trifluralin at 4 litres/ha + one interculture at 50 DAS at Indore. At Mandsaur, glyphosate 1.0 kg/ha + hand-weeding (HW) at 45 DAS was effective. The treatment glyphosate (1.0 kg/ha) + 1 HW at 45 DAS and Isoproturon (0.5 kg/ha) + 1 HW at 45 DAS proved highly effective. At Udaipur, Isoproturon (0.75 kg/ha) + 1 HW at 45 DAS was found the best method of weed control.

In vetiver (*Vetiveria zezanioides*), IC 82469 showed highest root yield,whereas highest oil yield was recorded in IC 78651 (4.8 litres/ha). In lemongrass (*Cymbopogon flexuosus*), NLG 48 was found the best in terms of herbage yield, oil content and oil yield/ha at Faizabad. Whereas at Hisar, H1 7 showed highest herb yield; HL 11 highest oil content and HL 2 highest citral percentage.

At Indore, CBI 3 and MCB 412 were found promising in safed musli. At Mandsaur, MCB 405 (for fresh root yield and steroid content) and MCB 409 (dry roots/plant) were found promising. MCB 405 was also found superior at Udaipur for fresh root yield. At Akola, significantly highest root yield was recorded due to application of 5 tonnes/ha vermicompost in 30 cm × 10 cm spacing. At Udaipur, increasing plant density from 1.66 to 3.33 lakh/ha significantly increased root yield. A new leaf spot disease was noticed. The causal fungus was identified as *Macrophomina phaseolina* (Tassi) Goid (IMI number 387291).

In satavari (*Asparagus racemosus*), highest dry fleshy root yield/plant was recorded in HAR 8 at Hisar. In isabgol (*Plantago ovata*), DM 1 was found highly resistant at Anand. Entry J.I. 80 gave highest yield with 23.67% over the existing variety. About 25 and 50 kg N/ha and 2 irrigation levels (25 and 75 days) were found to be best for isabgol at Hisar. At Udaipur, delay in sowing from 10 November during 2000–01 and from 20 November during 2001–02 resulted in significant decrease of various yield attributes, seed and husk yield of isabgol.

At Mandasur, J.A 16, MOP 278 and MOP 541 were high latex yielders. At Udaipur, Chetak Aphim proved its superiority over other varieties. Maximum yield of latex, seed and husk were also recorded in sowing done on 30 October. Morphine content gradually increased in petals collected on first day (0.46%), second day (0.55%), third day (0.64%) and fourth day (0.82%) of opening probably due to increased mobility of morphine due to certain metabolic activities. But it decreased in petals collected on the day of falling from the flower either fourth day or fifth day of opening (0.62%).

In long pepper (*Piper longum*), the effect of organic and inorganic source combinations showed that treatments significantly affected dry spike yield in Viswam and Anand types. Significant difference was noticed between treatments on rhizome yield in Kacholam (*Kaempferia galanga*) with the application of organic and inorganic source combinations.

At Solan, application of NPK at 90 : 60 : 60 kg/ha and harvesting 270 and 60 days after

OIL-YIELDING PLANTS

The Glycyrrhizic acid content in liquorice increased with increasing age at Hisar. Its maximum content was recorded after 2 years of plant growth. In Japanese mint, 2 years data revealed that Gomti and Himalayan were the best varieties yielding the maximum oil yield at Hisar. Deltametharin (1.0 ml/litre) was found to be effective in controlling *Helicoverpa armigera* and *Plusia orichalcea* pest and increased the yield at Solan.

- Safed musli CBI 3 and MCB 412 were promising.
- Isabgol DM 1 was highly resistant to diseases.

was found optimum for getting higher herb yield, oil content and oil yield in Melissa (*Melissa officinalis*). At Solan, 15 tonnes FYM + 40 kg N + 30 kg P_2O_5 + 2 kg *Azotobactor* was found to be optimum combination of fertilizers for getting maximum flowering shoot yield, oil content and oil yield in Salvia.

Application of 75 kg N and 50 kg P_2O_5 was found beneficial for maximum seed yield of Kastur Bhendi (Muskdana). The uptake of NPK was also found to be maximum with 75 kg N and 50 kg P_2O_5.

At Anand, *Botryodiplodia theobromae* (fungus) and *Pseudomonas* sp. (bacteria) were found pathogenic to guggal plant. At Solan, Endosulfan (1.5 ml/litre) was found to be effective in reducing the population of bugs and increasing flower yield, followed by malathion and deltamethrin (1.0 ml/litre) in *Matricaria*.

The white-seeded accessions of *Mucuna* species performed better as compared to *Mucuna pruriens* (black-seeded) accessions, in terms of L-DOPA yield/plant (39.73 g/plant) in IC 127363 (white-seeded) and 4.69 g/plant in Punba collection (black-seeded). However, L-DOPA content was maximum in Srahan collection (black-seeded) with 7.3% as compared to 5.76% in IC 127363 (white-seeded accessions).

The seeds produced as a result of controlled selfing between flowers on the same plant in *Gloriosa superba*, had maximum 100-seed weight (2.66 g), colchicine content (0.8%) and maximum seed germination rate (46.25%).

In Valeriana (*Valeriana jatamansi*), maximum contents of total valepotriates (3.56%) and maximum essential oil content (4.33%) in roots were observed in Dalhousie and Kalatop population respectively. Valtrate is the major constituent of valepotriates and in essential oil, patchouli alcohol is major constituent. Valepotriates undergo decomposition during storage, which can be minimized if unground rootstocks are stored in complete shade. Essential oil is localized in all the tissues of rhizomes and roots, whereas valepotriates are localized in cortex of both rhizomes, roots and rhizome pitch.

POST-HARVEST MANAGEMENT

The technology for uniform ripening of mango fruits has been developed which involves harvesting of mango fruits at optimum maturity and within 5 hours after harvesting fruits are immersed in hot water at 52 ±1ºC for 5 minutes. The fruits are to be allowed to surface dry before packaging and storage. This method results in uniform ripening, good quality fruits with reduced spoilage. Studies on Controlled Atmosphere (CA) storage showed that mature green Banganapalli mangoes could be stored for 5 weeks in unripe condition at 8ºC without any chilling injury symptoms under 5% O_2 and 3% CO_2 gas composition. The CA stored fruits ripen normally in one week with good surface colour, acceptable taste and flavour when shifted to ambient condition.

Three pre-harvest sprays of 2% dehydrated calcium chloride ($CaCl_2$) and 0.1% Bavistin at 10 days interval were effective to extend the shelf-life of fruits harvested with 8–10 mm stalks of mango Chausa and Mallika.

Modified atmosphere storage in 400-gauge sealed polybags at 13.5°C extended the storage life up to 19.33 days in Karpooravalli and 29 days in Poovan bananas. Hot-water treatment at 46°C for 30 minutes coupled with storage in sealed polybags of 150-gauge along with ethylene scrubber increased the storage life of Rasthali banana up to 39 days. The technologies of banana fruits and flowers for pickle, banana flour based products like health drink, baby food and banana biscuits have been standardized.

Technology pertaining to mechanized sorting, waxing, washing and packing in corrugated boxes in addition to degreening and storage to improve shelf-life of fruits has been developed. A low-cost evaporative cool chamber on a farm scale has also been developed. Storage of Nagpur mandarins at sub-optimum temperature showed that intermittent warming produced better colour development and fruits stored at 3–4°C (one week) + 20°C (one week) recorded highest colour index after 60 days. Physiological weight loss was significantly higher in acid

POST-HARVEST MANAGEMENT IN POTATO

The modified improved heap structures developed at CPRI campus Modipuram resulted in reducing storage losses in Kufri Bahar (17.0–9.83%) and in Kufri Jyoti (15.0–7.08%) compared to unimproved heaps. Lowest accumulation of sugars was observed in Kufri Chipsona 2 with storage at 10°C and treatment with CIPC even after 4 months of storage. Accumulation of reducing sugars was also high in tubers stored under CO_2 environment resulting in dark coloured chips. Fastest dormancy break was observed in tubers stored at 15% CO_2 concentration (24 days) followed by 20% (47 days) compared to the control (7 days). Best results were obtained in suppressing sprout growth when tubers were treated with carvone.

lime fruits packed without vented polyethylene liner as compared to fruits packed with polyethylene liner without affecting the juice content irrespective of wax treatments and TSS increased with extension of storage period.

In post-harvest management, SO_2 injury to grapes stored at 0–0.5°C, could be reduced by one or two pre-harvest spraying with *Trichoderma harzianum* isolate 5R, given 20 or 20 ± 3 days intervals and packing them with 2.3 g $Na_2S_2O_5$ in a 5 kg box. Pre-harvest spraying of *Trichoderma* has reduced the percentage of rotten berries, fallen berries and fungal growth on pedicle and retained freshness of grapes on 9th day in shelf after storage at 0–0.5°C. Pre-harvest intervals for methomyl, carbendazim and mancozeb were found to be 13, 50 and 48 days respectively for recommended dose spraying and 18, 60 and 60 days for double dose spraying. The *Trichoderma harzianum* was also found to have superior effect in degrading the residues on grape berries.

Natural Resource Management

- The soil map of India has been generated on 1 : 1 million from the state soil maps. The map elaborates soils designated to 7 orders, 62 great-groups and 1,649 soil units. The map can be harnessed in land use planning for sustainable agriculture.
- The soil resource atlases of Bhopal, Guna, Betul, Dhar and Ratlam districts have been brought out.

LAND USE PLANNING AT VILLAGE LEVEL

The detailed, micro-level and participatory land use planning (1 : 5,000 scale) has been undertaken for Sukli village, Nagpur (Maharashtra), using cadastral maps. The soil units were delineated at series and phase level. The farmers were motivated to adopt the alternate land use plan along with affordable crop management package. A perceptible change was noticed in the land use scenario and socio-economic condition of the farmers after adoption of the alternate land use plan. The transformation resulted in an increase in the per capita availability of cereals and pulses from 169 and 25.5 kg/annum to 172 and 96 kg/annum, respectively. Soybean got established as cash crop along with cotton.

- Soil erosion maps have been developed for Maharashtra, Madhya Pradesh, Gujarat, West Bengal, Uttar Pradesh, Himachal Pradesh and Tripura.
- The bioengineering measures were developed integrating soil-erosion control structures with appropriate vegetation.

SOIL RESOURCE INVENTORY

Soil Map of India

The soil map of India has been generated on 1 : 1 million scale from the state soil maps on 1 : 250,000 scale. The map comprising 11 sheets has soils designated to 7 orders, 62 great-groups and 1,649 soil units. The soils belonged to 9 major physiographic regions namely Himalyan mountain and Siwaliks, North-Eastern hill ranges and valleys, hill ranges (Ghat), Deccan plateau, Central highland, Indo-Gangetic alluvial plain, Gujarat plains, Coastal plains and Islands. The map is useful in land use planning for sustainable agricultural production.

Model District Resource Planning

The soil resource atlases of Bhopal, Guna, Betul, Dhar and Ratlam districts have been brought out containing 40–45 thematic maps each devoted to physiography, soils, vegetation, land use and demographic features, etc. The atlases are useful for district land use planning.

Soil Correlation

The soil series identified during the reconnaissance, rapid reconnaissance and detailed soil reconnaissance have been correlated, identified and published as soil series handbooks for Madhya Pradesh (240 soil series), Maharashtra (150), Chhatisgarh (67), West Bengal (81), Himachal Pradesh (90), Goa (32) and Rajasthan (117).

RESOURCE CONSERVATION AND MANAGEMENT

Soil Erosion Maps

Soil erosion maps have been generated for Maharastra, Madhya Pradesh, Gujarat, West Bengal, Uttar Pradesh, Himachal Pradesh and Tripura based on soil resource data and grid observations. These maps are useful for formulating appropriate soil-conservation measures.

Soil- and Water-conservation Measures

The cost-effective bioengineering measures were developed integrating soil-erosion control structures with appropriate vegetation like munj (*Erianthus munja* syn *Sachharum munja), Ipomea carnea,* giant napier, etc. In these structures, design lengths of headwall extension and apron were reduced by 20–30% to reduce the cost by 20–30%.

To rehabilitate wastelands in Salaviyur watershed in Western Ghats, 3 percolation tanks on private land and 2 on community land were constructed with a water storage capacity of 23.34 ha-cm. Significant increase in area under horticulture with mango, tamarind, amla, guava, pomegranate and sapota has demonstrated the outcome of the watershed studies on adoption of alternate land use plan and crop diversification. The Self-Help Groups (SHG) undertaking works have already paid back about Rs 14,362. The money has been ploughed back to support 3 new SHGs.

Watershed Management

Studies on impact of watershed management revealed that peoples' participation index (PPI) in 15 watersheds of Coimbatore district was 55, 44 and 27% at the planning, implementation and maintenance stages, indicating medium, low and very low level, respectively. Benefit : cost analysis of the project, considering 10 years life at 10 and 15% discount rate, gave benefit: cost ratio of 1.53 : 1 and 1.28 : 1, respectively with 28% internal rate of return. The credit utilization and repayment capacity have improved as a result of watershed programme.

A holistic development of Kokriguda micro-watershed was attempted following the multifaceted interventions based on needs, perceptions and priorities of the villagers known through participatory rural appraisal (PRA). With the dedicated efforts of Watershed Development Team (WDT), the area under vegetables increased from around 3 ha in 1998–99 to 18 ha in 2001–02, fetching net returns of Rs 14,245/ha during 2000–01. Not only cultivation, but consumption of vegetables has also increased from 15 to 33 persons. These developmental activities have increased working hours of women in farm activities by 70%. Contribution of villagers varied from 5 to 60% depending upon the activity.

The development of Kokriguda watershed was undertaken by means of interventions to make it a complete and self-contained system. Area under vegetables increased from 3 ha to 18 ha. A panoramic view of the Kokriguda watershed (*top*). A bumber crop of cabbage (*bottom*)

Adoption of Resource Conservation Technologies (Zero-tillage) in Rice-Wheat Systems

The project is based on cardinal principles of resource conservation technologies (RCT), which protects soils by reducing disturbance of soil structure due to tillage, build up of organic carbon, stimulate beneficial microbes, and improve infiltration of rainwater and reducing its loss. Zero-tillage sowing and surface seeding were undertaken in 43 canal irrigated villages consisting of 418 farmers in Patna. Observations collected from the farmers on zero-tillage sowing revealed that: (i) It reduced cost of tillage from Rs 2,000/ha to Rs 650/ha with a saving of Rs 1,350/ha; (ii) early seed germination under zero-tillage by 2–3 days; (iii) early sowing of 7–10 days in moist field can be done when conventional tillage is not possible; (iv) there is less incidence of weed small canary grass (*Phalaris minor*); (v) crop remains green after 1st irrigation due to early recession of water in the field; and (vi) in conventional tillage wheat became pale yellow due to prolonged water stagnation. According to the farmers' observations the constraints were: (i) Regular maintenance of machine is required to stop clogging of fertilizer and seed; (ii) initial training of machine operation is required which is lacking; (iii) spare parts are not available locally; and (4) tractor owners are waiting for the market demand trend this year and they will purchase the machine next year.

SOIL FERTILITY AND NUTRIENT MANAGEMENT

Total Carbon Stock in Indian Soils

The soil organic carbon (SOC) and soil inorganic carbon (SIC) stocks in soil orders, agro-ecoregions (AERs) and agro-eco subregions (AESRs) of the entire country were estimated. Total carbon stock in upper 30 and 150 cm soil depth has been estimated as 14 and 64 Pg (1 Pg=10^{15} g), respectively; SOC and SIC contributing 47–71% and 29–53%, respectively.

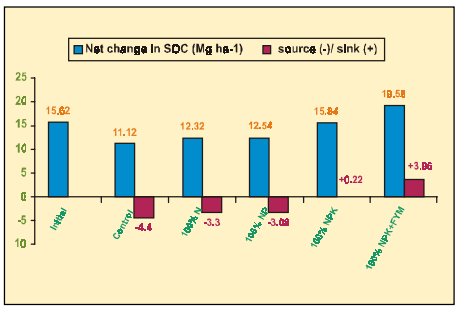
The carbon-transfer model indicates that both soil organic carbon (SOC) and soil inorganic carbon (SIC) are equally important for C transfer and potential CO_2 sequestration. With the adversity of the climate there will be depletion of organic carbon and that the carbon will be sequestered as inorganic $CaCO_3$ in soils.

Organic Pools and Dynamics

The rate of restoration of soil organic C with management was found to be in the

- The long-term application of FYM alone to maize-wheat in acidic red soil at Kanke, Ranchi, has produced significantly higher yields of crops compared to 100% NPK.
- The recommendations under Integrated Plant Nutrient Supply System have been made and tested on farmers fields in 3 major agro-ecoregions of the country under FAO-ICAR-IFFCO collaborative project.

- The rhizobial populations in the fields constantly cultivated with same legume crop are very low. Therefore, legume inoculation of rhizobial and other bacterial biofertilizers should be practised by the farmers every year.
- The vermicompost prepared from sugarcane trash, pressmud, poultry waste and soybean straw contained 30–40% higher nitrogen compared to the compost prepared by heap or pit methods.



Change in soil organic carbon with addition of NPK and farmyard manure.

order: Vertisols> Inceptisols> Alfisols, irrespective of cropping systems. Carbon sequestration was positive under 100% NPK and 100% NPK + FYM plots due to higher biomass production and residue turn over in the soil. C-mineralization rate was maximum under NPK + FYM compared to NPK, NP and N indicating need for regular application of organic manure for sustained soil productivity.

Impact of Nutrient Management on Soil Productivity

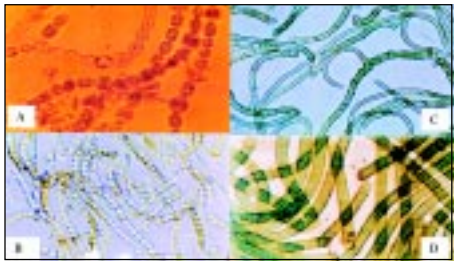
The long-term application of FYM alone (since 1956) to maize-wheat in acidic red soil at Kanke, Ranchi (Jharkhand), has produced significantly higher yields of crops compared to application of 100% recommended NPK. The yields of maize and wheat were 3.115 and 3.350 tonnes/ha in the former treatment compared to 1.688 and 2.580 tones/ha in the latter treatment became comparable with organic treatment for maize when it was supplemented with lime. The yields of wheat under NPK + lime were significantly higher over organic treatment. Organic manure addition increased soil pH and organic carbon content in the soils. With the addition of lime along with chemical fertilizers, there was increase in soil pH but organic carbon content remained low. Therefore, both liming and organic manuring along with balanced chemical fertilization could be the right proposition for better management of acid soils to sustain high productivity. The addition of lime and FYM are, therefore, crucial for sustainable management of acid soils.

Effect of continuous use of chemical fertilizers and FYM on soil productivity and properties

Treatments	Grain yield (tonnes/ha)		Soil properties	
	Maize	Wheat	pH	Organic C (%)
N	0.019	0.147	3.9	0.59
NP	0.485	1.567	4.8	0.74
NPK	1.688	2.580	4.8	0.85
NPK + lime	2.980	4.275	6.8	0.57
FYM	3.115	3.350	6.7	1.62
FYM + 50% NPK	3.161	3.793	5.6	1.22
CD (P=0.05)	0.468	0.611		

Integrated Plant Nutrient Supply System

The recommendations under Integrated Plant Nutrient Supply System (IPNSS) based on the soil tests, availability of irrigation and farmers' resources have been made and tested on farmers' fields under 3 agro-ecoregions of the country under FAO-ICAR-IFFCO collaborative project.



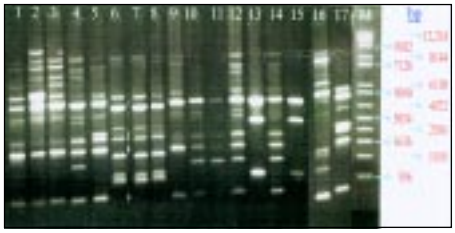
Cyanobacterial cultures. A, *Anabaena azollae* (MPK-SK-38); B, *Nostoc muscorum*; C, *Westiellopsis* (C_{100} TR_5 ST_3 PA-SK); D, *Oscillatoria*

Tracking Inoculated Bacteria in Soil

Methods for assessing the survival of inoculated diazotrophs—*Azospirillum* and *Azotobacter*—in soil were standardized using stable genetic markers lac Z and gus A. Inoculated *Azospirillum lipoferum* strains Cd and S-28 marked with lac Z survived in the rhizosphere of wheat up to 120 days. However, lac Z + strain of other heterotrophic soil bacteria were also present in the soil and thus did not provide a specific assay. Since lac Z is non-specific and gus A assays are expensive, using 'gfp' (green fluorescent protein) marker combined with tetracycline marker was found more useful for ecological studies as it was stably integrated. *Bradyrhizobium* sp. nodulating greengram was marked with gfp and identified in soil, nodule and charcoal-based inoculant.

Quality Control of Cyanobacterial Inoculum through Molecular Markers

Seventeen cyanobacterial strains belonging to 6 genera, viz *Anabaena*, *Nostoc, Aulosira, Tolypothrix, Westiellopsis* and *Fischerella* were selected and random amplified polymorphic DNA (RAPD) fingerprinting was carried out to develop potential markers. The primers OPB 09, OPG 04, OPAH 02 generated markers specific for *Nostoc*; OPAH 02 for *Westiellopsis;* OPG 01 for the acid tolerant *Westiellopsis*-4A 2; OPF 03 for *Tolypothrix tenuis*. Primers OPB 09, OPAG 03 and OPG 05 could be used for *Fischerella* cultures. The results suggested a marked variation among the cyanobacterial strains to different primers that could be used as molecular markers for identification of the standard strains used in preparation of cyanobacterial inoculum.



RAPD fingerprinting profile of cyanobacterial cultures for primer OPB 09. **1,** *Westiellopsis* (ARM 48), **2,** *Westiellopsis* sp; **3,** *Westiellopsis* ($C_{100}TR_5ST_3$ PA-SK); **4,** *Westiellopsis prolifica*; **5,** *Westiellopsis* (4 A2); **6,** *Nostoc muscorum*; **7,** *Nostoc* sp; **8,** *Anabaena variablis*; **9,** *A. azollae* (SK-SL-TNAU 1); **10,** *A. azollae* (MPK-SK-AM-24); **11,** *A. azollae* (MPK-SK-AM-25); **12,** *Azollae* (MPK-SK-AF-38), **13,** *Anabaena* sp; **14,** *Anabaena* (TR 52 ST 1); **15,** *Tolypothrix tenuis*; **16,** *Aulosira pseudoramosa*; **17,** *Fischerella* sp; M, marker

Survival of Rhizobia in Plough Layers

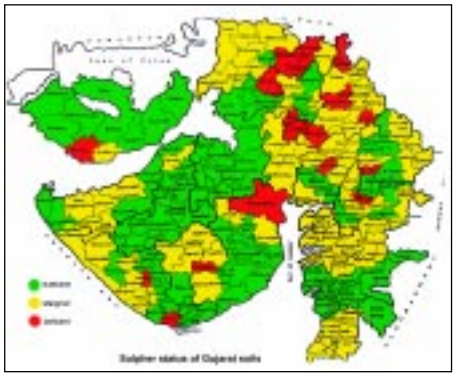
The results in a network experiments have showed that in sub-tropical soils, rhizobial populations even in fields continuously cultivated with the same legume crop are very low due to prevailing high temperature/low relative humidity in summer. The studies have reinforced the need to practise legume inoculation each year for vigorously promoting the use of rhizobial and other bacterial biofertilizers by the farmers.

Comparative Evaluation of Composting Methods

The vermicomposts prepared from sugarcane trash, pressmud, poultry waste and soybean straw contained 30–40% higher nitrogen compared to the compost prepared by heap or pit methods. Similarly, C : N ratio of vermicompost was, generally, lower compared to the manure prepared by other methods.

Sulphur Deficiency in Soils of Gujarat

Widespread deficiency of S has been reported from the soils of Gujarat with 37, 13, 50% of the 6,598 soil samples analyzing as deficient, marginal and sufficient in S, respectively. Sulphur deficiency was more than 45% in soils of Panchmahal, Bharuch, Mehsana, Ahmedabad, Saberkantha and Banaskantha; 24–36% in Bhavnagar and Surendranagar and less than 20% in Rajkot, Amreli, Jamnagar and Valsad. Soils irrigated with sulphate rich water showed adequate sulphur.



The soil samples analyzed from different districts of Gujarat indicated deficient, marginal and sufficient soils in sulphur.

Recycling of Crop Residues to Correct Zinc Deficiency

A 7-year study at Pusa, has indicated that application of 2.5 kg Zn/ha only to first, crop plus 50% crop residue of every crop was as much effective as 100% crop residue alone or 10 kg Zn/ha. Rice was benefited more than wheat from crop residue incorporation. Available Zn status of soil improved progressively with increasing levels of crop residues and applied Zn.

Influence of Sewage Irrigation on Heavy Metal Accumulation in Soil and Plants

The continuous irrigation with sewage water around Amritsar has resulted in more accumulation of Cd, Ni, Pb, Cu, Fe, Mn and Zn in surface (0–15 cm) layer by 2.76, 1.57, 1.96, 5.1, 1.08, 1.72 and 4.36 times compared to irrigation with tubewell water. Similarly, the studies around Calcutta have revealed the accumulation of heavy metals in various plant parts of vegetable crops irrigated with city sewage effluent compared to irrigation with tubewell water.

WATER MANAGEMENT

Water Resources Databases of Bihar and Jharkhand

The relational diagram of the database design of water resources of Bihar and Jharkhand was finalized. The database design of Water Resources Information

- The database designs of Water Resources Information Systems of Bihar and Jharkhand were completed.
- PBW 443, K 8047 and RW 927 wheat varieties were identified as drought tolerant.
- Crop diversification with profitability is workable in canal commands of coastal Orissa with the adoption of alternate raised- and sunken-bed system.
- Zero-tillage and raised-bed planting systems helped in considerable water saving in wheat.
- Multiple use of irrigation water, e.g. for fish culture and cultivation of crops advocated.
- Performance study of one type of sprinkler system was conducted under various operating pressures.
- Low-energy water application device has been designed, developed and evaluated. It has been promising even at low-operating pressures.
- Integration of rice farming with fish increased productivity.

System (WRIS) has been completed using MS ACCESS as its front end and Visual Basic V 6.0 as the database.

Enhancing Productivity of Land and Water Resources of Bihar and Eastern Uttar Pradesh

The project was implemented in the command of RP Channel-V of Sone Canal System in Bihar and Gandak Command of eastern Uttar Pradesh, where over 87% rural population are dependent on agriculture. Snowball sampling technique was followed for collecting data from key informants like non-agricultural women group, sharecroppers, members of Water Users Associations, and landless/agricultural labourers at Panchayat level. Constraints were identified and ranked by the informants and on-farm demonstrations were organised. The project embarked on to develop and test new practices like deep summer ploughing with tractor-mounted disc plough, mapping of field plots and existing natural resources using Differential Global Positioning System, GIS and remote sensing which reduced cost of field preparation and weeding time, and over all saving in labour requirement for land and water management that improved yield and net income for the livelihoods.

Evaluation of Drought Tolerance Traits in Wheat

Field experiment with 13 wheat genotypes was conducted to evaluate different drought (moisture stress)-tolerant traits calculated from the post-harvest data. Out of all the indices yield stability (YS) values showed clear distinction among wheat genotypes (YS > 50%). The genotypes, which showed drought-stress index (DSI) > 1.0 are susceptible. Depending on YS and DSI values, RW 899 and RW 890 were identified as most susceptible, while PBW 443, K 8047 and RW 927 were identified as tolerant. The DSI showed significant negative correlation with yield, whereas the YS index has a significant positive correlation with yield. Dry-matter stress index (DMSI) showed a highly significant correlation with yield under stressed condition.

Crop Diversification in Canal Command of High-rainfall Area

Kharif rice followed by dry season rice is the cropping sequence commonly pursued in canal irrigation commands of coastal Orissa. Studies were conducted with the objectives of diversification and intensification of crops with increased employment and economic return by modification of microenvironment through land shaping in this area. The experiment was carried out in dry season in the farmers' field at Balipatna block, Khurda, Orissa under Nimapara Branch Canal of Mahanadi delta. The fields were converted into alternate sunken and raised beds (50 : 50), with raised beds 60-cm higher than the adjacent sunken beds. Among different cropping sequences in modified land, rice + cabbage – malabar spinach produced the highest rice-equivalent yield (21.61 tonnes/ha), followed by the rice + tomato – ridge gourd sequence (16.74 tonnes/ha) and rice + cabbage (15.14 tonnes/ha). Rice alone in the modified land produced only 3.19 tonnes/ha. The highest net return and benefit : cost ratio (BCR) was recorded in rice + cabbage–malabar spinach sequence (3.01). The least BCR (1.13) and net return were recorded in unmodified land. Crop diversification with increasing cropping intensity, profitability and water-use efficiency is possible in high-rainfall, shallow-watertable areas of canal command with the adoption of alternate raised- and sunken-bed system.

Integrated Rice-Fish Farming in Rainfed Ecosystem

In the rainfed system, *in-situ* conservation of rainwater in rice fields by optimum weir height, conserving excess water in the refuges constructed at the down stream of rice field and rearing of fish in the refuges in medium land enhanced the productivity. Initially the study was carried out at the Research Farm, WTCER, Deras, Khurda, and demonstrated in 6 farmers' fields at Sadeiberini village of

Dhenkanal, Orissa. Three weir heights (15 cm, 20 cm and 25 cm) were constructed with refuges occupying about 6-8% of the area of the rice fields with depth of refuge kept at 1.8 m conducive for fish growth. Indian major carps (catla, rohu and mrigal) were stocked @ 20,000/ha only for 6 months with high-yielding rice varieties Jagannath and Padmini during the *kharif*. Results revealed that the average rice yield at the farmers' field increased from 1.6 tonnes/ha (before intervention) to 4.65 tonnes/ha. The average fish yield from the system was 1,106.9 kg/ha in 6 months duration with improved average rice equivalent yield to 5.07 tonnes/ha with highest rice equivalent yield of 5.67 tonnes/ha obtained in 20 cm weir height plots. Utilizing the water stored in the refuges, the cropping intensity increased from 100% to 131%.

Zero-tillage and other Water Management Methods

In a study at the Sabajpura Farm, Patna, to find out the suitability of zero-tillage practices, other water management methods, the root parameters at tillering and flowering stages were highest under raised bed planting, with higher values under 5- and 7-cm depth of irrigation. Zero-tillage has given similar yield (3.26 tonnes/ha) as obtained with conventional sowing (3.23 tonnes/ha) and raised bed planting (3.21 tonnes/ha). Mean water saving under zero-tillage and raised bed was 11.3 and 55.9%, respectively. Saving land preparation, sowing and irrigation were Rs 1,850, Rs 1,400 and Rs 450, respectively in zero-tillage. Maximum gross benefit of Rs 3,943/ha was achieved under raised bed with 3-cm depth of irrigation. The minimum benefit of Rs 481/ha was found under zero-tillage with 9-cm depth of irrigation.

Multiple Use of Irrigation Water with Fishpond and Secondary Reservoir

Efforts have been made to increase the productivity of the irrigation water through multiple use like fish production. A fishpond (16.5 m × 14.5 m × 2.25 m depth) with 1: 1 side slopes, lined with 250 micron low-density polyethylene (LDPE) film, was constructed at the Research Farm of the ICAR-RCER, Patna, to deliver pumped water to the tank in 4 nearly equal parts for better aeration and exchange of water for fish growth. Indian major carps (catla, rohu and mrigal) and Chinese carps, were grown in the pond at a density of 75,000/ha from July–August to harvest in February to May. The total harvest of fish was 10.89 tonnes/ha in 2000–01 and 6.22 tonnes/ha in 2001–02, respectively.

Evaluation of Pressurized Irrigation Equipment

Performance study of double nozzle and single nozzle type of sprinkler system (M/s Premier Irrigation Systems) has been conducted under various operating pressures for its application rate, uniformity coefficient and distribution efficiency. Various conclusions drawn were: (i) Double nozzles give higher value of uniformity as compared to single nozzle for same operating conditions; (ii) under low-wind condition (<1.5 m/s), double nozzle performs better as compared to single nozzle; and (iii) wind speed more than 1–1.2 m/s affect distribution pattern of double nozzle, while wind speed more than 0.5 m/s affect the distribution pattern of single nozzle.

Vegetable Crops with Drip- and Micro-sprinklers

Field experiments with tomato-brinjal, and cabbage-okra sequences for irrigation-scheduling through drip systems and on bitter gourd for fertigation studies have indicated that application of irrigation was promising for better yield at 80% ET with 3 days schedule in tomato, whereas 60% ET with 2 days schedule in cabbage.

Design, Development and Evaluation of Low-energy Water Application Device

The developed manifold-based low-energy precision application (LEPA) was found a suitable device for operating at low pressure with less weight compared to LEPA designed earlier. After evaluation it was found that soil erosion was a major

problem. So, perforated pipe system was designed and evaluated whose area of coverage is found to be less. A prototype rotating arm water application device was designed which is promising even at low-operating pressure. It was tested for various combinations of its arm length, hole diameter, operating pressure, spacing, etc.

Management of Agriculture under Arsenic Contaminated Ground Water

The ground waters at shallow depths (15–35 m) and the surface soils of Baruipur Block of South 24 Parganas district of West Bengal are contaminated with toxic levels of arsenic. The use of these waters for drinking purposes, and the consumption of crops/vegetables raised on contaminated soil may be potential harmful sources to humans and animals. Arsenic uptake was higher in plants raised in light textured soil compared to heavy textured soil showing higher arsenic fixation capacity.

Evaluation of Production Potential of Agrotechniques at Sone Canal system

Seed rate in rice cultivation has been reduced from 30 kg to 10 kg/acre. The optimization of date of transplanting (advancing in particular) increased the unutilized rainwater from 40–50% to 80–100% and doubled the production.

Institute-Village Linkage Programme in Sone Canal System

Technology assessment and refinement through Institute-Village Linkage Programme (IVLP) in irrigated agro-eco region in the command of Sone Canal System, Bihar was taken up in 4 villages (Bhelura Rampur, Beeranchak, Veerpur and Doshiya) of Majhouli distributary of Sone Canal. Border irrigation method in wheat resulted in 26.0 to 34.2% water saving in tubewell command and 21.3–31.4% in canal command under heavy soils of central Bihar.

- Along the Indira Gandhi Canal, adoption of high-water demanding crops, with flood irrigation leads to waterlogging and secondary salinization.
- In Haryana, subsurface drainage system facilitated the reclamation of waterlogged saline soils.
- The antagonistic effects of long-term use of alkali/sodic water on physical and chemical properties of soils can be mitigated by the use of soil amendments, e.g. gypsum and pyrite.
- A superfine grain, scented rice variety CSR 30 has been released for sodic soils of Uttar Pradesh, Punjab and Haryana.
- Waterlogging along with alkali stress was more detrimental compared to alkali or waterlogging stress alone in wheat.
- Lal-jhav, babul, mosquite, *Eucalyptus, Acacia tortilis, Casia siamea* and elephant apple are promising tree species for rehabilitation of calcareous soils.
- Management of salt-affected black soils of Gujarat was accomplished by growing mustard-tree forage grass. It gives seeds rich in oil and may be used in environmental-greening.
- Application of chemical fertilizers supplemented with organic manure gave higher rice yield in salt-affected coastal soils.

SOIL SALINITY AND COASTAL ECOSYSTEM

Morphological Benchmarking of Salt-affected Soils in Sunderban

In a benchmarking survey (after 29 years) salt-affected soils in Sunderban Delta, the colour in the surface horizon remained unchanged, while in the substratum, it changed from grey to dark greyish brown in cultivated conditions. The pH of the surface horizon declined from 6.8 to 6.2, while that of the next horizon from 7.9 to 7.2. At 1-meter depth, the soil pH increased from 6.0 and 6.7 to 7.0 and 7.3, respectively. In uncultivated condition, the colour changed from dark greyish brown to greyish brown in the surface horizon and from grey to dark grey in substratum. The pH of the surface horizon changed from 7.2 to 6.8 and and subsurface horizon from acidic (6.4 to 6.9) to alkaline (7.4 to 7.9), respectively.

Delineation of Salt-affected Waterlogged Soils

Along the Indira Gandhi Canal Project, the farmers' adoption of high-water requiring crops with flood irrigation practices are causing waterlogging and secondary salinization in the region. Image interpretation of satellite data showed that about 12% of the total area of a selected zone close to main canal were affected due to surface ponding and 25% was affected by critical (water-table depth<1.5 m) and potential waterlogging (water-table depth> 1.5 m). Further, visual interpretation of the satellite data evidenced by surface salt efflorescence revealed around 11% of the area to be salt affected.

Effect of Flyash on the Yield of Rice-Wheat on a Reclaimed Alkali Soil

Flyash, a by-product of thermal power plants is reported to cause serious environmental hazards due to its inappropriate disposal. The yearly addition of flyash to gypsum amended alkali soils (as a source of silica), did not display any

adverse effect on soil properties and crop yield even up to 50 Mg/ha. Further, the incorporation of flyash to the soil did not show any interaction with fertilizer N and also no significant effects were documented on the release pattern of exchangeable and non-exchangeable K.

Assessment of Land Drainage Problems in Irrigation Command

The precise assessment of soil salinity in large areas in an irrigation command makes it possible to develop appropriate approaches for managing such soils. Such estimates can be made using GIS technique by exploiting variation of reflectance properties of different land uses affected with waterlogging and salinity problems. The variations in reflectance properties of these areas in 3 different bands can be used to derive normalized difference vegetation index (NDVI); the relative difference of which makes it possible to distinguish waterlogging- and salinity-affected area. For the cultivated and drainage-installed fields, the NDVI value was maximum (0.4511) with minimum (–0.0327) for the ponded water and that each land use class can be identified in the irrigation command based upon its NDVI value.

Soil and Crop Improvement under Subsurface Drainage

Subsurface drainage system installed in an area of 1,200 ha under Haryana Operational Pilot Project in 1999, with an average depth of 1.6 m at 60-m drain spacing facilitated the reclamation of waterlogged saline soils, with varied salt removal in space and time. Significant reduction in soil salinity (ECe), SARe and chloride contents in 0–30 cm soil depth was recorded by leaching through subsurface drainage. Soil salinity in the drained area declined by 40% along with 50% reduction in SARe, compared to initial values. Further, leaching through subsurface drainage did not result in any nutrient loss as evidenced by the N, P and K status in drained and undrained areas.

Biological Oxygen Demand Tolerance of Crops

Disposal of urban and agroindustrial effluents into the rivers causes soil and water pollution by increasing their organic load, affecting crop yields when used for irrigation. Distillery effluents having typically high biological oxygen demand (BOD) values were exploited for their irrigation potential. Paddy yield improved by irrigation with waters having BOD up to 500 ppm (increase of 36%) compared to tubewell waters, and declined thereafter.

Research at the CSSRI, Karnal, has shown that sewage water (BOD up to 500 ppm) can be used for growing paddy and other crops

Methods to Improve the Efficiency of Soil Amendments

The adverse effects of long-term use of alkali/sodic water on physical and chemical properties of soils can be mitigated by the use of soil amendments. Crop performance was better with pyrite than gypsum application. Irrigation with neutralized alkali waters by passing over a specially designed amendment bed resulted in significantly higher yield compared to their respective soil applications. Alkali water application (9.1 Mg/ha) neutralized through pyrite bed produced maximum yield of sorghum followed by soil application of pyrite, equivalent to gypsum on sulphur basis, at the rate of 150% of gypsum requirement. Further, the yearly application of gypsum/pyrite to the soil produced significantly higher yields compared to their application after every 3 years.

CSR 30–A New Scented Rice Variety for Sodic Soil

A superfine grain and basmati type rice variety, CSR 30 (IET 14720) has been released by the Central Variety Release Committee for sodic soils (pH 8.8–9.5) of Uttar Pradesh, Punjab and Haryana, with 20% more yield over national check (Taraori Basmati) with comparable quality parameters. It has highly scented, long and slender grains (7.12 mm), good head rice recovery (59%), high-kernel elongation on cooking, intermediate-gelatinizing temperature (GT) and intermediate-amylose

CSR-30, a superfine grain and basmati type rice variety released for sodic soils. It gives 20% more yield over the national check (Taraori Basmati)

content (23%) at par with Taraori Basmati. In the panel test, it was rated as one of the best cultures due to its attractive flakiness, aroma and fine elongation of cooked rice. Under non-stress conditions, it reaches 155–160 cm with moderately strong culm, while it reaches intermediate height (120–125 cm) under sodic stress which prevents its lodging. It is a non-shattering, suitable and scented rice variety for timely sown and irrigated conditions.

Tolerance of Wheat to Saline and Waterlogging Stress

Wheat yields are affected seriously in reclaimed alkali soils by stagnating water due to untimely heavy rains during its growing season as well as by rising water-table in different areas of the country. In a study on tolerance of wheat variety (114 genotypes) to waterlogging (10 days during critical growth stages), revealed that waterlogging up to 10 days at grain-filling stage was the most critical with highest yield reductions. Waterlogging along with alkali stress was more harmful compared to alkali or waterlogging stress alone in wheat (5 days of submergence) at the sowing and emergence stage.

Performance of lal-jhav with saline water irrigation at Bir forest, Hisar

Evaluation of Tree Species Suitable for Highly Calcareous, Saline and Irrigated Soils

For the rehabilitation of calcareous soils, 31 tree species were evaluated at Bir Forest, Hisar. Saline water was applied for initial 3 years followed by saline irrigation for 3 subsequent years during winter only. Ten years of experimentation revealed that lal-jhav (*Tamarix aphylla* syn *T. articulata)*, babul *(Acacia nilotica),* mesquite *(Prosopis chilensis* syn *P. juliflora), Eucalyptus (Eucalyptus umbellata* syn *E. tereticornis), Acacia tortilis*, *Cassia siamea* and elephant apple (*Fironia limonia*) hold promise for plantation with furrow planting method in arid and semi-arid regions.

Mustard-tree forage Grass for Management of Salt-affected Black Soils

Management of highly saline black soils (EC 25–65 dS/m) of Gujarat was achieved by growing mustard-tree (*Salvadora persica*) forage grass based land use system (at a cost of Rs 2,760/ha at 4 m × 4 m spacing) economically. Due to the ability of mustard tree to germinate in saline water, it grows well under highly saline conditions. It produces seeds rich in oil and its multi-potential utilities like environmental-greening make it an ideal species for soil and water management in saline black soils.

Integrated Nutrient and Agronomic Management of Salt-affected Coastal Soils

Integrated nutrient management (application of chemical fertilizers supplemented with organic manure) of rice-based cropping system in salt-affected coastal soils gave significantly higher rice yield than chemical fertilizer alone. Highest rice yield was achieved by the addition of urea (4.2 Mg/ha) supplemented by city compost (1.52% N) in the ratio of 1 : 3 in terms of N equivalence. It was nearly 50% higher over the control (farmer's practice of using 20 kg N/ha) and about 7% higher over full-recommended dose (100 kg N/ha). Application of city compost along with urea improved soil health in terms of highest microbial biomass carbon (260 µg/g) and nitrogen (37 µg/g), dehydrogenase activity (3.5 µg TPF/g) and rate of soil respiration (9.17 µg CO_2/g).

RAINFED RESEARCH

Improved Models of *Tanka*

Tankas are traditional water-harvesting storage systems in desert regions. These are mostly owned and used by individual families. This is a very efficient system

but dogged by the problems of heavy load of sediments. The stored water is mostly used for home and livestock consumption. The Operational Research Project at Mohila village under All India Co-ordinated Research Project for Dryland Agriculture at the CCSHAU, Hisar, has improved the *tankas* in capacity and reduced sediment load. The capacity was increased to 5.6 m deep and 5 m diameter. There was a paved catchment developed with an inward slope towards the central well. There were more than 4 entry points each with its own silt trap and sieve of 2.5 cm diameter. The cost of construction of a *pucca tanka* was Rs 1.5 lakhs. The water is being used for gravitational drip irrigation to a kitchen garden and tree systems like ber (Indian jujube), pomegranate, kala jamun, neem, etc. The rainfed crops of the region like pearlmillet, guar, cowpea, greengram, mustard, barley, chickpea and fodder are also being taken up with a seasonal rainfall of 250–300 mm.

Combined Use of Inorganic and Organic Fertilizer Sources

Under the national network of All India Co-ordinated Research Project for Dryland Agriculture, permanent manurial trials are being conducted with location specific crops. In an attempt to reduce the recommended dose of inorganic fertilizer by substituting 50% of the recommended nitrogen by crop residue, FYM, etc. Application of 50% N (inorganic source) + 50% N (organic source) was found to be at par with recommended dose of fertilizer for *rabi* sorghum (Solapur), pearlmillet (Agra), groundnut (Anantapur), and cotton and greengram (Akola). Significantly higher fingermillet yield was attained at Bangalore with a combination of fertilizer and organics. However, recommended dose of fertilizer was superior for rice at Ranchi.

Common Pool Resources in Semi-arid India Surveyed

A survey was conducted at Hyderabad, to understand the dynamics, management and livelihood contributions of common pool resources (CPRs) in semi-arid India. The survey covered the area from Punjab in the northwest to the southern Tamil Nadu and encompasses over 206 districts. The results revealed that the extent and productivity of CPRs is declining since independence. In the case of village lands, decline is large due to breakdown of traditional management systems which resulted in a shift from common property to open-access regimes, and to some extent privatization and encroachment denying access to the poor. These CPRs are now subject to a series of problems of erosion and land degradation resulting in irreversible damage to the semi-arid ecosystem. Vast parts of the potentially productive CPRs are rendered unproductive or under productive.

Low-tillage and Integrated Nutrient Management Strategies

The highest sorghum grain yield both under conventional and reduced tillage was recorded with 2 tonnes *Gliricidia* loppings + 20 kg N. Application of 4 tonnes FYM + 2 tonnes *Gliricidia* loppings was the next best treatment. The 4-year study concluded that by following low-cost nutrient management strategy, the expenditure on fertilizers could be reduced significantly without concurrent yield loss. However, greengram, 2 tonnes FYM + 10 kg N and 2 tonnes FYM + 1 tonne *Gliricidia* loppings outyielded the control both under conventional and reduced tillage systems, respectively.

Rainwater Management

Conservation furrows across the slope at 3 m interval, as a measure of moisture conservation and runoff management, were evaluated in 10 farmers' fields in 5 villages in the Nalgonda district of Andhra Pradesh. Castor was intercropped with pigeonpea in 5 : 1 ratio. During the growing season, the study area received 429 mm rainfall in 33 rainy days (rainfall 2.5 mm/day). The plots with conservation furrows stored 8–35% additional soil moisture over the control throughout the

- Application of 50% N (inorganic source) + 50% N (organic source) was found to be at par with recommended dose of fertilizer for *rabi* sorghum, pearmillet, groundnut, cotton and greengram.
- Construction of conservation furrows in the fields resulted in higher yield of castor and pigeonpea crops by 16–17% over the control.
- Integrated pest management strategy for castor semilooper was worked out. The efficacy of castor semilooper parasitoid baculovirus alone, or in combination with insecticides was demonstrated in large-scale on-farm trials.
- Prototype-3 of groundnut stripper, power tiller-drawn seed-cum-fertilizer drill-planter and air-assisted tractor-drawn orchard sprayer were developed for dryland crops.

A survey of common pool resources in semi-arid India was conducted to comprehend livelihood output from these. The area and productivity of common pool resources is declining since Independence. The combined effect of cultivation on marginal lands and increase in livestock population has resulted in declined share of wildlife in the common pool resources. Over-exploitation has led to the depletion of vegetation and accelerated runoff.

The highest sorghum and greengram yields were obtained by adopting integrated nutrient management strategy (combined application of FYM, *Gliricidia* loppings and nitrogen) both under conventional and reduced tillage

Environment friendly integrated pest management strategy for castor semilooper was demonstrated on large-scale on-farm trials. It involved the induction of biocontrol agent baculovirus alone, or in conjunction with insecticides. Baculovirus is host specific and locally produced bioagent

growing season. This resulted in better plant growth and higher yields of castor and pigeonpea crops by 16–17% over the control.

Integrated Pest Management

Castor semilooper, *Achaea janata*, is a key pest on castor that causes severe damage to the crop during July–September. In the field, 3 natural parasitoids are active against the pest. Baculovirus of castor semilooper is one such bioagent. During the past efficacy of this virus was confirmed in the laboratory as well as in large-scale on-farm trials. The efficacy of baculovirus alone, or in combination with insecticides, was demonstrated in large-scale on-farm trials through farmers' field schools. Rural youth were also trained on virus-production technology.

Improved Machinery for Dryland Crops

Prototype-3 of groundnut stripper was developed at the CRIDA, Hyderabad. This powerized version's stripping efficiency is maximum at 400 rpm for 1-day-old harvest.

Groundnut stripper was developed at the CRIDA, Hyderabad. Its efficiency is maximum at 400 rpm for 1-day-old harvest

Power tiller-drawn seed-cum-fertilizer drill/planter was engineered for sowing blackgram, greengram, sorghum, groundnut, maize and castor. It has an area coverage of 0.25–0.3 ha/hour

Power tiller-drawn seed-cum-fertilizer drill/planter was developed for sowing blackgram, greengram, sorghum, groundnut, maize and castor. The implement which sows seeds in 4 rows simultaneously, has a field coverage of 0.25–0.3/ha/hour.

An industrial model of air-assisted tractor-drawn orchard sprayer was fabricated, and is now ready for commercialization. This sprayer is significantly superior to the conventional ones and saves time, money and energy.

A SUCCESS STORY

DRUMSTICK PLANTATION

A young farmer Mr Buchi Reddy Janardhan Reddy, Meerkhanpet village, Kandukur Mandal, district Ranga Reddy, is reaping rich benefits by taking up drumstick plantation in his field. He adopted the recommended practices advocated by the KVK in his 0.16 acre land after planting approximately 400-drumstick saplings (cv PKM 1). To effectively utilize the inter-space tomato was taken up as an intercrop in the plantation. A total expenditure of Rs 7,160 was incurred. The gross return from the sale of pods, drumstick seeds and tomato was Rs 17,186 within a span of 6 months (July–December), realizing a net profit of Rs 10,026.

AGROMETEOROLOGY

Agroclimatology

Analysis of monthly rainfall data over eastern dry zone of Karnataka for the period 1972–99 indicated shift in rainfall pattern when the monthly rainfall during 1972–90 were compared with that during 1990–99. A comparison of the data sets indicated that in the recent decade there has been a fall in July and September rains, while an increase is noticed in August and October rainfall. These shifts influenced the sowing and subsequent growth of crops in the region. Similar observations were noticed in the adjoining districts of Anantapur and Bijapur. Based on these rainfall shifts, new cropping strategy has been suggested in the above region to match the change in rainfall pattern.

Climate change at Palampur in Himachal Pradesh has been worked out using the data collected over the period 1945–99. The rainfall pattern indicated a decreasing trend for the months January to March and again for the months of July and October. However, increase in pre-monsoonal rainfall to an extent of 20–80% has been noticed.

Crop-Weather Relationships

Rabi: The radiation-use efficiency (RUE) of 3 wheat cultivars, viz. HD 2285, HUW 234 and HP 1633 sown under 3 dates of sowing at Faizabad in Uttar Pradesh showed that HUW-234 recorded higher RUE values compared to other 2 varieties.

Kharif: The effects of shading on the grain yield of 20-hybrid rice varieties at Dapoli, showed that varieties, Karzat 4, Indrayani, Panvel 2, Palgarh 1 and Palgarh II were shade tolerant and are thus suitable for regions experiencing excessive clouding during the *kharif* crop season.

Analysis of the influence of weather parameters on the grain yield of rice at Kanpur, showed that average RH, mean wind speed, minimum temperature and total rainfall during the crop growing season recorded highest correlations with grain yield. At Faizabad, it was noticed that irrespective of the date of transplantation, if initiation of flowering in the rice crop occurred around 5 September, it led to highest yields across all the cultivars. This suggests that adjustment of sowing/ transplantation date, to match the flowering stage around 5 September, can help achieve higher yields in this region.

Weather Effects on Pests and Diseases

Prediction equations for powdery-mildew disease incidence in ber plantations as well as in grape vines were developed by Bijapur centre. The equations, which predict the disease occurrence two weeks in advance in ber, explains the variability of disease up to 69%. Night time temperatures (minimum) between 13–18°C are responsible for triggering tea mosquito bug population in cashew plantation during flushing and flowering stages. Hence based on minimum temperature distributions in the cashew-growing regions during reproductive phase, the regions prone to infestation of tea mosquito bug have been identified and demarcated. The populations may be moderate to severe across west coast and low to moderate along the east coast and in the hill ranges in southern peninsula. The areas, which are relatively free from the pest, are the tracts along West Bengal and northeastern states due to low temperatures in winter season.

Advance Estimation of Food Grain Production Using Monsoon Rainfall and Southern Oscillation Index

A simple model has been developed by the Co-ordinating Unit of the AICRP on Agrometeorology (AICRPAM) for advance estimation of national food grain production. The model uses rainfall indices based on selected sub-divisional rainfall (with 1% significance correlation with production index) during June to September months, southern oscillation index (SOI) based on winter to spring pressure tendency (March to May – December to February values) and trend value. The model was developed using 40 years national food grain production data (1952–92) and has been validated using the past 8 years actual production.

It can be said that the model could successfully predict the national food grain production within ± 2% (sometimes at zero per cent) except in 1 out of 8 years of testing. The model has predicted the 2001–02 year productivity at 210.9 million tonnes, which is very close to the official estimate of 211.0 million tonnes, provided in June. The significant feature of this model is that it can predict the total (*kharif* and *rabi*) food grain production about 8 months in advance (by October itself).

Weather-based Forewarning Systems for Crop Pests and Diseases

From the historical data collected on the incidence of important crop pests and diseases in respect of 6 major crops, viz. cotton, rice, pigeonpea, groundnut, sugarcane and mustard grown in different agroclimatic regions of the country the corresponding weather data, prediction equations have been developed.

- Analysis of monthly rainfall data over eastern dry zone of Karnataka for the period 1972–99 indicated shift in rainfall pattern. Based on these rainfall shifts, new cropping strategy has been suggested.
- At Dapoli, Karzat 4, Indrayani, Panvel 2, Palgarh I and Palgarh II rice varieties were shade tolerant and are thus suitable for regions experiencing excessive clouding during the *kharif*.
- Predictions equations for powdery-mildew disease in ber and grape were developed.
- The regions prone to infestations of tea mosquito bug have been identified and demarcated.
- A model has been developed for advance estimation of national food grain production.
- Prediction equations of important pests and diseases in crops, viz cotton, rice, pigeonpea, groundnut, sugarcane and mustard have been developed.

- Efficient cropping systems for different agro-ecozones have been identified.
- The total productivity of rice-wheat system was higher (9.3 tonnes/ha) under direct seeded puddled condition rice.
- At Modipuram, a technique for rapid decomposition of rice straw using pre-treatment followed by composting was developed to prepare superior manure.

CROP PRODUCTION

Cropping Systems

Efficient cropping systems for different agro-ecozones have been identified. Under arid ecosystem; at Hisar, cotton-wheat (Rs 69,417/ha) followed by pearlmillet-potato-greengram (Rs 67,027/ha) and at S.K. Nagar, castor-castor-greengram (Rs 80,707/ha) followed by pearlmillet-fennel-cowpea (Rs 74,260/ha) were identified as more remunerative systems. Under semi-arid ecosystem; at Kanpur, maize-potato-sunflower (Rs 58,892/ha) followed by maize-potato-wheat (Rs 81,039/ha), at Bichpuri, dhaincha (green manure)-potato-sunflower (Rs 80,719/ha) followed by pearlmillet-wheat-greengram (Rs 45,822/ha), at Rudrur, soybean-safflower (Rs 43,028/ha), at Junagadh, groundnut-onion-fallow (Rs 136,694/ha) followed by pearlmillet-onion-cowpea (Rs 118,632/ha), at Parbhani, soybean-onion (Rs 116,621/ha) followed by cotton-cotton-groundnut (Rs 55,110/ha) and at Kathalegere, hybrid cotton-hybrid cotton-groundnut (Rs 92,234/ha) followed by hybrid cotton-cotton-sunflower (Rs 81,213/ha) were more remunerative cropping systems. Under sub-humid ecosystem; at Palampur, rice-vegetable pea-potato (Rs 46,676/ha), at Sabour, berseem (F) -maize + cowpea (F) (Rs 141,081/ha) followed by rice-potato-sunflower (Rs 95,651/ha), at Pantnagar, rice-wheat-greengram (Rs 71,892/ha) followed by rice-vegetable-rice (Rs 70,312/ha), at Varanasi, rice-wheat-cowpea (F) (Rs 70,867/ha) followed by rice-potato-greengram (Rs 70,555/ha), at Chiplima, rice-groundnut-sesamum (Rs 53,182/ha) and at Jabalpur soybean-wheat (Rs 47,863/ha) were found more suitable in terms of economic return. Under humid ecosystem; at Jorhat, rice-brinjal (Rs 78,789/ha) and at Kalyani, rice-cabbage-rice (Rs 100,923/ha) were identified more remunerative. Under coastal ecosystem; at Bhubaneswar, rice-maize (cob) -cowpea (Rs 94,891/ha) followed by rice–maize (cob) -greengram (Rs 68,325/ha), at Navsari rice-sorghum (F) -groundnut (Rs 51,940/ha) followed by rice-wheat-greengram (Rs 50,396/ha), at Karjat, rice-maize (F) (Rs 86,171/ha) followed by rice-groundnut (Rs 57,420/ha) and at Thanjavur, rice-rice-pigeonpea (Rs 60,899/ha) followed by rice-rice-sesamum (Rs 54,993/ha) were noted most promising systems.

Direct Seeded Rice in Rice-Wheat System is More Remunerative than Transplanted

Studies conducted at the PDCSR, Modipuram, indicated that various crop establishment methods of rice, viz. direct seeding (dry), direct seeding (puddled) and transplanting produced almost similar grain yield of rice (4.43–4.91 tonnes/ha). Transplanting of rice resulted in significantly lower yield of succeeding wheat (3.5 tonnes/ha) as compared to direct seeded rice with either puddled or unpuddled conditions (4.25–4.72 tonnes/ha). However, the total productivity of rice-wheat system was higher under direct seeded rice with puddled condition (9.3 tonnes/ha) followed by transplanted (9.10 tonnes/ha) and direct seeded dry condition (8.99 tonnes/ha).

Rice-wheat system was more remunerative under direct seeded rice with puddled condition (9.3 tonnes/ha) than transplanted rice (9.10 tonnes/ha)

A New Technique for Rapid Decomposition of Rice Straw Developed

A technique for rapid decomposition of rice straw employing pre-treatment followed by composting for 21 days was developed to prepare quality manure at Modipuram. Rice straw alone, or in combination with pigeonpea hull (4 : 1), was treated with aqeous solution containing 1.25% urea, 1.25% $ZnSO_4$, 0.625% $FeSO_4$ and 0.0625% $CuSO_4$ in the first step for 48 hours for altering the lignocellulosic complex of the rice straw. In the 2nd stage, the treated materials were composted for 21 days. Pre-treatment followed by composting helped in lowering the C : N ratio of the substrate and improving the quality of compost in terms of N, P and K content. The highest response was obtained in the mixture of treated rice straw + pigeonpea hull (4 : 1).

ARID ECOSYSTEM

- The CAZRI, Jodhpur, has developed an upgraded design of *khadin* for different ecological sub-zones of the arid ecosystem.
- Maru Sena 3, a bioformulation of the biocontrol agent *Bacillus firmus* against *Macrophomina phaseolina* developed. *M. phaseolina* causes dry root-rot and charcoal-rot in clusterbeen, cowpea, mothbean, greengram, etc.

Khadin: Novel System for Drought Proofing

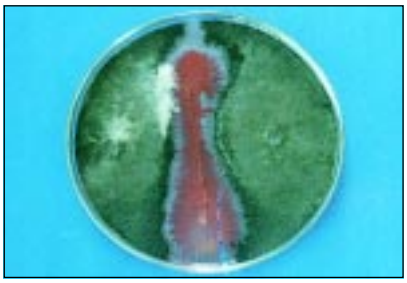
Khadin is an age old unique practice of water harvesting and moisture conservation in arid lands for raising a successful crop, even during drought years. In this system runoff is collected from upland and rocky surfaces in the adjoining valley by enclosing a segment with an earthen bund. The CAZRI, Jodhpur, has developed an improved design of *khadin* for different ecological sub-zones of the arid ecosystem. One such improved *khadin* farm of 6 ha is located in Baorli-Bambore watershed. The effective rainfall during the monsoon of 2002 that contributed runoff to this *khadin* was only 11.6 mm. Nearly 35% (4 mm) runoff from upland catchment was harvested and stored in the *khadin* farm, which enriched the soil profile moisture. The stored moisture was effectively used for raising successful fodder crop of sorghum (CSV 10) during the drought year.

The improved *khadin* at Baorli-Bambore watershed. The entire *khadin* system becomes a self-contained unit for winter cultivation. However, during severe drought years the *khadins* are used for monsoon cultivation also

Sorghum fodder crop grown in the *khadin* during the *kharif.* The stored water was used in growing efficaceous fodder crop during the drought year

Maru Sena 3: A Bioformulation of the Biocontrol Agent *Bacillus firmus* against *Macrophomina phaseolina*

Under the dry and warm growing conditions of arid region, *Macrophomina phaseolina*, a soil pathogen causes dry root-rot or charcoal-rot in clusterbean, cowpea, mothbean, greengram, etc. During the course of developing management strategies, a soil-bacterium, *Bacillus firmus*, inhibiting the growth of *Macrophomina phaseolina*, was isolated from arid soils. After working out the potential value of the biocontrol agent, bioformulation of this strain was developed in an inert material at the CAZRI, Jodhpur.. This bioformulation has been named as Maru Sena 3. One packet of 200 g is sufficient to treat legume seeds for sowing in 0.4-ha land.



Production of inhibition zone and scarlet pigmentation by the biocontrol agent *Bacillus firmus* against *Macrophomina phaseolina,* a causative bacterium of root-rot and charcoal-rot in clusterbean, cowpea, mothbean, greengram, etc. The CAZRI, Jodhpur, has developed a bioformulation of *B. firmus* Maru Sena 3.

WEED MANAGEMENT

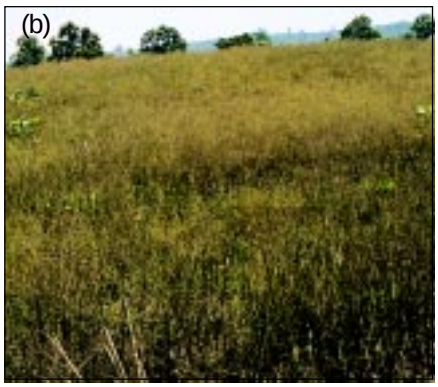
- Management of *Parthenium* weed accomplished through Mexican beetle has been a tremendous success.
- Intercropping of cowpea in maize suppresses weeds and supplements nitrogen.

Management of *Parthenium* through Mexican Beetle (*Zygogramma bicolorata*)

A release of 500 Mexican beetles was made on *Parthenium* weed during the year 2000 in Sonpur village of Jabalpur district. Today vast area (more than 100 hectares) of waste and grazing land in and around Sonpur village is witnessing excellent control of *Parthenium*. A very heavy population of both adults and larvae has completely defoliated the plants along with fruits and flowers. Several releases involving hundred and thousands of beetles have been made in the past both in rural and urban areas.

Intercropping Cowpea in Maize Suppresses Weeds and Supplements Nitrogen

Weeds often invade inter-row spaces in wide spaced crops like maize. The quick growing and rapid canopy forming crops such as cowpea can be successfully intercropped with maize (1 : 1). Experiments conducted at Jabalpur have revealed



A release of Mexican beetles to control *Parthenium* weed was enormous success in Sonpur village of Jabalpur district. Many hectares of land was infested with *Parthenium* (*a*). Defoliated *Parthenium* attacked by Mexican beetles (*b*). Mexican beetle (*c*). Taking advantage of the success, a field day was organized involving the farmers, residents, school children, teachers and Bharat Forest Organization, Jabalpur (NGO), to create awareness about its deleterious effects and management strategy.

Weeds often infest inter-row spaces in wide spaced crops like maize (*top*). Swiftly growing and vigorous canopy forming crops such as cowpea can be intercropped with maize. Cowpea for fodder or green manure suppressed weeds emphatically (*bottom*).

GROWING PROBLEM OF INVASIVE WEEDS IN INDIA

The alien invasive weeds have been a growing problem in Indian agriculture and environment. In north-eastern states, a serious invasion of exotic weed shiah-kanta *(Mimosa himalayana* syn *M. rubicaulis*) has been reported in the world famous Kaziranga National Park, Assam. The weed originally used as a cover crop to prevent soil erosion in tea gardens has escaped into the forest areas. Spread by wind-blown seeds, the profuse growing weed has virtually taken over the entire game sanctuary. The weed, being very competitive has become successful in smothering local vegetation and creating food shortage to the herbivores inhabiting the forest. It may be pointed out here that Kaziranga is the home for endangered single horned rhinoceros which is also a herbivore.

The reports of weed small canary grass (*Phalaris minor*) infestation in wheat in central Gujarat have also been received recently. The infestation is believed to have come through contaminated combine harvesters originating from infested areas of north west India. It is estimated that about 25% species have become invasive in a short period of 50–100 years. Some of these species include, *Lantana* (*Lantana camara* var *aculeata*), sian weed (*Chromolaena odorata), Mikania* (*Mikania micrantha*), *Mimosa* (*Mimosa invisa*), water hyacinth (*Eicchornia crassipes*) and *Parthenium* (*Parthenium hysterophorus*). All of these invaders from the neotropics are rapid colonizers, with high reproductive capacities and dispersal rates. *Lantana* is well adopted to western and eastern Himalayas. Whereas, *Mikania* is distributed in north-eastern hilly region and Western Ghats. The distribution of *C. odorata* is limited to areas receiving a rainfall of 150 cm and above. In hilly range and pasture lands of northern Himalayas, the species like *Ageratum conyzoides, A. houstonianum, L. camara* are shrinking the cultivable and grazing areas to a great extent.

In north-eastern states, a dangerous exotic weed shiah-kanta has spread into the forest of the Kaziranga National Park, Assam. Intially the weed was used as a cover crop to check soil erosion in tea gardens. The weed has stifled local vegetation and created food scarcity to the herbivores in the forest.

that growing cowpea for fodder or green manure suppresses the weeds quite significantly. It reduces the requirement of labour or herbicides at least by half. Further, being a legume crop, cowpea supplements substaintial quantity of nitrogen to maize crop. This technology is considered sustainable and suited to small and marginal farmers who practice subsistence farming.

FARMING SYSTEM RESEARCH

- In Goa, Sahyadri and KRH 2 recorded highest yield of 7.15 tonnes/ha and 6.87 tonnes/ha, respectively as compared to local check varieties Jaya (5.72 tonnes/ha) and Jyothi (4.68 tonnes/ha).
- Economic analysis revealed that integration of rice-brinjal with mushroom and poultry was advantageous with net returns of Rs 77,305/ha.
- Jackfruit bulbs could be stored in sugar solution with potassium meta bisulphate or sodium benzoate for 4 months in polythene bags at room temperature.

Evaluation of Rice-based System in Goa

Among the 8 hybrids of rice evaluated during the *kharif* 2001, Sahyadri recorded the highest yield of 7.15 tonnes/ha and was closely followed by the hybrid KRH 2 which recorded a yield of 6.87 tonnes/ha. Both were significantly superior to the local check varieties Jaya and Jyothi which yielded 5.72 tonnes/ha and 4.68 tonnes/ha, respectively.

In trials under the rice-based farming system, it was observed that rotating groundnut with rice increased the grain yield of subsequent rice crop by over 5 tonnes/ha. Also rice grown under recycled paddy straw with mushroom substrate in 2 : 1 ratio consistently registered higher productivity (4.5 tonnes/ha). Among the different cropping systems tried, rice-brinjal system, registered the best productivity level particularly under recycled FYM. It was also observed that rice-cowpea system was the best option under residual moisture situation. Rice-cowpea rotation resulted in a 78% higher productivity over rice fallow system. Pooled economic analysis revealed that integration of rice-brinjal with mushroom and poultry was economical with the best net returns of Rs 77,305/ha.

Sahyadri—one of the hybrid rice varieties—taken up for large-scale cultivation in Goa

Performance of Plantation Crops

In a high-density cropping model involving coconut (main crop), banana, mango and black pepper, an average yield of 77.86 nuts/palm/year was recorded in coconut (Benaulim). Amrapalli was found to perform well in this high-density cropping model registering an yield of 4.75 kg/plant.

Post-harvest Technology of Fruits

Studies on storage of jackfruit bulbs indicated that the ripe bulbs could be stored in refrigerator for 23 days when packed in polythene bags. Those stored in sugar solution (40° B) with potassium meta bisulphate (250 ppm SO_2) or sodium benzoate (250 ppm) kept well for 4 months in polythene bags at room temperature. Matured, but unripe jackfruit bulbs could be stored for 12 months with their original colour and firm texture in brine solution at room temperature. Carambola (sweet type), squash (48° brix, 0.5% acidity and 250 ppm SO_2) could be stored under ambient as well as refrigerated conditions for more than 12 months. Proximate analysis of nutmeg rind, parts of jackfruit and breadfruit revealed that these fruit wastes are rich sources of fat and fibre and can be incorporated in livestock feeds.

In our extensive agro-ecological regions, most crops display a great deal of diversity. The variability in local brinjal types in Goa is shown here

AGROFORESTRY

Genetic Improvement of Neem

Genetic improvement work in neem *(Azadirachta indica)* was carried out at Jhansi. Two hundred sixty five accessions of neem were collected from 8 states. In provenances trial of 26, provenance Bhopal was identified as an outstanding for growth parameters. In plus tree progenies trial of neem, progenies PT 24 and PT 15 were performing well when compared to check. Ten selections were identified in provenances and plus tree progeny trial based on fast growth and high fruit yield. Out of these, Sel 1, Sel 3, Sel 4 and Sel 5 had more than 0.60% azadirachtin A and 44% oil content in their kernels, while seeds of Jhansi provenance had 0.47% azadirachtin A and 41.0% oil content.

Clonal Propagation of White Silk Cotton Tree

Clonal propagation techniques were standardized for white silk cotton tree *(Ceiba pentandra)* using cuttings, grafting and air layering at Mettupalayam. Maximum

A SUCCESS STORY

USE OF PHEROMONE TRAPS TO MANAGE RED-PALM WEEVIL IN COCONUT

A series of field and laboratory experiments were conducted to assess the impact and refine the existing technology of using food-baited pheromone traps to manage red-palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Cuculinadae) in coconut plantations of Goa. The significant findings of these experiments are presented below.

- A surveillance programme to monitor the activity of the pest with pheromone traps (Ferrolure +) revealed a high incidence of red-palm weevil throughout Goa. On an average 28.15 weevils were captured per trap.
- Red-palm weevil was most active in the State during the month of October, while it was least active during June. A similar trend in its activity was observed during the previous year.
- For mass trapping programmes field testing of various trapping densities revealed that, the recommended trap density of 1 trap/ha can be effectively reduced to 1 trap/3 ha, without impairing weevil captures.
- Trap colour did not significantly influence weevil captures. However, jute sack wrapping on the exterior of bucket traps enhanced weevil captures.
- Weevil captures were not impaired even when the kairomone-releasing food bait (coconut petiole bits) was not replaced in the trap for 1 month. However, water in the trap had to be replenished if traps were not serviced beyond 15 days.
- Vertical preference for trap heights indicated that highest weevil captures (30.4 weevils/trap) were recorded when traps were placed at a height of 1.0 m from the ground.
- Laboratory reared monsoon, winter and summer broods of pheromone trap captured weevils indicated that young, gravid and fertile female weevils were attracted to the pheromone traps. Thus, pheromone trapping of red-palm weevil is beneficial as it suppresses the build-up of red-palm weevil in the field.
- Mass trapping programmes in weevil infested coconut plantations, successfully control the pest with no new reports of fresh infestation.
- Different kairomone-releasing food baits indicated that dates when used in the pheromone traps gave the highest captures (62 weevils/trap), which was at par with sugarcane (49.33) and significantly different from coconut petiole (32.66)
- Oil palm fruit when used in pheromone traps has a repelling effect on red-palm weevil adult.
- The field life of the costly pheromone lure (800 mg Ferrolure +) can be extended for up to 6 months by setting traps under shade to attain slow release of the chemical into the environment.
- The efficiency of the pheromone-trapping system can be maintained with even a low release of 0.13 mg per day. Release of ferrolure + in the field was significantly and negatively correlated (r = -0.59) to rainfall, while it was positively correlated (r = 0.43) to maximum temperature.
- Carbofuran 3G (0.05 %) was found to be most suitable for use in red-palm weevil pheromone traps.
- Field trials revealed that the best weevil captures were obtained when traps were serviced (replacing food bait and insecticidal solution) every 10 days.
- A 2 months field trial during May and June 2002 with a formulation of pheromone lure developed by the CPCRI, Kayangulam, when tested separately with banana and coconut petiole, recorded mean weevil captures of 11.33 and 8.00 weevils/trap, respectively. However, the regular formulation (ferrolure +) with coconut petiole recorded a mean weevil catch of 18.66 weevils/trap.
- Laboratory studies with 6 coconut cultivars, revealed that the coconut cultivar, Malayan Yellow Dwarf was least preferred by the weevil for egg laying.
- Spatial distribution of red-palm weevil in coconut plantation showed that the pest was highly aggregated and followed the negative binomial pattern of distribution. Hence plantations in the vicinity of heavily infested palms are most prone to red-palm weevil attack and need protection from the pest.

As a result of the above findings the use of pheromone trap to manage red-palm weevil in coconut is becoming popular among the farmers in the State and also elsewhere in the country.

Pheromone traps used for capture of red-palm weevil. The food-baited pheromone traps to manage red-palm weevil are appropriate and popular among the farmers

Red-palm weevil adults. A surveillance programme to watch the activity of the pest indicated a higher incidence of red-palm weevil in coconut plantations of Goa

rooting of cuttings was achieved on treating with IBA 3000 ppm. Successful grafts were produced through cleft grafting method, and air layering was successful when air layers were treated with IBA at 3% power formulation.

Vegetative Propagation of Chironjee and Amla

A total of 178 chironjee plants have been established at the IGFARI, Jhansi, in 1 hectare area. Vegetative propagation efforts indicated maximum (40%) success through veneer grafting in August and 20% through chip budding. Vegetative propagation of amla (emblic myrobalan) through cleft grafting was standardized. It was observed that seedlings grown in February–March attained graftable growth by August. August was found to be the best month for grafting giving 85% success. Varietal response to grafting was not significant. Capping of grafts for 21 ± 2 days was instrumental in graft success. The technique was successfully demonstrated in mango and custard apple also.

Teak-based Agroforestry

In teak-based agroforestry system at Dharwad, marketable wood value of teak was significantly higher (Rs 222,520/ha) in 10 m spacing compared to 20 m spacing (Rs 121,760/ha). The teak-based agrisilvicultural system developed at Parbhani, revealed that pigeonpea is the most suitable intercrop up to 5 years, after that yield reduction is more than 50%. After 5 years, turmeric and ginger were economically remunerative crops.

Tree-Crop Interactions

The influence of tree species such as safed siris *(Albizia procera)*, neem *(Azardirachta indica)* and teak *(Tectona grandis)* and tree-management practices (pruned up to 50% height and unpruned) and cropping system (with and without understorey crop) was studied on nutrient recycling, soil properties and productivity of companion crops (blackgram and wheat) at Jhansi. The yield of wheat was affected under the canopy of all the tree species compared to the control; maximum effect being under safed siris. Pruning has positive effect on crop yield and the variation between pruned and unpruned treatment within the species was in the range of 7.8–8.8% only.

In teak-based agrisilviculture system turmeric was economically remunerative intercrop after 5 years. Here 7-year old teak spaced at 5 × 2 m has been shown with turmeric.

- At Jhansi, in neem provenances trial, provenance Bhopal was found outstanding for growth parameters.
- Several contrivances were developed for clonal propagation of white silk cotton tree.
- Vegetative propagation of chironjee and amla was successful.
- In teak-based agroforestry system at Dharwad, market value of teak wood was significantly higher (Rs 222,520/ha) in 10 m spacing compared to 20 m spacing (Rs 121,760/ha).
- The yield of wheat was impaired under the canopy of safed siris, neem and teak compared to the control.

Tree-crop interaction in agroforestry systems was probed. Intercropping of teak with wheat was taken up. The yield of wheat was declined

A SUCCESS STORY

ADOPTION OF AGROFORESTRY

This is a success story of a marginal farmer, Mr Tijju of village Karai, district Jhansi (Uttar Pradesh). He used to cultivate only *kharif* crops before the adoption of agroforestry. He was the target farmer of an extension programme initiated by the NRCAF, Jhansi, in 1993–94. Mr Tijju adopted agrihorticultural system involving growing guava, amla, pomegranate and ber (Indian jujube) with crops namely groundnut, wheat and urdbean in 2.5 acres of land after obtaining training on management of fruit trees. Prior to the adoption of agroforestry, his annual income from agriculture produce was merely Rs 9,400/ha. The annual net income of this farmer in 5th year of agroforestry adoption raised to Rs 21,715/ha. In addition to higher returns, Mr Tijju obtained fuelwood, fodder, fruit and small timber from the same price of land for his domestic consumption. Earlier his wife used to walk 2–3 km in the search of fuelwood for cooking food. His standard of living improved considerably. Mr Tijju became role model for other villagers who are coming forward for the adoption of various agroforestry systems.

Agrihorticulture system associating amla (*left*) and ber (*right*) with wheat

- The genetic diversity in forage crops was enriched by 1,318 accessions of various forage crops.
- Combined use of urea and FYM in 1 : 1 ratio produced maximum biomass yield of sorghum and cowpea.
- The volatilization losses of ammonia could be reduced significantly by combined use of 25% urea-N + 50% FYM-N + biofertilizers.
- Performance of local goat was found better in terms of kidding percentage, birth weight and reproductive problems like still birth under stall feeding than grazing.
- In local goat, the total ingestion time under stall feeding was 55.33 minutes, whereas under grazing it was 55.91 minutes.
- Maximum seed yield was obtained in common sesban with the application of phosphorus.

Soil Respiration under Trees

Soil respiration studies conducted at Jabalpur under different tree species revealed higher respiration values during summer (March–June; mean 6,268 mgCO_2/m/hour) followed by rainy season (July–October; mean 3,590 mgCO_2 m/hour). Lowest CO_2 evolution (mean 3,094 mgCO_2 m/hour) was in winter (November–February). Among different tree species, maximum CO_2 evolution was observed under bamboo (3,345 mg CO_2 m/hour) and lowest under jamun (1,409 mg CO_2 m/hour).

FODDER CROPS AND GRASSLAND MANAGEMENT

Fodder Crop Improvement

The genetic diversity in forage crops was enriched by 1,318 accessions of various forage crops. In lucerne, somatic embryos induced in the cotyledonary callus of 3 genotypes and 6 generated plantlets of LLC 3-34, 1 regenerated plantlet of LLC 3-36 and 1 regenerated plantlet of LLC 3-40 were transferred to the field.

Response of Fodder Crops to S Application

The productivity of napier and seasonal legume-based cropping system increased by 38% for green fodder and 49% for dry matter with added sulphur level of 40 kg S/ha in all the 3 seasons over no sulphur (143.96 tonnes/ha green and 39.26 tonnes/ha dry matter) in soil having low sulphur (8 ppm). Sulphur application in 2 continuous seasons, i.e. in the *kharif* to cowpea and in the *rabi* to berseem was sufficient for napier grown in summer season. Among sulphur source, single superphosphate proved superior to gypsum and elemental sulphur. The quality of napier + seasonal legume mixed fodder improved by increasing crude protein from 13 to 20% with decreasing N/S ratio from 27 to 16 with the application of sulphur.

SUCCESS STORY

COMPLETE FEED BLOCK FOR CATTLE FEEDING

The wheat *bhusa* (40%) was mixed with berseem hay (20%), molasses (20%), concentrate mix (19%) which includes linseed cake and ground barley in a ratio of 1 : 1 and mineral and vitamins (1%) to produce a complete feed block (CFB). The linseed cake was soaked overnight in water. Molasses were heated in an open pan up to a temperature of 70°C to liquidize it and then mixed with remaining ingredients to have proper mixing. These ingredients were thoroughly mixed manually. The added moisture was adjusted at 20% to have proper binding of the material. The mixture was then processed at the IGFARI, Jhansi, in densifying machine hopper to get desired blocks. The complete feed blocks of size 31 × 31 × 50 cm were made weighing 20 kg each, which can be easily handled by a single person. The machine had an output capacity of about 500 kg/hour with an average density of prepared bales as 400.0 kg/m^3. A total of 5 labourers are required for the complete operation. The prepared blocks have 88.31% organic matter, 9.72% crude protein, 44.02% NDF, 31.11% ADF, 12.91% HC, 3.27% lignin and 11.69% ash.

On-farm feeding trial of prepared CFB were conducted in nearby villages of Jhansi to assess the acceptability of the product. Two groups of buffaloes were made, 1 group was fed with CFB and the second with traditional material (wheat *bhusa ad lib* and 2 kg concentrate) as usual. In addition, 5 kg green berseem was also fed to each animal. After 1 month feeding of CFB as adoption period, 7 days digestibility trial was also conducted. Feeding trials indicated that average dry-matter (DM) intake/animal and average and dry-matter intake/100 kg body weight was similar in the group fed with CFB and the traditional feeding system. The dry-matter digestibility and average milk yields were, however, 9.15% and 19% higher in the group fed with CFB. Average milk fat content (8.3%) was similar in both the groups.

Reduction of Volatalization Loss of NH_3 through Combined Use of Inorganic and Organic Manuring

Combined use of urea and FYM in 1 : 1 ratio produced maximum biomass yield (35.4 tonnes/ha green and 8.67 tonnes/ha dry) of sorghum + cowpea. However, it was at par with 100% FYM, 25% urea + 75% FYM and 25% urea + 50% FYM + biofertilizers. The volatilization losses of ammonia could be reduced significantly by combined use of 25% urea – N + 50% FYM-N + biofertilizers. The level of organic carbon, available N and K and microbial biomass carbon improved maximum in case of 100% manuring (FYM).

Plant-Animal Relationship

Performance of local goat was found better in terms of kidding percentage (100 vs 56), birth weight (1.47 vs 1.32 kg), and reproductive problem like stillbirth (nil vs 22.22%) under stall feeding than grazing. Overall total ingestion time per hour under stall feeding was 55.33 minutes, whereas under grazing condition it was 55.91 minutes. Under hot dry environment, supplementation of extra energy (20%) through barley improved feed intake of 18.2% with positive effect on weight gain in crossbred (Jersey × Tharparkar) heifers fed on iso-nitrogenous mixed ration of concentrates and forages.

Phosphorus Application Improves Common Sesban Seed Production

In common sesban *(Sesbania sesban)*, the maximum seed yield (1,112 kg/ha and 1,115 kg/ha) was recorded with the application of 80 kg and 120 kg P_2O_5/ha, respectively. In the lopping management treatments, the highest seed yield (925.5 kg/ha) was obtained without lopping.

Livestock and Poultry Improvement and Management

- Population data of various livestock species are available.
- Kankrej, Ponwar, Gangatiri and Kherigarh cattle were studied.
- Jalauni,Kheri,Mandya,Hassan and Mecheri sheep surveyed in their home tract.
- Higher absorbance of immuno-globulins reduces mortality in calves.
- Insulin-like growth factor binding protein 3 gene studied in cattle.
- Dwarf and naked neck birds superior in antibody titres compared to their crosses.
- Molecular characterization of Indian livestock and poultry breeds is being done.
- DNA repository established for Indian livestock and poultry breeds.

Kankrej are mostly kept by *rabbaries*.Evaluation of bulls through progeny testing is under process.

ANIMAL GENETIC RESOURCES

Livestock Information Management

A database based on the information collected from various sources was developed. Descriptors and questionnaires for collecting information on various breeds of livestock and poultry through field surveys, and a software package for entry and analysis of this data were developed. An information system on Animal Genetic Resources of India (AGRI-IS) containing information on breed habitat, management practices, breed characteristics, farms, literature, photographs, habitat map, etc., was also developed. This system is available on CD medium. A database on district-wise livestock and poultry census from 1961 onwards is also being maintained. This databank was updated with the population data of various livestock species for the year 1997 and now contains data for 14 states and Union Territories. Information on camel breeds of India was added to AGRI-IS.

Software package: A progamme for analysis of sheep data was developed and added to software package for analysis of data collected through survey.

Database development for buffalo genetic resources: Questionnaires for buffalo breeds were developed for various data environments containing the most typical conformation traits under study. Reporting system is being designed.

Characterization and Conservation of Animal Genetic Resources

Kankrej cattle: The Kankrej breed, distributed in 14 districts of Gujarat and Barmer and Jodhpur areas of Rajasthan, has its origin from Kankrej area of Banaskantha district. Kankrej animals are mostly with the *rabbaries*, the semi-nomadic people. Very few animals are in milk at a given period of time. The average lactation milk yield, fat percentage and lactation length were 1,535.8 kg (ranging from 578 to 3,258 kg), 4.3% (ranging from 2.8 to 6.2%) and 302.1 days (ranging from 159 to 369 days), respectively. The coat colours are white, grey and iron grey. Muzzles are grey, white and black. Hoofs are black, grey and white. Hump is large and well developed. Dewlap is medium, thin and pendulous. Face is short. Horns are grey, white or black, long, curved and lyre shaped. Ears are long, large and pendulous. Udder is small and milk veins are not prominent. Gait is *Swai chal*. Temperament is furious. Evaluation of bulls through progeny testing is being undertaken at the DURA, Mehsana. The dam milk yield of bulls put to test ranged from 2,257 to 3,065 kg.

Ponwar cattle: This breed is primarily maintained for draught purpose. Ponwar cattle constitute approximately 30% of the cattle population in its breeding tract—Puranpur block of Pilibhit district. Bullocks are fast and good for agricultural operations. These animals are maintained on grazing in the forest area. Coat colour of the animals is brown or black with white patches in different proportions. Colour of the muzzle, eyelids and hoofs is generally black. Tail switch is white in black animals and black in those having more patches of white. Body is small, compact and non-fleshy. Skin is tight. Face is small and narrow and ears are small. Forehead is slightly concave, narrow and has a white marking. Horns are small to medium and curving inward with pointed tips. Ears are erect sideways and have pointed tips. Dewlap is medium. Hump is small in females and developed in males. Tail is long and reaches below the hock. Cows have small udder and teats. The animals of this breed are aggressive.

Cows produce little milk about 0.5 to 2.5 kg/day for 8 to 10 (average 8.85 ± 0.24) months. Lactation milk yield averaged 458.75 ± 24.02 kg. Age at first calving ranges from 40 to 60 (average 50.8 ± 1.27) months. Intercalving period averaged 12.65 ± 0.27 months and service period varied from 60 to 100 (average 76 ± 2.75) days. Cows remain dry for an average of 114 ± 6.89 days. Bullocks of this breed can easily transport 8 to 10 q of load up to 10 km and can plough one acre of land in a day working for 6 to 8 hr.

Gangatiri cattle: Gangatiri is an important dual purpose cattle breed of Uttar Pradesh. They are mainly found in the *doaba* belt of eastern Uttar Pradesh and adjacent area of Bihar. The breeding tract includes Chandauli, Ghazipur and Ballia districts of Uttar Pradesh and Rohtas, Shahabad and Bhojpur districts of Bihar.The coat colour is white with two variants greyish known as *sokan* and totally white known as *dhawar.* The milk production is 4–6 kg/day and lactation length 150–250 days. The inter calving period varies from 14 months to 2 years.

Kherigarh cattle: The breeding tract of Kherigarh cattle is Nighasan and Palia-Kalan blocks of Lakhimpur Kheri district. Some animals are also available in Ramia Behar block. The herd size of the cattle has dwindled to 20–100 animals from 500 because of shrinkage of the grazing area.Kherigarh cattle are lighter in appearance than Hariana. The bullocks are good for light draught and quick for light transport. They have white and grey coat colour. The horns are lyre shaped, thin, curving outward, upward, tapering and pointed at the tip. The face is small, narrow, flat or dished. The ears are small and horizontal, neck short but strong, hump is well developed in males as compared to females. The dewlap is thin, pendulous, starts below the chin and continues down to the brisket. The muzzle is black, sheath is short and moderately tight, the legs are thin and straight, the hooves are small and black, the tail is long, nearly touching the ground and ending in black switch. Cows are poor milkers producing only 0.5–2 kg of milk for 9–12 months. Several farmers do not milk the cows and milk is suckled by the calves. The age at first calving ranges between 3–4 years. Service period ranges between 3–5 months and calving interval between 13–15 months. Bulls attain maturity between 3–3.5 years and start servicing.

Buffalo milk production in rural areas of Karnataka: At the SRS, NDRI, Bangalore, the first day milk yield and peak yield in the lactation curve were influenced mostly by breed-graded buffalo having 3.85 litres of milk in the first day and 6.54 litres as peak production. The first day yield of local buffalo was 1.3 litres in Kolar and 1.7 litres in Chitradurga, whereas, the peak yield was 2.6 litres in Kolar and 2.8 litres in Chitradurga. The persistency of lactation was low because of poor feeding and adverse environmental factors.

Buffalo populations of Orissa: The conservation efforts are required for Parlakhemundi and Chilika buffaloes because of their dwindling numbers. Survey coupled with special conservation efforts are required for Manda buffaloes as their breeding tract is located in hilly areas of Ganjam and Gajapati districts of Orissa. Jirangi animals are muscular and suitable for draughting but the animals have large-scale admixtures of Parlakhemundi and Manda, hence, it was difficult to locate very distinct animals.

Jalauni sheep: Jalauni sheep are migratory but mainly distributed in Jalaun, Jhansi and Lalitpur districts of Uttar Pradesh, and Tikamgarh and Datia districts of Madhya Pradesh. Average flock size was 37 and ranged from 6 to 81. Generally one adult male is maintained in each flock for breeding purpose. Farmers generally practice docking. Age at first lambing was 1.5–2 years, and on an average 7–9 lambings take place in the lifetime of an ewe. Lambing interval is one year. There was no specific lambing season and lambing takes place throughout the year, however, mostly in October and November. Jalauni sheep are maintained for mutton and wool production. The wool quality is coarse. Shearing is practiced 3-times in a year in October–November, March–April and June–July. Average wool production is 150–200 g/shearing. Males, 9–12 month old, are sold for slaughter with an average body weight of 16–20 kg.

Parlakhemundi buffaloes are to be conserved as their number is decreasing

Jalauni sheep are kept for meat and wool purpose.Lambing takes place throughout the year

Kheri sheep: Their breeding tract is Jodhpur and Nagaur Districts of Rajasthan. The sheep breed is migratory and is maintained both for meat and wool production. The average flock has 1–3 rams and 50–150 females including young ones. The major breeding season (July–September) is followed with major lambing season (December–February), and the minor breeding season (April–May) is followed with minor lambing season (July–September). Age at first lambing raged from 20 to 24 months with a lambing interval of 7–8 months, and lamb production was 8–10 in its lifetime. In males, the age at first mating is 12–18 months. Males are selected on the basis of dam's milk production and physical appraisal; wool weight was given some weightage. The rams are used for a maximum of 2 years and replaced thereafter to avoid inbreeding. Average wool production is about 1.5 kg in 2–3 shearings/annum.

Mandya sheep: Mandya sheep is distributed in Mandya district and bordering area of Mysore district of Karnataka. The breed is also referred as Bannur and Bandur. Bandur sheep, mostly restricted to a part of Malvalli blocks, forms a distinct strain within the Mandya breed characterized by a compact, low set body and typical meaty conformation. The flocks are generally small, mostly with 16 animals. The animals are small, white with light brown face usually extending up to neck; some animals may be completely white. Almost all the animals have wattles. The neck is comparatively short. Bandur animals have compact and low set body, small legs and typical reversed-U shape from the rear. Animals of this strain have typical meaty conformation and are valued for meat quality with intra-muscular fat giving a marbling effect to the mutton. However, the animals of this strain are restricted within a pocket of Malvalli taluka of Mandya district. In the remaining area, the animals are comparatively larger in size and do not possess the typical meaty conformation of Bandur animals. The ears are medium, long and drooping but alert. Average ear length is 13.0 ± 0.08 cm (range: 9–18 cm). Nose line is slightly roman. Both the sexes are polled; males may rarely have scurs or rudimentary/small horns. Tail is short and thin (range: 7–16 cm). Fleece is extremely coarse, open and hairy.

The flocks are generally purebred; males are selected on the basis of size and conformation. In Bandur animals, Roman nose, medium sized head, white patch from poll to neck, long body with medium height, short and strong legs, particularly the hind legs and presence of wallets are the desirable traits for selection of breeding males and females. Typical Bandur ewes are selected and maintained with great

MECHERI SHEEP

Under the Network Project on Animal Genetic Resources, Mecheri sheep was studied. Mecheri is a promising hairy breed, which occupies the first position in population and area of distribution in Tamil Nadu. The breed is mainly distributed in Salem, Erode and Dharmpuri districts of Tamil Nadu. Its approximate population is about 0.58 million. Kongy, Vellar and Vanniyars are the communities responsible for developing this breed. The average flock size of this breed includes about 16.6 breeding ewes, 1.02 breeding rams and 4.12 lambs. The coat colour of this breed is mixture of brown and white. The animals are polled, medium sized with pendulous ears, hairy coat "v" shape thin and short tail.The Mecheri sheep skin is superior for the quality viz., softness, grain tightness, fullness, surface smoothness, uniformity of colour and general appearance. The histology of Mecheri skin has thick stratum corneum, more number of hair follicles in the papillary layer and sebaceous glands in the reticular layer. The population in the present status does not require conservation but genetic improvement for better growth needs to be undertaken.

Adult Mecheri ram

Adult Mecheri ewe

Patti with bamboo sticks

Round enclosures (koodu) for lambs

efforts and care for producing breeding rams; the cost of such ewes and their progeny is comparatively very high. November to December is the main lambing season and August to October the minor. Lambing rate is about 70% with an average lambing interval of 8–12 months. An ewe produces 10–12 lambs in its lifetime. The animals are generally sheared twice a year (January–February and July–August). Average greasy wool production is about 400–450 g/annum in two clips.

Hassan sheep: Hassan sheep breed prevails in Hassan district of Karnataka; the name was derived from the name of its habitat. The flocks are of medium size—average flock size is 34—very small flocks are rare. The animals are small to medium in size. The body colour is white or white with light brown or black spots on head and different parts of the body. Ears are medium long and drooping. Average ear length was 14.1 ± 009 cm (range: 8–17 cm). Females are usually polled; about 30–40% of the males are horned and remaining polled. Tail is short and thin (range: 8–24 cm). Fleece is white, extremely coarse and open; legs and belly are generally devoid of wool. The animals are generally shorn twice a year in October–December and April–June. Average greasy wool production is about 300 g/annum in two clips.

Hassan sheep produces about 300g/annum greasy wool

Biochemical Polymorphism

At the IVRI, Izatnagar, polymorphic studies were conducted on insulin-like growth factor binding protein 3 gene in 138 animals of indian and taurine breeds. Indian cattle (Nimari, Sahiwal and Gir) were homozygous for allele 'A' (genotype AA), while taurine cattle (Holstein-Friesian and Jersey) were heterozygous (genotypes AA, AB, BB) possessing both A and B alleles.

Biochemical markers identification: Biochemical markers associated with growth and production status in buffaloes were identified, and some markers, which are associated with high vs low milk production (nucleic acid metabolites) were established. Genetic contribution was assessed for some biochemical parameters in body fluids (blood Hb, milk proteins etc).

Role of immunoglobulins to enhance survivability in calves: Higher levels of absorbed immunoglobulins within first 16 hr after birth (about 90%) reduced the mortality in calves and resulted in faster growth rate by 20–22% by 2 years of age. Status of immunoglobulin levels at 24 hr post birth could predict the health status of calves. A critical level of these blood proteins, was assessed for the survivability of calves in buffaloes. Supplementation of some fat soluble vitamins enhanced Ig secretion up to 80% in colostrum and 30% in blood of calves.

Immune competence of dwarf and naked neck lines: The use of tropical adaptable major genes like dwarf (dw) in broiler parent line (for efficient egg production) and naked neck (Na) gene (for superior growth, better feed efficiency and tolerance to heat stress) was studied for immunological aspects. The dwarf and naked neck gene lines maintained consistently higher antibody titres, implying superiority of these pure lines over their cross combination. However, the cutaneous basophil hypersensitivity response remained uniform for all the genotypes.

Equines: Haemoglobin polymorphism studies indicated presence of two phenotypes in equine blood. The most common had single band, only two samples exhibited two bands. Albumin exhibited two phenotypes controlled by two co-dominant autosomal alleles. The fast homozygotes were common. No slow homozygote was observed. Five phenotypes controlled by three autosomal alleles were recorded in equine blood transferrin. Two phenotypes were observed for carbonic anhydrase control by two co-dominant autosomal alleles. Horse amylase did not show any genetic variability till now and only single band was observed.

Molecular Characterization

Sahiwal and Hariana cattle: At the NBAGR, Karnal, the number of alleles and allelic frequency at 25 microsatellite loci for Sahiwal and Hariana breeds of cattle were calculated from the silver stained gels. The total number of alleles generated

MILK CASEIN POLYMORPHISM IN INDIAN GOATS

Milk protein polymorphism study, carried out to analyze the genetic variability of milk protein in the Indian goats, revealed variation in electrophoretic pattern mainly in αS1-Cn and αS2-Cn loci between breeds. The frequency of αS1-Cn AA allele (which was directly related to higher casein yield) was 0.89, 0.89, 0.93, 0.78 and 0.85 in Jamunapari, Barbari, Marwari, Sirohi and Jakhrana goats, respectively. The F variant was also observed as homozygous FF in two samples of Jamunapari goats. The most prevalent variant was A type at αS2-Cn locus in these breeds. The αS2-Cn allele was absent in all the breeds, highest frequency was in Jakhrana (0.43) and lowest in Marwari (0.22) goats. A faster migrating variant in ß-Cn locus, observed in Jamunapari goats indicated the existence of an additional ß-Cn allele in the electrophoretic pattern. The distribution frequency of αS1-Cn was higher in all goat breeds except Sirohi. The five Indian goat breeds studied were in H.W. equilibrium at αS1-Cn and ß-LG loci.

GAROLE SHEEP

Molecular genetic characterization of Garole sheep was achieved using 48 unrelated genomic DNA samples and 25 microsatellite markers. Number of alleles at 25 microsatellite loci and genotype of each animal was recorded from air-dried gels. The data thus generated were used to calculate allele frequency; expected, observed heterozygosities and polymorphism information content (PIC) values. The number of alleles varied from 2 to 11. Effective number of alleles ranged from 1.09 to 6.46. Allele frequency distribution at 25 loci ranged from 0.01 to 0.92. Other genetic variability measures calculated on the basis of allele frequency included heterozygosity, PIC for each marker and mean diversity indices for the investigated breed. Expected heterozygosity estimates for different microsatellite loci varied from 0.0 to 0.85, and observed heterozygosity values for different markers ranged from 0.004 to 1.000. PIC varied from 0.08 to 0.84. The average high number of alleles (6.20), observed heterozygosity (0.603) and PIC values (0.63) reflected high level of genetic variability in the Garole breed. Estimated means of Wrights fixation index (Fis-0.228) revealed a low rate of inbreeding.

by 25 microsatellite markers in Sahiwal and Hariana breeds were 151 and 169, respectively. In Sahiwal detected alleles ranged from 3 to 13 with a mean number of 6.04 alleles/microsatellite marker. In Hariana detected alleles ranged from 4 to 15 with a mean number of 6.76 alleles/microsatellite marker. Within breed, diversity for each marker was calculated in terms of heterozygosity and polymorphism information content (PIC) value. The unbiased estimates of expected heterozygosity at different microsatellite loci ranged from 0.200 to 0.877 in Sahiwal and 0.388 to 0.916 in Hariana. The PIC values were 0.186 to 0.861 in Sahiwal and 0.367 to 0.901in Hariana.

Buffalo: The number of alleles and their frequencies at eight microsatellite loci in Murrah, Nili Ravi, Jaffarabadi and Mehsana breeds, were studied. Locus BT13 had maximum (11) alleles and locus B246 minimum (5). The overall average number of alleles at these loci was 8.37 ± 1.76 and overall average number of effective alleles was 4.27 ± 1.72. The overall observed heterozygosity across all loci ranged from 0.491 to 0.891 and expected heterozygosity ranged from 0.470 to 0.870 for the same loci, indicating suitability of these microsatellite loci for genetic diversity study in Indian buffaloes. Overall observed heterozygosity across all four breeds ranged from 0.590 to 0.709 and H_e ranged from 0.657 to 0.690, which indicated random sampling and genetic variation of these populations. Most of the loci studied, were at HWE indicating the loci to be neutral. This is an important criterion for selection of microsatellite locus in biodiversity analysis. However, the locus BT13 showed a significant departure from HWE in all the breeds.

PCR based mtDNA studies: Mitochondrial DNA marker, viz., cytochrome-b (Cyt-b) was analyzed in indigenous buffaloes using PCR based approach. Conserved primers for Cyt-b region were used to amplify corresponding region in buffalo mitochondrial DNA. A panel comprising Murrah, Jaffarabadi, Toda and Mehsana breeds of buffaloes was taken to check for the PCR-amplification of Cyt-b region. Successful amplification was achieved in all the four breeds having similar MW of 380bp. This was further confirmed by amplification of Cyt-b region in cattle, sheep, goats and camels. The PCR products were RE digested and analyzed on agarose and polyacrylamide gels to detect polymorphism. Both *Msp*I and *Sau3A*I patterns revealed similar Cyt-b haplotypes.

Digoxigenin (DIG) based system was used for labeling of microsatellite oligo probes and detection of DNA fingerprint pattern in buffaloes. Genomic DNA from Murrah and Mehsana buffaloes was digested with either *Hinf* I and *Hae*III restriction enzyme and fractionated on 0.7% agarose gels. Southern blotting was carried out by capillary transfer. Oligo microsatellites, viz., $(GTG)_5$ and $(GGAT)_4$ were used to evaluate the best possible enzyme-probe combination for generating informative DNA fingerprint pattern. Evaluation of DNA fingerprints indicated more number of scorable DNA bands with $(GTG)_5$ than $(GGAT)_4$ probe. The *Hinf*I-$(GTG)_5$ probe-enzyme combination was more suitable than *Hae*III-$(GTG)_5$ combination in generating informative DNA fingerprint pattern in indigenous buffaloes.

At the IVRI, Izatnagar, the PCR-RFLP analysis of DRB 3.2 gene of major histocompatibility complex of Murrah buffalo with *Pst*I and *Hae*III, revealed the presence of 284-bp fragment with different restriction patterns demonstrating the polymorphic nature of the gene.

Heritability estimate of growth traits in Muzaffarnagri sheep: At the CIRG, Makhdoom, heritability estimates of body weight of sheep at birth, 3, 6, 9 and 12 months were 0.20 ± 0.07, 0.23 ± 0.07, 0.14 ± 0.06, 0.20 ± 0.07 and 0.34 ± 0.08 respectively. The genetic progress of body weights at birth and 9 months of age were 0.146 ± 0.04 and 1.11 ± 0.50 respectively. The overall replacement rate was 31.13%.

RFLP analysis of κ-casein fragment: The B-variant of κ-casein was favourable for milk quality, as it is associated with highest protein percentage. The genotyping of animals at κ-casein locus may be one of the criteria for selection of dairy animals. Using the primers, K1 and K2 reported for buffalo, amplification of κ-casein fragment was successfully done in cattle, buffalo and sheep. Fragment size observed in cattle,

buffalo and sheep was 379 bp. The RFLP analysis with the restriction enzyme *Hin* fI and *Hind* III revealed that all the buffaloes under investigation were homozygous for most favourable allele "B". The cattle under investigation were heterozygous for this allele, and the sheep had altogether different genotype.

Conservation of Animal Genetic Resources

Nicobari and Aseel breeds of poultry: Nicobari and Aseel breeds of poultry were subjected to microsatellite analysis at the NBAGR, Karnal. Aseel birds were collected at random from its breeding tract—Baster (Chhattisgarh) and Khammam (Andhra Pradesh). Number of alleles ranged from 3 to 11. Microsatellite loci having PIC values higher than 0.5 were considered highly informative. Unbiased heterozygosity ranged from 0.3472 to 0.8373 in Nicobari and 0.0832 to 0.8513 in Aseel. Both populations revealed higher unbiased-heterozygosity and average-heterozygosity. These high heterozygosity values far exceed the values estimated for commercial breeds. High level of heterozygosity in both the populations signifies that (i) there was very little selection in the population with respect to single/multiple traits of economic importance, and (ii) sufficient numbers of alleles representing genetic diversity existed in the populations studied. The values obtained as mean unbiased heterozygosity over all loci were 0.62 and 0.61 and heterozygosity (direct count) were 0.51 and 0.55, respectively, for Nicobari and Aseel birds. All the loci selected were highly polymorphic and suitable for genetic diversity analysis.

A resource population for naked neck gene introgression was developed, and the crossing up to BC1 generation involving two genetic groups (Na. nn and nn. Na) was completed by crossing the F_1 and recipient line in reciprocal way. Two panels of microsatellite markers, i.e., panel I of 11 markers from chromosome 3, and panel II of 10 markers from other chromosomes, were identified. Initially the microsatellite markers from chromosome 3 were used in genotyping. The genetic similarity between grand sire and BC 1 progenies ranged from 0.25 to 0.86. Similarly the estimates of genetic distances ranged from 0.15 to 1.39.

Salient findings of the study on "Evaluation of genetic distances among long-term selected and control lines of WL using DNA methods" were: (i) highly polymorphic bands were observed with most of the primers, and some primers revealed unique line specific bands of different sizes; (ii) BSF estimates were obtained with RAPD-PCR and DFP. DFP with *Hinf* I digest and Jeffreys 33.6 probe revealed marked variability among the lines; DNA fingerprinting revealed similar trends of genetic distances but resolved finer genetic differences more than RAPD-PCR; (iii) biodiversity in chicken could be measured conveniently with simple and rapid method of RAPD-PCR, however, DFP was more cumbersome and expensive.

Identification of molecular markers and marker assisted selection to improve performance in buffaloes: DNA samples (60) were isolated and stored at the recommended status of the quality/quantity basis in the DNA repository. Fingerprinting of DNA is under progress, initializing with the bovine/caprine/ovine RAPD primers/markers to test their suitability for buffalo genome study. Some polymorphic sequences of other species were able to identify the polymorphic sites associated with the variation in performance status in buffaloes.

Molecular genotyping of pure egg lines using ISSR-PCR: The emphasis is on PCR based genotyping of the various pure lines through random primer based multi-locus profiling. Inter simple sequence repeat based polymorphism studies were conducted on poultry using random oligoes of 17 or 18 primers containing dinucleotide repeats as the core units. A set of 30 primers that amplify successfully in the other eukaryotic genome, mostly incorporating "AT", "TA", "CT", "TG" and "CA" repeats incorporating 3' anchors was tried on the above resource population (egger line base). The AT and TA based primers failed to amplify any amplicons, while the $(CT)_n$ primers gave rise to isomorphic amplicons following the ISSR-PCR. Promising results in diversity analysis could be possible by using the primers consisting of AG and TG cores. All the amplified PCR products of ISSR analysis confirmed the expectations and parameters relevant to the distribution of

MOLECULAR CHARACTERIZATION OF INDIAN GOAT BREEDS

At the CIRG, Makhdoom, Kutchi, Jakhrana, Sirohi, Jamunapari, Barbari and Marwari goat breeds were analysed using 15-microsatellite markers. MILST S076 and lysozyme were monomorphic having sizes of 120 bp and 236 bp, respectively, in all the samples. Microsatellite markers BM 4521, IDVGA 7, BM 6526, Oar HH 56 and Oar AE 101 were highly polymorphic loci in Indian goats. Allele frequencies of all the loci were used to generate phylogenic tree to establish the genetic relatedness of the goat breeds. Mitochondrial-HVRI of goat was amplified and sequenced, and analyzed for evolutionary relationship of Indian goats. Comparative genomic approach was successfully adopted by using cattle and sheep microsatellite markers to obtain goat microsatellite markers.

IMPROVEMENT AND *IN-SITU* CONSERVATION OF JAMUNAPARI GOATS IN THEIR HOME TRACT CHAKARNAGAR, ETAWAH

The traditional technical knowledge regarding selection criteria of bucks by farmers was studied and supplemented with scientific methods of selection in field condition. The body weight of male kids at birth, 3, 6 and 9 months of age were 2.60, 14.02, 16.47 and 24.01 kg, respectively. The total average milk yield in field condition was about 1.03 litre/day. The kidding rate was 1.60 with 53.21 and 16.5% in twin and triplet both, respectively. The 90 days milk yield was 100.65 litres. The body weight is showing increasing trend over the years indicating use of superior sire for breeding purpose. The bucks selected from villages were reared in semi-intensive and intensive system of rearing. The goats reared under intensive system attained about 30.05 kg and 47.75 kg at 9 and 12 months of age, whereas, the goats in semi-intensive system attained about 21.46 kg and 25.64 kg at 12 months of age. Reproductive ability and fertility percentage of bucks varied from 66.6 to 100% in natural mating.

microsatellite loci in the chicken genome. The BG region polymorphisms are being studied using the MHC class –IV region probes along with the minisatellite based profiling for the diversity analysis within and across the purebred populations.

At the NRC on Camel, Bikaner, blood samples of 55 unrelated camels of Bikaneri, Jaisalmeri and Kachchhi breeds were collected. Six microsatellite primers were utilized for characterization. The microsatellite analysis of 30 samples of Bikaneri and Jaisalmeri breeds with six primers was completed. All the six microsatellite primers used were polymorphic.

RFLP analysis of MHC-DRB3 fragment: At the NRC on Camel, Bikaner, amplification of MHC-DRB3 locus was successfully attempted in cattle (BoLA), horse (ELA), donkey (ELA), sheep (OLA) and buffalo (BuLA). The fragment size in all species was 308 bp in 1% agarose gel electrophoresis. RFLP analysis was then carried out using the restriction enzymes *Hin*fI, *Hae*III and *Rsa*I.

Indigenous pigs: Blood samples (50; 25 samples per population) were collected from genetically unrelated local pigs from Haryana (North Indian type) and Assam (North-Eastern type). Allele frequencies for the 23 microsatellite loci in each population were calculated by allele counting. All alleles ranged between 4 and 12 with generally little difference between the breeds. The effective number of alleles ranged from 2.8 to 7.9 in NR and from 2.5 to 8.7 in NE. The mean effective number of alleles for all 23 loci was 5.0 in NR and 5.3 in NE. These numbers are also reflected in mean observed heterozygosity of 0.71 ± 0.14 and 0.68 ± 0.12 in NR and NE, respectively.

The mean effective number of alleles and the mean observed heterozygosity is quite similar in both the pig types. The heterozygosity values in Indian pig populations, however, were a little higher compared to that of European breeds. It is likely that the Indian pig types studied are represented by large effective population in comparison to European pig breeds which are well defined, purebred stock, and are represented by smaller population. Nei's original measure of genetic distance and Nei's unbiased measure of genetic distance between these two populations were 0.196 and 0.160, respectively. These data suggested that the two populations

ANIMAL GENETIC RESOURCE DIVERSITY (MISSION MODE)

The DNA repository was established for the following breed/species:

Garole sheep	56	Pugal sheep	34
Bengal goat	48	Jaisalmeri camel	55
Aseel poultry	38	Nicobari	36
Miri poultry	20	Bhadawari buffalo	52
Tarai buffalo	60	Kashmir Favorolla	45

- 26 micro satellite loci were analyzed in four poultry breeds (Aseel, Nicobari, Kashmir Favorolla and Miri). The polymorphic information content was very high for all the loci in all the four breeds. The four breeds have shown deviation from the Hardy-Weinberg Proportions in most of the microsatellite loci.
- The genetic distances calculated revealed separate clusters using method of allele sharing for all the four breeds/sub-populations.
- Dendogram analysis revealed that Nicobari and Aseel breeds are more closer to one another than Kashmir Favorolla and Miri. The dendograms, topology and phylogenetic tree were constructed using various methods.
- Heterologus microsatellite were studied in goat, buffalo and camel breeds and were utilized for biodiversity analysis. PIC values, heterozygosity values were also calculated for goat and buffalo breeds.
- Breed descriptors were developed for Tarai and Bhadawari buffaloes, Chegu goat and Nicobari poultry.
- Survey of Bengal goat, Pugal and Garole sheep, Miri and Kashmir Favorolla breeds of poultry was completed.
- General awareness about the indigenous breeds of livestock and poultry was generated among the farmers/breeders.

are very closely related indicating that domestic Indian pigs have evolved from the same parent stock.

Conservation and utilization of indigenous fowl: Aseel (Peela and Kagar) and Kadaknath fowls are being maintained in pure form. Third generation of grading up of Naked-Neck and Frizzle population with WL showed significant improvement in the part time egg production. Identification of genes like Silky, Bantam, V-shaped comb and Duplex comb in *desi* fowl for creation of gene pools of major genes and their introgression was taken up as the major challenge in this area. Characterization of Kashmir Commercial layer chicken was also undertaken for cytogenetic profiles, biochemical analysis and molecular genetic studies.

ANIMAL BREEDING

CATTLE

Analysis of data of IVRI dairy herd for the years 1970–1999 indicated that the effect of generation was significant for production, reproduction and production efficiency traits of cows belonging to FH, FBH, BFH, JFH genetic grades. The performance of cows of F_2 and F_3 generations in all the genetic groups improved compared to F_1.

- Production, reproduction and production efficiency traits improved with generations.
- Season affected milk yield in Frieswal cattle.
- Indigenous bulls are being selected by progeny testing at organized farms.

Frieswal

The present cattle population consists of 21,369 females including 14,290 Frieswal and 7,079 other crosses located at 43 Military Farms under this project. At present 837 elite cows are available at different Military Farms out of which 604 are Frieswal, and 233 are 3/8 and other of lower crosses.

Lactation yield, 300 days milk yield, lactation length and peak yield of Frieswal cows were 3,146.12 ± 79.42 kg, 3,011.31 ± 73.66 kg, 317.67 ± 9.15 days and 14.53 ± 0l.36 kg, respectively. The average age and weight at first calving, dry period, service period and calving interval of Frieswal cows were 987.71 ± 10.59 days and 360.15 ± 4.24 kg, 110.73 ± 11.23 days, 179.36 ± 13.80 days and 426.86 ± 13.97 days, respectively. The overall age and body weight of Frieswal bulls at first semen donation were 628.9 ± 26 days and 399.3 ± 8.13 kg, respectively. Year and seasons significantly affected the milk production performance of Frieswal cows. The wet and herd averages (kg) of Frieswal cows during summer, rainy season and winter were 10.08 ± 0.04 and 7.39 ± 0.03, 8.53 ± 0.04 and 6.18 ± 0.04, and 9.53 ± 0.03 and 6.99 ± 0.03, respectively. Hot humid weather conditions adversely affected the production performance of Frieswal cows. The reduction in wet and herd averages from March (highest average yield) to October (lowest average yield) was 23.39 and 26.67%, respectively. Nearly 630,000 doses are presently available for future use, and 36 bulls are under collection semen in the project.

Indigenous Breeds

Indigenous cattle breeds, viz. Hariana, Ongole, Gir and Tharparkar are being covered under Indigenous Breeds Project .

Hariana: At the CCS HAU,Hisar, the breeding population consisted of 782 females, 6 breeding bulls and 37 young bulls (above 2 years). Overall conception rate in heifers and cows was 46.7% and 50.6%, respectively. In total 1,124 (348+213+238+261+64) daughters have so far been produced due to 5 sets, respectively. On closing date 36,531 doses of frozen semen of test bulls were available. Average age at first calving, first lactation milk yield and peak yield was 51.87 months, 866 kg and 4.415 kg, respectively. First dry period, service period and calving interval averaged 269, 207 and 497 days, respectively.

Ongole: At the ANGRAU, Lam, female herd strength was 1,118, the breeding population consisted of 692 females, 11 breeding bulls and 11 young bulls (above 2

Best indigenous bull from Karnataka

years). Overall conception rate in heifers was 41.7% and in cows 55.4%. In test matings 33 bulls have so far been used in 4 sets (8+8+8+9). The balance of semen doses available on closing date at Germplasm Unit was 12,810, 12,355, 29,010 and 18,595 (total 72,770) from first, second, third and fourth set of bulls, respectively.Average age at first calving, first lactation milk yield and peak yield were 51.15 months, 588 kg and 3.77 kg, respectively. First dry period, service period and calving interval averaged 331, 240 and 544 days, respectively. Based on the daughters' first lactation yield, two sets, which comprised 8 bulls in each set, were evaluated and ranked. Top two bulls from first set were L–15 (sire index = 583) and L–10 (sire index = 579), and from second set L–12 (sire index = 517) and L–35 (sire index = 503).Draught power studies revealed that power varied from 0.64 to 1.13 HP among the bulls.

Gir: At the GAU, Junagadh, the germplasm herd reported 87 calvings out of which 11 were from the heifers. Age at first calving of these heifers was 53.0 months.Mean lactation yield, lactation length, dry period, service period and calving interval were 2,100 litres, 338 days, 133 days, 184 days and 457 days, respectively.

Field Progeny Testing

Under the Frieswal Project and other Holstein–Friesian crossbred bulls are being progeny tested under field conditions at the PAU Ludhiana, KAU Mannuthy, and BAIF, Uruli-kanchan.At the PAU, Ludhiana, inseminations were done from bulls of third set (746 inseminations) and fourth set (4,084 inseminations) of the Network programme. The production performance of the first set of bulls showed that the daughters of bull No. WAM 303 recorded highest average milk production of 3,208.1 ± 405.7 kg (first lactation 305 days), and daughters of bull No. DON recorded the minimum (2,030.7 ± 300.3 kg) indicating considerable variation in their breeding values–the age at first calving was 34.7 ± 0.03 months, and the fat percentage at second, fifth and eighth month of lactation was 3.4 ± 0.03, 3.8 ± 0.03 and 4.2 ± 0.03, respectively.

At the BAIF, Uruli-kanchan the average milk production of 8,076 daughters of 19 bulls was 2,969.8 ± 9.99 kg, ranging from 1,892.32 kg for the daughters of Tony bull to 3,753.35 kg for the daughters of Nabha bull. Out of 17,239 inseminations followed for pregnancies, 7,673 pregnancies were confirmed and the conception rate was 44.51%.

At the KAU, Mannuthy, the overall average first lactation milk yield of the daughters of tested bulls was 2,056.7 litres as compared to their dams yield of 1,764.1 litres in different parities. The average age at first calving of the daughters was 34.5 months. The overall averages of fat percentage were 3.51 and 4.27 in the morning and evening milk samples, respectively, at second month, 3.87 and 4.47 at the fifth month, and 4.06 and 4.68 at the eighth month of lactation, showing that fat percentage increased with the stage of lactation.

MULTIPLICATION OF ELITE GERMPLASM

The technique of IVF was assessed for its practicability in buffaloes, and the different steps were standardized using slaughterhouse oocytes. Available knowledge and practical techniques were made available to concerned scientists and teachers through ICAR sponsored Summer School entitled — Application of cryopreservation of germplasm for improving productivity of dairy buffaloes.

BUFFALO

Evaluation of Bulls under Progeny Testing

On basis of the data on 305 days milk yield of daughters, received from various centres, bull number 392 and 896 of the CIRB were ranked as first and third. Superiority over contemporary daughters for the two bulls was 22.8 and 5.5% respectively. The semen of these bulls is being used for nominated matings on the elite animals.

Network Project on Buffalo Improvement

The test mating from sixth set resulted in 413 inseminations, out of which 165 pregnancies were obtained. Seventh set started from July 2002.

SHEEP

Carpet Wool

Avikalin: The strain has the potential to be developed as dual-type sheep for carpet wool and mutton production. Annual tupping and lambing per cent on ewes' available basis were 84.79 and 87.88% respectively. Least squares means of body weight at birth, 3,6 and 12 month were 2.88, 11.20, 16.53 and 24.72 kg.

Magra: Magra, an important breed of arid area produces the best carpet wool of unique luster. The birth, 3, 6, 9 and 12 months weight were 2.79, 12.98, 20.06, 21.30 and 24.43 kg, respectively. The tupping, lambing on available and lambing on bred basis were 84.3, 74.5, 88.4%. The adult spring, autumn and annual and lambs first and second clip greasy fleece weight were 0.907, 0.791,1.779 and 0.757 and 0.517 kg respectively. The adult spring clip was 1.021 kg. The overall least squares for fibre diameter, hetro fibre, medullation, staple length and crimp were 33.07µ, 37.08%, 50.15%, 5.32 cm and 0.77/cm, respectively. The survivability was 94.5%.

Marwari: The Marwari breed, important sheep population of Rajasthan, was improved for carpet wool production through selection. At birth, 3, 6, 9 and 12 month weights were 3.00, 12.17, 16.72, 20.86 and 23.29 kg respectively. The overall tupping and lambing on available and bred basis were 88.4, 80.9 and 91.5%. The least squares means of fibre diameter, hetro fibres, hairy fibres, medullation, staple length and crimp were 31.15µ, 34.72%, 20.48%, 56.59%, 3.69 cm and 0.57/cm. The overall survivability was 96.3%.

Fine Wool

Gaddi synthetic: The flocks maintained at the CSWRI, Garsa Station, showed the pooled birth weight as 2.685 kg. The tupping percentage on ewes available basis in spring and autumn was 16.6 and 100 respectively. The overall conception rate on the basis of ewes tupped was 81.92%. The lambing during autumn and spring on ewes tupped basis was nil and 71.08. The adult GFY of males and females were 0.846 kg and 0.582 kg, respectively, during spring whereas in autumn, GFY in males and females were 0.957 kg and 0.721 kg respectively. The pooled GFY was 0.771 kg. The 6 monthly wool yield was 0.462 kg. Staple length was 2.75 cm, diameter 20.14µ and medullation 1.5%. The preweaning survivability was 54.23%.

Chokla: At the CSWRI, Avikanagar, average annual wool yield was about 2 kg. Average body weight at birth, 6 and 12 months of age were 2.72, 16.76 and 23.52

Marwari sheep, was developed as a carpet wool breed through selection

- Twin lambing in Garole × Malpura strain improved to 52%.
- Milk yield and body weight at marketable age of Jamunapari, Barbari and Sirohi goats improved.
- Rabbits weaned at 28 days of age showed highest daily weight gain.
- Strain cross developed at CARI produced 301.8 eggs, 3-times higher than commercial strains.
- Feed requirement in layer birds reduced by 174 g to produce one dozen eggs.
- Synthetic broilers attained 944 g at five weeks of age.
- Caribro-Dhanraj weighed 1,595 g at 7 weeks of age.
- Poultry germplasm adapted well in different agro climatic conditions.
- Phenotypic and genetic responses for economic traits in quails studied.
- Turkey birds performed well in huts.
- Breed affected the growth in camels.
- Calving was highest in Kachchhi camel.

Elite sheep flock

Garale × Malpura ewe with triplet

kg respectively. Overall survivability of the block was 93%. Annual lambing (based on ewe available) was 93%.

Mutton Production

Malpura: Overall means for birth, 3, 6 and 12 month body weight were 2.92, 12.51, 20.18 and 29.28 kg in Malpura. The twin lambing in Garole × Malpura ewes was 52%, and it was 19% higher compared to previous year.The Malpura ewes gave birth to mostly single lambs except 4% twin lambing. Survivability in Garole × Malpura genetic group was almost at par with that of Malpura.

Network Project on Sheep Improvement

Improvement in fleece weight and body growth in Muzaffarnagri sheep: At the CIRG, Makhdoom, the Muzaffarnagri sheep was improved for faster growth and high feed conversion efficiency. It is one of the best mutton breeds in India and is widely distributed in the semi-arid region of western Uttar Pradesh, Uttaranchal, and in some parts of Delhi and Haryana.

Selection of males was done on the basis of 6-months body weight and first clip greasy fleece weight. Under semi-intensive feeding system the average body weights of animals, maintained at birth, 3, 6 and 9 months body weight were 2.99 ± 0.05, 14.65 ± 0.32, 22.95 ± 0.66, 25.65 ± 0.66 and 29.57 ± 0.91 kg, respectively. The average daily weight gains of animals were 385.55 ± 9.54 and 52.09 ± 1.71 g at pre- and post-weaning ages. The least-squares means of greasy fleece yield at first clip (6 month) and second clip (12 month) were 423.98 ± 8.01 and 494.75 ± 10.96 g. The adult annual wool yield was 1,248.15 ± 32.10 g. Animals under intensive system of management weighed 14.17 ± 0.43 and 23.84 ± 0.98 kg at 3-month and 6-month of age, respectively. The average first clip wool yield was 475.51 ± 60.61 g and feed conversion efficiency (FCE) 12.16 ± 0.69%.

Animals under intensive feeding management had higher 6-month body weight than animals reared under semi-intensive system, which indicated the exploitation of potentiality of these animals under optimum (*ad lib.*) feeding system. The tupping per cent was 95.16%, whereas lambing per cent on the basis of ewes available and ewes tupped was 93.00 and 95.60% respectively.

BHARAT MERINO

At the CSWRI, Avikanagar, genetic improvement process was continued by selection of ram lambs for future breeding on the basis of selection index developed by incorporating first 6-month wool yield and 6-month body weight. The average body weight at birth, 3, 6, 12 month were 3.13,13.12, 22.00 and 31.64 kg respectively. The strain has the potential to be developed as dual-type sheep for fine wool and mutton production. At the elite flock maintained at the SRRC, Mannavanur, mean body weight at birth,3, 6 and 12 month was 4.209,20.69, 25.5 and 38.22 kg respectively. Survivability was 100%, and lambing per cent based on ewes allowed and ewes bred were 82.6 and 88.8% respectively.

GOAT

Sirohi performance improved after selection

AICRP on Goat Improvement

The goat improvement programme is being carried out with farm and field-based programmes. In farm based programme production performance of Jamunapari, Barbari at the CIRG, Makhdoom, and Sirohi at the CSWRI, Avikanagar, was improved by selection. The major emphasis was to improve milk production and body weight at marketable age of Jamunapari and Barbari goats through use of selected bucks. The bucks were selected on the index basis combining 9/12-month body weight of the buck and 90 days milk yield of their dams.

Jamunapari: The production performance of the nucleus flock was improved through selective breeding in the nucleus flock based on selection index. The genetic potential of Jamunapari goat in intensive system of management was 26.9 kg and 34.10 kg at 9 months and 12 months of age, respectively. The body weight gain in intensive system of management was 86.07 ± 4.54 g/day during 6–9 months of age followed by 79.70 ± 3.27 g/day during 9–12 months of age. The milk yield was 68.72 ± 0.95 kg and 95.86 ± 1.39 kg at 90 days and 140 days, respectively. The milk yield was 22.76 and 22.26% higher over the previous year. The average kidding rate in Jamunapari goats was about 1.30. The population growth during the year was about 45.64% and overall mortality 10.42%.

Barbari goats: The breed is best known for meat and milk as well as its adaptability over wide range agroclimatic conditions. The kidding rate of Barbari goat was about 1.5, indicative of high reproductive potential of the breed. The present milk yield at 140 days was 93.79 litres. The Barbari goat has shown impressive population growth of about 145% during 2001–02. The first kid was obtained at 377 days indicating the potential of Barbari goat as a successful commercial breed. The flock mortality was 8.46% during the year.

PIG

Under the All India Coordinated Research Project on Pigs, 50–80% crossbred F_1 progenies were produced at all the Centres. Energy-protein ratio for optimum production is being worked out.

RABBIT

Rabbit for Wool

Kit survivability in German Angora was 97.45% and British Angora 90.90% respectively. Average litter size at birth (LSB) and litter size at weaning (LSW) were 5.39 and 5.25 in German Angora, and 6.60 and 6.00 in British Angora, respectively. Average LSB of GA and BA were 249.70 and 333.0 g while pooled weaning weights (42 days) were 560.74 g and 630.83 g respectively.

Rabbit for Meat

In broiler rabbits maintained at the CSWRI, Avikanagar, the overall means of LSB litter weight at birth, LSW, litter weight at weaning and weight at kindling were 5.45, 268.95 g, 4.80, 1,894.44 g and 3.16 kg respectively. The body weight at 4, 6, 8, 12 and 24 weeks were 390.07, 604.25, 808.55, 1,179.83 and 2,041.45 g respectively.

At the NTRS, Garsa, the LSB were 6.23, 5.41, 5.26 and 5.0 in GG, WG, SC and NZW, respectively, and LSW were 5.3, 4.66, 4.29 and 5.00 respectively. The body weight at 84 days was 1.75, 1.7, 1.48 and 1.35 kg in NZW, WG, SC and GG respectively. Daily weight gain was highest in rabbits weaned at 28 days as compared to the animals weaned at 35 and 42 days. The kits survivability ranged from 81 to

100%. The rabbits reared during winter performed better than those reared during summer and rainy season.

At the SRRC, Mannavanur, 883 kits were produced. Overall kit mortality was 24.7%. Mean weight at 6 weeks was 0.728 and 0.764 kg in WG and SC, respectively. Weight at 12 week was 1.525 and 1.507 kg in WG and SC, respectively. LSB, LSW, LWB and LWW were 6.8 and 6.5, 403 g and 375.8 g; 6.0 and 5.1 and 4.337 kg and 3.898 kg for WG and SC, respectively.

POULTRY

Poultry for Egg

Parents of White Leghorn cross

Comparative performance of White Leghorn pure strains: At the CARI, Izatnagar, various strains of White Leghorn population completed part record egg production up to 40th week of age after S25 generation of selection. Their pullets matured between the average age range of 134 and 145 days compared to 164 days of age in the control line. In WL strains early egg weight at 28th week of age ranged from 46 to 49.60 g and at 40th week 53.50 to 57 g, while in the control population 60.87 g. The egg production ranged from 96.74 to 104 eggs up to 40th week of age in WL selected strains, and 75 eggs in the control population. The genetic changes in ASM and 40th week egg weight were highly significant and negative in direction. The ASM declined to the tune of –0.46 to –1.04 days, whereas, egg weight declined from – 0.10 to – 0.21 g per generation. The genetic response in 40-week egg production ranged from 0.99 to 1.52 eggs/generation. The regression coefficients for various important economical traits in the control population were nonsignificant indicating its stability in eliminating the environmental trend.

Evaluation of strain/breed crosses for egg production: Among 2-way, strain and breed crosses JG strain cross produced the highest number of eggs followed by JR, HR, HI, RH and CD in order of merit. The JG strain cross pullets also matured with the lowest age at sexual maturity of 129.41 days.

Comparative performance of Rhode Island Red pure strains: The RIR selected line revealed superior economic traits compared to the control population. Average genetic response per generation for egg number and egg mass up to 40th week of age and 40th week egg weight were highly significant and positive. The corresponding estimates for the above traits on genetic scale were 1.21 eggs, 76.77 g and 0.12 g, respectively.

The poultry for egg component of the AICRP on Poultry Improvement, has egg-strains, IWD and IWF at ANGRAU, Hyderabad; IWN and IWP at KAU, Mannuthy and GAU, Anand, besides IWG, IWH, IWI and IWJ at the CARI, Izatnagar. The response of selection for enhanced period of 64 weeks showed an increase in egg number by 10 to 12 eggs in IWD and IWF strains over controls at the ANGRAU centre. The realized genetic gain in egg production was 1.25, 0.99 1.52 and 1.18 eggs up to 40 weeks of age per generation in IWH, IWI, IWG and IWJ, respectively. This gain was statistically significant. The egg weight at 28 and 40 weeks of age was, respectively, 50.47 g and 54.04 g for IWN, and 50.2 and 54.1 g for IWP. On selection of the same strains for feed efficiency at the GAU, the average feed consumption/day was 109 g and 106 g for IWN and IWP, respectively, up to 40 weeks of age. A significant decline in feed requirement of 500 g in IWN and 400 g in IWP lines to produce 1 kg egg mass was noticed in this generation.

A strain cross developed at the CARI, Izatnagar, produced 301.8 eggs, which was higher than three prominent commercials, in 31st RSPPT, Bangalore. The feed intake (117 g/day), feed efficiency (1.77 kg/dozen eggs) and margin of receipts (Rs 58.29) over feed cost were markedly better over commercials. Another cross from the KAU recorded 282 eggs in the same test with a margin receipt of Rs 40.14 over feed cost.

Selection for efficiency of feed utilization in egg type chicken: IWK was evaluated for feed efficiency. The pullets of selected line matured 9 days earlier compared to

IMPROVEMENT OF LAYER POPULATIONS

At the PDP, Hyderabad, pure lines IWH and IWI are being maintained under this programme. In S3 generation the selected lines matured 4–14 days earlier, and produced 15–21 eggs more than the control. The body weight declined by 110–140 g at 40 weeks of age in these lines. The egg weights were 44.69 g and 45.26 g; 49.38 g and 49.89 g for 28 and 40 weeks of age, respectively, for both the lines. The frequency distribution of egg production up to 40 weeks of age indicated that 62 to 73% of birds laid more than 100 eggs as compared to only 32% in control birds, indicating the efficiency of selection method used. The heritability estimates of age at sexual maturity, body weight at 18 and 40 weeks of age, egg weight at 28 and 40 weeks of age and egg production up to 40 weeks of age were low to moderate in magnitude, with the evidence of dominance and or maternal effect in inheritance of body weight at 18 and 40 weeks of age in IWH line and all the traits in IWI line.

the control. The residual feed consumption per day, a multiple regression of egg mass production, weight gain and metabolic body size was 2.36 g in IWK and 1.72 g in control. Heritability of egg production and feed efficiency was low. Genetic correlations of part period egg production with feed efficiency traits in IWK line were in general negative, indicating that any attempt to improve feed efficiency will result in improvement of egg production efficiency. The average feed consumed per day, feed per dozen egg, and feed per kg egg mass production during 21–40 weeks of age were 88.2 g and 95.4 g; 1,382 g and 1,556 g and 2,332 g and 2,974 g in IWK and control lines respectively. The feed consumption was reduced by 7 g in selected lines and the feed requirement was less by 174 g to produce a dozen eggs or 642 g less to produce 1 kg egg mass.

Evaluation of strain crosses of layers: Two- and three-way crosses were generated utilizing the available pure lines. HI combination was better for production up to 40 weeks of age. The reciprocal crosses differed in degree of manifestation of heterosis suggesting influence of both maternal and sex-linked effects. Three-way crosses almost performed equally till 40 weeks of age and the egg weight recorded at 28 and 40 weeks of age was around 1 g and 1.5 g more, respectively, in KIH cross combination.

Analysis of a resource egg type population for quantitative, immunogenic and molecular profiling: Three sub populations were produced with inbreeding infused in FS and HS groups @ 0.25 and 0.13 per generation, respectively, apart from the usual non-inbred group. As envisaged, these constituted the genotypic groups with varying degree of homogeneity, moving towards establishing near-congenic layer populations for the B-haplotyping studies.

Poultry for Meat

The synthetic broiler dam line (SDL) at the CARI, Izatnagar, has undergone 12 generations of selection. The fertility was 81.2% and hatchability per cent of TES and FES were 65.3 and 80.5%, respectively. The mean body weights at 4, 5, 6, 20 and 24 weeks of age were 880.3 ± 2.5, 1048.74 ± 3.70, 1341.80 ± 27.88, 2875.93 ± 11.42 and 2876 ± 11.9 g, respectively. The heritability estimates for body weights at 4 and 5 weeks were 0.194 ± 0.046 and 0.12 ± 0.032, respectively. The genetic correlation between body weights at 4 and 5 weeks was 0.850 ± 0.029 and phenotypic correlation 0.824. The phenotypic correlation between 4 and 20 weeks body weights was 0.125 and between 5 and 20 weeks 0.098.

The selection and breeding programme for development of specialized broiler male lines with white and coloured plumage continued in Coloured Synthetic Male Line (CSML), Coloured Synthetic Female Line (CSFL) and Synthetic Broiler male line (SML-2). The SML-2 line had two sub lines growth line (SG), selection was based on 6 week body weight, and index line (SF), selection criterion was 4–6 weeks feed efficiency (FE). So far, CSML and CSFL have reached seventh generation and SML-2 line has reached 11th generation of selection. Average body weight at 3 and 5 weeks in CSML were 504.04 ± 2.83 and 944.53 ± 4.69 g, respectively. The corresponding means in CSFL were 510.29 ± 2.02 and 928.74 ± 3.53 g. The average body weight of male, female and combined progeny in growth line (SG) were 551, 441 and 476 g at 3 weeks; 938, 746 and 812 g at 4 weeks; 1,210, 992 and 1,101 g at 5 weeks; 1,576, 1,356 and 1,466 g at 6 weeks; and 1,860, 1,682 and 1,770 g at 7 weeks of age. The corresponding body weights in index line (SF) were 465, 425 and 445 g at 3 weeks; 736, 686 and 711 g at 4 weeks; 1,035, 918 and 976 g at 5 weeks; 1,360, 1,216 and 1,288 g at 6 weeks and 1,800, 1,580 and 1,690 g at 7 weeks of age.The phenotype gain in combined sex of SG for body weights at 4, 6, 7 and gains during 4–6 weeks were 28.60, 39.16, 28.70 and 8.55 g/generation, respectively. Corresponding values for realized responses in SG line were 23.06, 42.79, 39.30 and 14.5 g/generation. In SF line the phenotypic gains for body weight at 4, 6, 7 weeks, FCR (4–6 weeks) and FE (4–6 weeks) were 22.05, 27.42, 17.77 g/generation, –0.02 and 0.003/generation. The corresponding genetic gains were 16.50, 30.83, 30.15 g/generation, –0.04 and 0.006/generation.

CARI-PRIYA

CARI-Priya, the unique white-shelled egg layer, achieved the first rank among all the entries in 31st random sample poultry performance test for egg production held at Bangalore centre. CARI-Priya topped in the hen-housed egg production under cage-house system. The average egg weight of 57.41 g was also ideal from commercial point of view. The performance of CARI-Priya in deep-litter system ranked among the best commercial layers available in the country. It edged over other commercial layers in almost all important economic traits and thus recognized as the ideal bird for commercial layer farmers in India.In RSPPT at Bombay the strain crosses from GAU and ANGRAU achieved excellent hen-day production of 291 and 289 eggs, respectively, and the feed consumption was well under 100 g/day. The margin of receipts was Rs 30.65 and Rs 33.26 over feed cost for both the entries.

PERFORMANCE OF CARI-DEBENDRA

CARI Debendra, a dual-purpose breed cross showed an average fertility of 85.19%, while the hatchability on fertile eggs transferred basis was 51.69%. The body weights at 6, 8 and 10 weeks of age in the combined sexes were 730.95, 1,154.17 and 1,452.74 g, respectively. The average gain in body weight between different age groups, viz. 6 to 8 weeks; 8 to 10 weeks and 6 to 10 weeks,was

517.86, 404.88 and 922.74 g, respectively; and average feed consumed per bird during the afore-mentioned period was 1,024, 1,119 and 2,143 g, respectively; and feed conversion rates were 1.98, 2.76 and 2.32, respectively. The CARI-Debendra pullets matured at an average age of 139.46 days. The mean egg weight was 53.42 and 60.35 g at 28 and 40 week of age, respectively, with the egg production performance of 80.18 eggs up to 40-week of age.

Performance of Frizzle cross, IC-3 and IR-4: The programme for introgression of frizzle into broiler completed fifth generations of back crossing. The overall mean body weight of Frizzle × SDL and SDL × Frizzle crosses at 5 weeks of age were 922.0 ± 13.7 and 925 ± 8.5 g, respectively. The averages of body weights at 5 weeks of age in IR-3 and IC-3 were 828.5 ± 18.71 and 843.3 ± 11.02 g, respectively

All India Coordinated Research Project on Poultry

The synthetic dam line of the CARI centre showed positive genetic response of 16.85 and 24.13 g for body weight at 4 and 6 weeks of age, respectively. At the PAU, Ludhiana, the body weight of female line was 1,207 g at 6 weeks of age and they matured by 162 days of age and produced on an average 99.6 eggs by 52 weeks of age. The average egg weight at 40 weeks of age was 56.1 g. At the UAS center, Bangalore, the average body weight was 94.6 g at 5 weeks of age in S7 generation. These birds matured at 172 days of age and produced 72 eggs by the end of 40 weeks, with an average egg weight of 56.2 g. The dam line maintained at the OUAT centre recorded 1,407 g and 1,164 g body weights in males and females, respectively, at 6 weeks of age. They matured at 180 days of age and produced on an average 47.23 eggs, and the eggs weighed 58.4 g at 40 weeks.

At the JNKVV, Jabalpur, the existing purebred dwarf line, and three dwarf crosses were maintained and tested. Coloured and white dam line from the CARI and a single dam line from the PD on Poultry were utilized to produce the crosses of dwarfs at this centre. The mean body weight at 6 weeks of age was 580 g in pure dwarfs and 910 g, 882 g and 872 g in the 3 crosses with dwarfs. Compared to G2 generation an improvement of 20 g in body weight was achieved in dwarf pure line at 6 weeks of age. During the last 3 generations, the phenotypic response for 4 and 6 week body weight was 26 g and 17 g/generation. The egg production of dwarf dams improved by 1.8 and 3 eggs/generation, respectively, for 40 and 72 weeks of age and, the trend was in the desirable direction. The egg weight improved by 0.4 g/generation. The egg production of dwarfs in G 3 generation up to 40 weeks of age was 60, with average egg weight of 43.3 g and 53.6 g at 28 and 40 weeks of age, respectively. The egg production in the 3 crosses was 56 and 62 for the 2 crosses at CARI and 54 for PDP combination. Compared to the pure dwarfs the egg weight of crosses was higher at 28 and 40 weeks of age.

The crosses evaluated at the CARI, PAU, UAS and OUAT centers, produced promising results in RSPPT conducted at Bangalore, Mumbai and Gurgaon. CARI-Bro-Vishal recorded 1,484 g and 1,866 g body weights, respectively, at 6 and 7 weeks of age with corresponding feed efficiency of 2.19 and 2.33 and yielded a margin of Rs 20.63 and Rs 23.56 over feed cost. The entry from UAS achieved 1,407 g and 1,734 g at 6 and 7 weeks of age and ranked second.

In Gurgaon test, another cross the Caribro-Dhanraj from CARI, recorded body weights, 1,361 g and 1,595 g at 6 and 7 weeks of age, respectively, with the corresponding feed efficiency of 2.15 and 2.33. The margin of receipts was Rs 24.25 and Rs 25.95 at both the ages. In the same test, the PAU cross recorded 1,430 g and 1,900 g at 6 and 7 weeks, with feed conversion of 1.65 and 1.78, for both periods.

Rural Poultry

The introduction of 'Rural Poultry' component in the later part of IX plan period at the ICAR Research Complex, Agartala, was intended to field test the germplasm developed by the PD on Poultry, for rural farming under scavenging conditions. Vanaraja dual purpose germplasm developed by the PD on Poultry, Hyderabad, and Giriraja from UAS, Bangalore, were tested both on farm at Agartala centre, and at household level in the hilly tracks. Both the varieties adapted well to the free-range scavenging situation.

Improvement of male and female lines for production of rural germplasm: At the PDP, Hyderabad, the male line is used to produce the terminal cross, Vanaraja.

Genetic parameters showed sufficient scope for improvement and, intense selection was imposed for shank length and antibody titre but not on body weight. Breeders in S 3 generation matured 12 days earlier with a reduction in egg weight by 1–2 g over S 2.

The multi-colour female line is being improved using family index and it is in S 2 generation. Due weightage was given for juvenile body weight, shank length, antibody titers and plumage colour in selection at 6 weeks of age and a desirable blend of these traits was achieved in the terminal cross for efficient rural adaptation. In S 2 generation, 4 and 6-week body weight were, respectively, 357 g and 699 g in males and 328 g and 626 g in females. The shank length and antibody titers at 6 weeks of age in males were 3.04 inches and 5.21 $\log_2$, respectively, and in females the same were 2.88 inches and 5.75 $\log_2$. In S 2 generation the average body weight at 4 and 6 weeks of age declined by 35 g and 140 g, respectively, over earlier generation, which was desirable for making the bird acceptable for rural situation shank length an important criterion in selection, to overcome the predator problem in free-range system of rearing. Chicks from various colour combinations were selected and saved to achieve desired pattern of plumage colours in the terminal cross. Final selection at 6 weeks of age was done based on humoral response to SRBC and develop birds, which will respond well to initial vaccination. The average intensity of selection for shank length and SRBC titers was 0.46σ and 0.32σ. The heritability for 4 and 6 weeks body weight was moderate in magnitude and low for shank length.

Tinted egg layer for backyard poultry farming: A pedigreed line of Dehlam red was utilized for generating the colour terminal cross for rural poultry production. In S 0 generation the age at sexual maturity, body weight at 20 and 40 weeks of age, egg weight at 24, 28 and 40 weeks of age and egg number up to 40 weeks of age were 169.4 days, 1,425 g, 1,789 g, 45.68 g, 51.24 g, 54.57 g and 69.81 eggs, respectively.

Development of naked neck (*Na*) *and dwarf genelines* (*dw*) *for tropical adaptation:* The juvenile body weight of naked neck gene line for 4- and 6-week body weights were 588 g and 1,273 g in males, and 518 g and 1,031 g in females respectively. The 6-week body weight showed an improvement of 230 g compared to earlier generation.

The introgression of available naked neck gene into layer background was attempted (IWH line) and the advantages of adaptability and egg weight were evaluated against the pure line White Leghorn. They matured at 146 days of age, produced 109 eggs which weighed 45.5 g, 49.7 g and 53.5 g at 24, 28 and 40 weeks of age, respectively. These birds were heavier by 400 g over pure Leghorn and produced eggs that weighed 2–6 g more than pureline. The first generation of backcross progenies was produced and its performance is being recorded.

The body weight of dwarf gene line at 4 and 6 weeks was 449 g and 849 g for the combined sexes, respectively. The intensity of selection was only 0.23σ and 0.15σ correspondingly for males and females. The average age at sexual maturity was 154.8 days and the egg number up to 40 weeks of age was 66.39 eggs with egg weight of 51.6 g and 58.2 g at 32 and 40 weeks of age.

Improvement of colour broiler population: The colour male line is an open nucleus population and has completed two generations of random mating. The average intensity of selection for body weight at 5 weeks of age for the males, females and for combined sex was 0.92 σ, 0.56 σ, and 0.61 σ, respectively. At 16 weeks of age, 505 females and 125 males were saved for recording of production and other body weight traits after screening for skeletal and other deformities. The mean body weight at 20 and 40 weeks of age, egg weight at 32 and 40 weeks of age, and egg number up to 40 weeks of age were 2512 g, 3,488 g, 56.7 g, 60.8 g and 59 eggs, respectively. As compared to earlier generation the egg production up to 280 days of age and egg weight at 32 and 40 weeks of age remained stable.

In female line,body weight at 5 weeks of age was recorded in S 11 generation. At 6 weeks of age, females and males were selected based on 5-week body weight

Vanaraja male parent

Vanaraja female parent

Colour broiler population

PROPAGATION OF VANARAJA FOR RURAL POULTRY FARMING

Vanaraja was under focus for its inherent trait of adaptability under varying climatic conditions and diverse topographical regions of the country. Day-old chicks and fertile eggs of Vanaraja were provided to user agencies in Andhra Pradesh, Maharashtra, Karnataka, Orissa, North-eastern states, and Andaman and Nicobar Islands. Feed resources under scavenging conditions were scanty in dry areas and rich in forest and hilly regions. Vanaraja birds adapted extremely well to regional variations and seasonal fluctuations. Under free-range conditions the adult female birds produced 120–140 eggs in a year. The males were utilized for the meat purposes, as they attained 1.5–3.0 kg live weight by 12 weeks of age depending upon the feed resources available to them.

and were maintained on restricted feeding schedule. The average intensity of selection for body weight at 5 weeks of age for the males, females and combined sex was 0.96 σ, 0.56σ and 0.56σ, respectively. The mean body weight at 20 and 40 weeks of age, egg weight at 32 and 40 weeks of age and egg number up to 40 weeks of age were 2,482 g, 3,432 g, 56 g, 60 g and 59 eggs, respectively. As compared to earlier generation, the egg production up to 280 days of age showed an improvement of 2 eggs on phenotypic scale without any change in egg weight at 32 and 40 weeks of age.

Backyard poultry production in Orissa: At the CARI Regional Centre, Bhubaneswar, field performance of colour broiler, frizzle cross, naked neck cross and CD birds was studied. CARI-Dhanaraja and CARI-Debendra attracted the tribals more due to their colour pattern, rapid growth, better adaptability and survivability in free-range system. They attended the body weight of more than 1 kg in 10 weeks of age (1,165 ± 83 g) and above 1,500 g at 14th week (1,686 ± 17 g). These birds started laying at 24–26th week with average of 150–180 eggs/year. The CARI-Gold started to lay brown eggs of good size at the age of 140 days. The production varied from 200–230 eggs/year. The average egg weight was 51 g at 35 weeks of age. Maintenance of parent lines and collection of data (on farm research) is continuing. Three-way cross B77, as male line performed very well as compared to a female line.

QUAIL

The regeneration and selection programmes in different quail lines continued for meat and egg production. Individual selection for high 5-week body weight was the major selection criterion in CARI-Uttam, CARI-Ujjawal, CARI-Sweta and control. Further, the CARI-Pearl (White egg shell line) was selected initially on the basis of high 5-week body weight, and later mild selection on the basis of egg production and egg weight at 18th week of age was carried out to improve the reproductive traits. The phenotypic and genetic responses for different economic traits in broiler and layer quail lines were estimated in respective lines.

GUINEAFOWL

Mass selection continued in Pearl variety of guineafowl for 12 weeks body weight. Divergent selection continued in Lavender variety of guineafowl and S_2 generation was generated in high and low SRBC lines.

CHANGING THE LIFE OF DONKEY OWNERS BY ENHANCING GENETIC POTENTIAL OF THEIR EQUINES

The National Research Centre on Equines, Hisar, made an effort to improve the socio-economic status of the poorest of the poor class of the society engaged in donkey and mule activities. Good quality donkey germplasm produced at the Centre was supplied to the village level equine breeding societies for increasing the production potential of the indigenous donkeys. The reports from the societies indicated enhancement of their income from Rs 3,000–4,000 to Rs 10,000–12,000/year. Thus the centre is helping the underprivileged community of donkey owners in improving their socio-economic status through enhancement of potentiality of their donkey germplasm.

TURKEY

Production performance of female turkey housed in bamboo and thatched house: Daily egg production, feed consumption, FCR and mortality pattern revealed that numerically lower feed intake and better FCR was observed in the birds housed in hut as compared to those in conventional *pakka* house during first phase (20–42 weeks). During second phase (43–55 weeks) numerically higher egg production and average egg weight were observed in birds housed in hut, whereas better FCR was observed in conventional *pakka* house.

CAMEL

Qualitative and quantitative genetic parameters in Indian camel: The growth data over the years (1984–2002) was analyzed at the NRC on Camel, Bikaner, for studying the effect of breed and sex on growth. The weight at birth, 3, 6, 9, 12, 24, 36 and 48 months were 34.76 ± 1.24 (201), 102.42 ± 4.61 (132), 161.74 ± 5.36 (119), 190.48 ± 6.32 (120), 219.44 ± 6.93 (151), 278.97 ± 6.14 (104), 354.49 ± 8.03 (79) and 448.19 ± 15.44 (78) kg, respectively. The effect of breed was significant at various stages of growth. The effect of sex was nonsignificant at almost all stages of growth. Except initial decline for 2–3 years body weight showed increasing trend in all camel breeds in 2, 3 and 4 years weight. This can be attributed to selection and improved management practices adopted at the centre.

Improvement was also observed in per cent conception and calving pooled over breeds and years, 63.98% and 73.42%, respectively. Highest calving percentage was observed in Kachchhi (81.82%) followed by Bikaneri (72.22%) and Jaisalmeri (81.82%) breeds. Analysis of gestation length indicated significant breed effect. The gestation length in Bikaneri, Jaisalmeri and Kachchhi females was 390.04 ± 0.73, 389.54 ± 1.12 and 384.04 ± 1.12 days respectively. The calving interval, pooled over breeds, was 715.50 ± 8.46 days. The year to year variation in the gestation length and calving interval was significant.

YAK

Preliminary survey in Sikkim and Jammu and Kashmir revealed conditions of yak husbandry akin to that of Arunachal Pradesh.

ANIMAL HEALTH

Foot- and-mouth Disease

Antigenic analysis revealed that 32% of the FMDV type O field isolates recovered in the year 2002, are antigenically different from the vaccine strain IND R2/75, indicating an upsurge in the number of such heterologous strains in the field. However, in type Asia 1, majority (>95%) of the field isolates collected during the last 3 years indicated adequate serological relationships (r value > 0.4) with the vaccine strain IND 63/72. In type A, 64% of the isolates are antigenically divergent (r value < 0.20) from the two vaccine strains (IND 17/77 and IND 490/97 [WBN 17/82]) used in the country. Of the two genotypes of 'A' presently co-circulating, genotype VII gave a better antigenic coverage (r value > 0.40) to 64% of the isolates compared to genotype VI (r value 0.40 and above) that gave coverage to 24% of the isolates. Genetic analysis of type O FMDV field isolates indicated emergence of a new group which is about 8% divergent at the nucleotide level from hitherto predominant Pan-Asia group. The newly emerged strain overtook the well-established Pan-Asia strain and was responsible for type O FMD outbreaks in 11 states. In Asia 1, 1D gene-based analysis indicated the prevalence of co-circulating genotypes A and B, and the later is widely circulating and majority of the recently

- Upsurge in heterologous strains of FMD observed.
- Indigenously developed C-ELISA kit. for rinderpest was validated by IAEA,Vienna.
- IBR continues to be the major herd problem.
- India.AdmasEpitrak software was made more user friendly.
- PCR for amplification of RNA gene of *Theileria annulata* standardized.
- Repository of *Pasteurella multocida* isolates established.
- Faecal egg count reduction test revealed resistance against albendazole in sheep infected with haemonchosis.

- Vaccine against *Salmonella* Abortus-equi was prepared.
- Rajasthan –98 strain of EHV-I was the most virulent pathotype.
- Zero level achieved in EIA infection in equines in India.
- Antitrypanosomal potentiality of *Lantana camara* needs more investigation.
- PCR tests were standardized for *Babesia equi* infection in equine and trypanosomiasis infection in camel.
- Dwarf and Naked neck gene lines showed antibody titres higher than pure lines.

ECO-PATHO ZONES

Identification and delineation of livestock health specific eco-patho zones based on the endemicity of disease profile during 1987 to 2002, was worked out. This is a unique and intensive effort as the present agro ecozones are based on plant production system and there are no similar approaches to demarcate the country into livestock disease based zones. A five-stage approach was conceived to identify disease specific national eco-patho zones. The first phase is now being accomplished using statistical methods and GIS technology.

INDIGENOUS MEDICINES

The *Delonix regia*, popularly known as *Gul-mohar,* has promising medicinal activity and the studies conducted at the IVRI, using various experimental models, with flavonoid-rich fraction of flowers of the plant revealed significant anti-inflammatory and analgesic (pain killing) activities, thereby suggesting its potential use in inflammatory conditions.

Studies conducted on several fractions derived from medicinal plants, IVR-8 and IVR-9 (coded fractions) showed significant inhibitory effect on the motility of *Fasciola gigantica* (liverfluke), and paralytic effects on the parasite. These fractions show good promise as anthelmintic compounds.

sampled isolates formed a separate group within this genotype and are > 9% nucleotide divergent from the remaining isolates. Sequencing of the capsid-coding region of type A isolates revealed that genetic recombination is another mechanism of genetic and antigenic divergence. Recombination between strains of a serotype could be a ploy by the virus to evade immune response. In high disease endemic region like India, role of recombination needs further investigation.

The liquid phase blocking-ELISA, which is used to determine the protective antibody level following vaccination, revealed lesser than desired level of antibody titres against the four FMDV serotypes in majority of post-vaccinated sera samples tested. The virus repository maintained at the Project Directorate had by the end of the year, about 1,055 isolates comprising type O–684; type Asia 1–206; type A–151; and type C–15.

Animal Diseases Monitoring and Surveillance

National sero-epidemiological survey revealed that overall incidence of brucellosis was 24.6% and IBR 23.3%. The milk based brucellosis kit was further field validated on 3,820 pooled milk samples at Ludhiana, Tirupati and Ahmedabad, and the overall incidence was found 14%. IBR continues to be major herd problem and semen production centers are concerned about this situation as the virus is excreted through semen. The IBR milk version of the ELISA kit was tested on 413 pooled milk samples at Ludhiana and Tirupati, and showed evidence of infection in 31.8 and 9.7% tested respectively. The recombinant rinderpest, C-ELISA kit was validated by IAEA, Vienna, after undertaking field performance trials in Kenya.

The epidemiological study on leptospirosis has made 54 isolations making it 500 in the past five years. The present isolates originated from bovine, pigs and dogs. Using the MAb based typing kit 21 isolates were indentified as belonging to autumnalis, icerohaemorrhagiae, conicola, hebdomadis, grippotyphosa and hardjo serovars. The remaining needs to be identified.

The warehousing of animal health information database through upgradation and integration of the India.AdmasEpitrak software, was accomplished. Its specific application in the Web based National Animal Disease Referral Exert System (NADRES) of PAD_ADMAS is in the final stage of launching. Using this data warehouse, top ten locations of epidemiological importance with respect to 22 endemic diseases would be identified along with their disease precipitating factors.

Blood Protista

A PCR for amplification of small sub-unit ribosomal RNA gene of *Theileria annulata* in lymphnode biopsy and blood of infected cattle was standardized. Infected blood showed intra-erythrocytic parasitaemia up to 0.00062%.

Seroprevalence study by IFAT of bovine babesiosis, from cattle revealed 43.5% positivity. Slide enzyme-linked immunosorbent assay (S-ELISA), revealed that 41 out of 48 samples from Orissa and 19 out of 47 from Uttar Pradesh, were positive for *Babesia bigemina* antibodies. Heparinized blood from cattle was subjected to PCR for detection of *B. bigemina* infection using specific primers.

Random amplified polymorphic DNA analysis of *T. evansi* isolates derived from buffalo, camel and horse was carried out using 12 random oligonucleotide primers, and informative primers (AP_{14}, AP_{17}, AP_{18}, AP_{19}, AP_{22} and AP_{23}) were identified. Nucleotide sequencing of the 5' and 3' ends of a RAPD-DNA fragment using M_{13} forward and reverse primer resulted in sequence ladder, which resolved 230 bases from the RAPD primer binding site. The partial sequence determined was 232 bp from the 5', and 110 bp from the 3' end of the fragment.

Haemorrhagic Septicaemia

Epidemiological survey and prevalence of different serotypes of *Pasteurella multocida* resulted in identification of serotypes, viz. A : 1, A : 3, A : 1, 3, A : 3, 4, A : 4, A : 3, 4, 12, B : 2, D : 1, D : 3, F : 1, F : 3, F : 3, 4, F : 4, 12 from cattle,

buffalo, sheep, goat, pig, chicken, quail, duck, lion, tiger, dog and leopard. The field isolates were characterized by biochemical tests, toxin production and antibiotic resistance. A repository on *Pasteurella multocida* isolates from different species of animals was established, and currently it is maintaining more than 250 isolates collected from different parts of the country.

PM-PCR, HSB-PCR, multiplex PCR and nested PCR for *P. multocida* serotype A specific and serotype B : 2; B : 2, 5; B : 5 were standardized for identification of *P. multocida*. A new set up primers for serotype A were developed which amplified a product of ~564 bp. REA, RFLP, AFLP, ribotyping using 16S rrn gene, RAPD, REP and ERIC-PCR were used for characterization of *P. multocida* strains from different animal species. The molecular characterization of field isolates of *Pasteurella multocida* from different regions of the country was carried out by using REA, REP-PCR, ERIC-PCR, RAPD-PCR, ribotyping and AFLP.

A low volume saponified HS vaccine showed good protection against challenge up to 9 months and 12 months post-vaccination in cow and buffalo calves, respectively. A combined HS (serotype B : 2 and D : 1) and FMD (serotype A, O and Asia 1) vaccine for pigs gave protection up to 9 months post-vaccination on challenge test (maximum period tested).

Bluetongue

Bluetongue (BT), an economically important vector-borne viral disease (OIE-List A) of sheep and other ruminants like goat, cattle and wild animal species, is endemic in India and out of 25 known serotypes of virus 21 are prevalent in India.This complicates the diagnosis and control of disease. Out of 769 clinical/samples 188 were positive in sheep, goat, cattle and buffaloes from Andhra Pradesh, Uttar Pradesh, Jammu and Kashmir, Gujarat, Punjab, Rajasthan, Maharashra and Tamil Nadu.

AGID-based bluetongue disease diagnosis kit, developed at Izatnagar centre, was effectively used for sero-diagnosis of disease. One virus isolate from Tamil Nadu was typed as type-1 at this centre. Sero-epidemiological survey in 6 districts of Karnataka indicated the presence of antibodies against BTV serotypes 1,2,12,16,17 and 20, 21 and 23 as typed at the Animal Virus Research Laboratory, Onderstepoort. Out of 25 blood samples collected by the Parbhani Centre from five villages of Maharashtra, one sample gave positive reaction in chicken embryos.

Variations in fragments of RNA genome of 6 isolates of BTV types—18 and 23—were detected in RNA-polyacrylamide gel electrophoresis at the IVRI, Izatnagar. Reverse transcriptase polymerase chain reaction (RT-PCR) and nested PCR were standardized at Izatnagar and Hisar centres for the detection of BTV genomic nucleic acid using the VP3, VP7, NS1 and NS3 specific primers.

Three samples of *Culicoides* suspected flies submitted were identified as *Culicoides oxystoma*.

Inactivated bluetongue vaccines, prepared by inactivating type-18 isolate of BTV with BEI or hydroxylamine and adjuvanted with aluminium hydroxide gel and/or saponin, provided encouraging protective immune response in sheep against virulent BTV challenge. No untoward reaction of vaccine was observed in pregnant sheep and lambs borne to them.

Gastro-intestinal Parasitism

Prevalence of gastro-intestinal parasitism in goats was studied. Albendezole resistance was recorded in sheep naturally infected with *Haemonchus contortus* by faecal egg count reduction test (FECRT). In DID, hyperimmune sera raised against somatic antigen of *H. contortus* showed double precipitin line with homologous antigens. Soluble larval extract antigen showed entirely different antibody response. The antibody level remained higher in third and fourth week and the OD values were almost 3–4 times more than the controls. Characterization of somatic antigen of *H. contortus* by SDS-PAGE revealed polypeptides ranging in molecular weight from 16–69 kDa of which 26 kDa appeared to be common

PATENTS FILED BY IVRI WITH CONTROLLER OF PATENTS, GOVERNMENT OF INDIA

- An Asian linkage liver attenuated homologus vaccine for peste des petits ruminants (PPR) virus infection.
- Indigenously developed cost-effective and potent aluminum hydroxide gel concentrated oil adjuvanted vaccine for foot-and-mouth disease.
- Indigenous drug formulation against skin disease of animals.

PATENT APPLICATIONS OF IVRI SUBMITTED TO THE COUNCIL

- Oligonucleotide primer sequences for rapid identification of *Mycobacterium bovis* and *Mycobacterium tuberculosis* by a single-tube multiplex PCR.
- Development of indigenous methodology–IVRI crystoscope as a field tool for determining optimum time for fertile insemination in animals.
- A process for preparing a herbal formulation for the treatment of mange.

COMPLETE GENOME SEQUENCE AND DEVELOPMENT OF VACCINE STRAIN OF INFECTIOUS BURSAL DISEASE VIRUS

Infectious bursal disease is a highly contagious immuno-suppressive viral disease of young chickens. The virus primarily destroys antibody producing B-lymphocytes, birds become more susceptible to other bacterial and viral infections and also show poor response to vaccines. The virus possesses bi-segmented double-stranded RNA genome of around 6.1 kb in length. Significant difference was noticed in the genome of various strains of IBD viruses. The Indian field isolate of IBD virus was characterized. The sequence of Indian IBD field virus is available in the EMBL database under accession numbers AJ427340 and AJ496637. The sequence analysis revealed 1.2 to 4.9% divergence at nucleotide level in segment A, and 1.8 to 12% in segment B within serotype 1 IBD viruses, whereas this difference was 19.6 and 11.8% from serotype 2 virus, respectively. Deduced amino acid sequence of segment A also revealed 5 amino acids to be specific to Indian field virus with amino acids 222Ala, 256Ile and 291 Gly in VP2 protein to be specific to very virulent viruses. In segment B encoded VP1 protein, there were 7 amino acid changes unique to Indian field virus. Phylogenetic analysis based on nucleotide sequence of both segments A and B revealed that the Indian field virus KT1/99 is similar to very virulent viruses of Europe, Japan and other countries as they clustered together in the same lineage. Sequence analysis of virus segments A and B revealed very close phylogenetic relationship between the Indian field virus KT1/99 and the Bangladesh very virulent strain BD3/99 and Japanese very virulent strain OKYM, respectively. The sequencing data generated will help in better understanding of the disease by identification of pathogenic markers and in developing better immuno-prophylactics.

A thermostable vaccine strain of intermediate virulence was developed from an indigenous virulent IBD virus isolate. The vaccine strain is free of immunosuppressive effect and provides good protection against IBD. The thermostability of the vaccine strain makes it an ideal choice for use in the tropical countries.

between *Bunostomum trigonocephalum* and *Oesophagostomum columbianum* and *H. contortus.*

Double immunodiffusion test with hyperimmune serum raised against somatic antigen of *H. contortus* showed double precipitin lines with the homologous antigen. Similarly hyperimmune serum raised against *O. columbianum* with its homologous antigen showed two precipitin lines, whereas, homologous antigen of *B. trigonocephalum* showed single precipitin line.

Serially diluted (1 : 200 and 1 : 400) sera of infected and control groups of goat when subjected to different *H. contortus* antigen showed variable OD values in ELISA. Maximum OD value could be recorded with soluble larval extract during III week (0.647 ± 0.08) and IV week (0.90 ± 0.14) in the infected group, whereas, in the control group it was 0.250 ± 0.021.

In sheep and goats SDS–PAGE analysis of somatic antigen of different GI nematodes *H. contortus* revealed 16, 19, 22, 26, 32, 39, 50 and 69 kDa protein, *B. trigonocephalum* 15, 19, 26, 31, 50, 56, 63 and 71 kDa, and *O. columbianum* 16, 22, 20, 26, 42, 64 kDA. Most prominent band of 26 kDa was common to all antigens. In soluble larval extract antigen of *H. contortus* 83 kDa protein band was the most prominent. These proteins of 26 kDA and 83 kDA need further investigation for immunodiagnostic potential.

Among alternate control methods, spray of low level (1.25 g nitrogen%) urea on pasture significantly reduced the translation of worm eggs to infective larvae on single as well as continuously contaminated pastures. Among nematophagus fungi, *Duddingtonia flagrans* trapped the nematode larvae to the extent of 98% in 24–48 hr postinoculation whereas *Arthrobotys oligospora*, trapped only 67% larvae in 144 hr Pl. Single oral administration of 1.5 million chlamydospores of *D. flagrans* in sheep caused significant reduction in the number of infective larvae in faecal culture 24 hr post-dosing. No such effect could be seen for *A. oligospora*.

Sheep

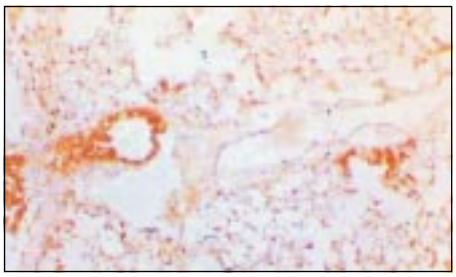
Based on FECRT, 92% of the flocks tested showed emergence of anthelmintic resistant strain of parasites. Resistance to tetramisole in *H. contortus* was observed in 33.3% of flocks tested. The resistance to closantel was not observed. Egg hatch assay detected 75% of the flocks harbouring BZ resistant GI nematodes with a mean ED_{50} of 0.188 ± 0.017 µg TBZ/ml. Russian Merino and Rambouillet were more susceptible to GI nematodosis. The highest prevalence (88.75%) was recorded in Russian Merino. In Rambouillet sheep highest EPG (8,000) was recorded during winter. Sheep infected with haemonchosis showed resistance against albendazole when treated @ 7.5 mg/kg body weight orally. Per cent reduction in EPG was 70.7.

Equines

Vaccine against *Salmonella* Abortus-equi infection, prepared using outer membrane protein extracted from the causative organism, gave encouraging results. It was superior to that of the existing vaccine as it can be used along with the EHV-1 vaccine, which was not possible with the existing vaccine. Rajasthan-98 strain of EHV-1 was the most virulent pathotype. Coggins test revealed absence of the EIA antibodies indicating that India has achieved zero level infection for EIA and it is a great achievement for the country as it would boost export of equines from the country. The prevalence of *Mycoplasma equigenitalium* was recorded for the first time indicating existence of mycoplasmosis in equines in the country, and it needs thorough investigation. One case of EHV-1 induced abortion revealed that EHV-1 infection is still persisting, which indicated the necessity for continuing the investigations against this infection. Serum samples revealed a variable level of fluoride content (0.018 ± 0.002 to 0.32 ± 0.02 ppm) indicating wide significant regional differences but within the normal values reported for the equids abroad. Antitrypanosomal potentiality of the crude extract of *Lantana camara*, was found

unsuitable for parenteral use in its crude form. Purification of the extract is required to exclude its toxic principal.

Sero-surveillance was conducted on 1,715 sera samples from thoroughbred horses and indigenous mules, donkeys and ponies/horses, for detection of *Babesia equi* infection by COFEB-kit. Among indigenous equids, an overall rate of infection was 21.68%. The state-wise prevalence rate was: Uttaranchal (50.00%), Rajasthan (45.71%), Punjab (28.20%), Uttar Pradesh (20.14%), Karnataka (19.11%), Maharashtra (8.43%), West Bengal (0.00%), Gujarat (0.00%). Among donkeys infection rate was 45.00%. PCR test was standardized specifically for detection of *Babesia equi* parasite in blood.



Lung of Balb/c mice infected with EHV-1 showing brown staining of viral antigen in bronchial epithelium and lung parenchyma by indirect immuno-peroxidase technique

Camel

Parasitological examination of 72 camel blood samples (10 ml) collected from trypanosome-endemic area, revealed no positive sample. PCTR amplification revealed that six samples (8.3%) were positive.The amplified PCR product is genome-specific. With this PCR detection method drug sensitivity test, field monitoring for incidence and prophylaxis can be performed with high accuracy.

Indigenous formulations comprising locally available herbal ingredients were evaluated for its efficacy against naturally occurring mange, caused by *Sarcoptes scabiei* in dromedary camel. Herbal preparations were capable of relieving animals from symptoms of intense itching, scratching and biting, oozing of thick brown scabs in some cases, thickening and wrinkling of skin, etc. Microscopically skin scrapping became negative for parasites (mites/eggs) between 10th–15th day of its local applications without any noticeable relapse even up to 30th day post treatment. Haemato-biochemical examination failed to yield any significant diagnostic alteration except eosinophilia, hypoproteinemia, hypoalbuminemia and reverse trend of A/G ratio, which all together were restored after drug application. The preliminary screening of the formulation encourages to carryout further detailed study for which a collaborative research is in progress.

Poultry

Naked neck chicken vaccination with live attenuated fowl-pox vaccine intramuscularly at 21 days (early) and 42 days (late) of age revealed better antibody titres against Newcastles disease (ND) when they were vaccinated for pox at 21 days than that at 42 days of age. This boost in ND titres was significant after 6 weeks. Better response was also observed in the antibody titres to SRBC and CBH to PHA-P due to early pox vaccination. Priming of the chicken immune system with fowl-pox at an early age yielded better immune response to ND vaccination and generalized immune response.

Technologies developed

- A monoclonal antibody (MAb) based competitive-ELISA developed at the IVRI, Mukteswar Campus, for rinderpest antibody detection in serum samples was validated by IAH, Pirbright, UK. The test kit is the second of its kind in the world for rinderpest diagnosis. The kit has also been approved by OIE
- A MAb based competitive-ELISA was developed for the detection of PPR antibody in serum samples
- A sandwich-ELISA for PPR antigen detection in clinical samples was developed for specific diagnosis of PPR virus infection
- A recombinant bluetongue group specific antigen coding VP7 region of BTV was developed and tested successfully for its potential diagnostic use
- An RT-PCR technique was standardized for detection BTV in bovine semen
- A non-structural protein 3AB of FMD virus was cloned and expressed in

DIAGNOSIS OF ANIMAL MYCOPLASMOSIS

Mycoplasma, the smallest self-replicating prokaryote, is responsible for a number of dreaded diseases in livestock and poultry of which the contagious bovine pleuropneumonia (CBPP) in cattle and contagious caprine pleuropneumonia (CCPP) in goats are of considerable economic significance. The diagnosis of these diseases is generally based on isolation of the organism and serology. However, due to very high DNA-DNA relatedness and sero-crossreactivity among the causative agents, it is very difficult to diagnose the infections rapidly with serological tools. A polymerase chain reaction (PCR) was standardized and used extensively using various *Mycoplasma* spp. Primers, which can detect mycoplasmas up to the genus as well as species level in a few hours, as compared to 1 to 4 weeks required while using the conventional methods. The disease can be detected directly in lungs, spleen, lymphnodes and pleural fluid collected at postmortem or from slaughterhouses, and from the nasal discharges of clinically affected animals collected on filter paper strips. The technique of detection of mycoplasma from the filter strips will be very helpful in future, particularly as the materials transported from field cases can be stored at room temperature for a very long time. The detection of mycoplasma contamination if any, in cell cultures is also possible by PCR, which may be a boon to the animal virologists. The Referral Laboratory at the IVRI, has also developed a colour antigen of *Mycoplasma mycoides* subsp. *capri* for field diagnosis of CCPP which has shown encouraging results. In near future, the antigen will be available for field use.

yeast system. The cloned viral protein showed a good potential as a serological marker for differentiation of FMD infected animals from vaccinated stock

- Polyclonal and monoclonal antibodies were raised against the purified recombinant bovine interferon γ protein. The interferon γ assay was successfully used in detection of bovine tuberculosis in two organized cattle farms and the test was more sensitive than SID
- PCR assay for differential diagnosis of *Mycobacterium tuberculosis* and *M. bovis* targeted to oxyR and pncA genes of mycobacteria were standardized and field tested
- A sensitive PCR for detection of *Mycobacterium a. paratuberculosis* from faecal samples was standardized with a threshold sensitivity of 10^6 bacilli/g of faeces. Lymphocyte stimulation test (LST) was sensitive in detecting subclinical *paratuberculosis*. PCR was standardized on clinical and postmortem samples for the diagnosis. Luminol-dependent chemiluminescence activity was higher for *M. paratuberculosis* than staphylococcus antigens
- SDS-PAGE profile and immunoblotting of cell surface proteins of *Listeria* spp. and outer membrane proteins of 32 different serotypes of *Salmonella* revealed 28 and 75 kDa polypeptides to be immunodominant and *L. monocytogenes*-specific, and 32 kDa of OMP to be common and immunodominant among *Salmonella* spp
- Using synthetic peptide approach, VP7 protein sequences of bluetongue virus (BTV) were exploited and three most reactive VP7 specific peptides were identified at the IVRI using BTV specific sera, which were 122–139, 163–180 and 339–349. Antipeptide antibodies against multiple antigen peptide (MAP) 122–139 reacted up to 1 : 12,000 and also specifically to VP7 of BTV in western blot, ELISA and dot-ELISA
- An indirect ELISA was standardized for serodiagnosis of caprine toxoplasmosis. Major polypeptides of tachyzoite antigen of *Toxoplasma gondii* in the MW range of 104-12 kDa were identified in silver stained SDS gradient (5–15%) gels. Immunodominant antigens of *T. gondii* in the ascitic fluid of infected mice were identified by western immunoblotting with positive caprine sera
- *Diagnosis of parasitic diseases of domestic animals*: At the IVRI, Izatnagar, the antigen (s) of *F. gigantica* were purified, and evaluated using *F. gigantica* infected sera from experimentally infected buffalo yearling calves by using ELISA, western blot and dip-stick ELISA with 100% sensitivity. Anti-fasciola antibodies were detectable as early as two weeks post-infection. Cysteine proteinase (defined protein antigen) was purified from *F. gigantica* regurgitant and the isolation protocol was standardized. A cDNA of *F. gigantica* fatty acid binding protein (FABP) was cloned in a suitable vector and expressed as recombinant protein using prokaryotic (*E. coli*) expression system. Purification was achieved up to 90 to 95% level. The usefulness of FABP fusion protein of *F. gigantica* as a diagnostic antigen needs to be tested by ELISA and dot-ELISA.
- *Diagnostics for classical swine fever were developed*: The CSF virulent virus obtained from CADRAD, IVRI, Izatnagar, and CSF vaccine virus (lapinised) obtained from Biological Products Division, IVRI, Izatnagar, were used for standardizing the RT-PCR for detection of CSF virus. For the virulent strain, spleen, lymphnodes and tonsil samples from an experimentally infected pig were used, while the vaccine virus was used after suitable dilution of the freeze-dried vaccine (spleen suspension of rabbit). The protocol was standardized with known positive tissue samples. The protocol was successfully applied to field outbreak samples originating from the last reported outbreak of swine fever in Punjab.

SUCCESS STORY

BIOMATERIALS IN TENDON RECONSTRUCTION

Tendons, important constituents of the musculoskeletal system of an animal, are anatomically placed superficially in the body and are therefore more prone to injuries. The use of draught animals is still very much in practice in India despite mechanisation in agricultural operations. Direct trauma inflicted by agricultural implements is the most common cause of tendon injuries. Detailed studies were conducted at the Indian Veterinary Research Institute,Izatnagar,to evaluate various implant materials for the reconstruction of tendons and to prevent adhesions formation following tendon surgery.

Carbon fibres as implant for tendon reconstruction in cattle

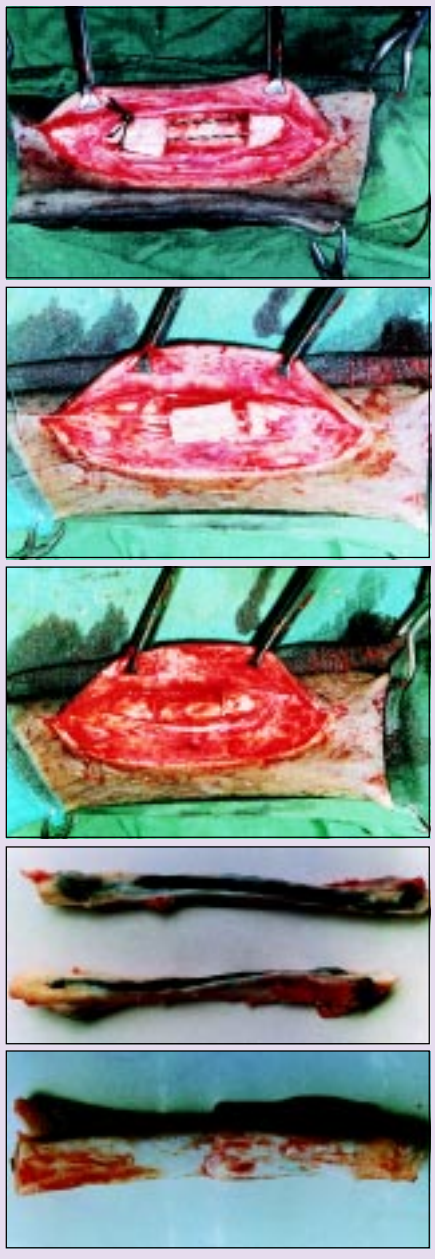
Carbon fibres (6,000 filaments of 7.5 µm each) were used to fill the 2.5 cm long defect of tendon in crossbred calves weighing 80–260 kg. At day 30, there was formation of neotendon around the carbon fibres which simulates to normal tendon at day 90. Histological observation did not reveal any untoward reaction. Scanning electron microscopic (SEM) observation revealed growth of neotendon in between the carbon fibre filaments. The study suggested the carbon fibres to be promising implant material for tendon reconstruction.

Allogenic/xenogenic acellular grafts in the reconstruction (repair of tendon defect) in bovids

Antigenicity of allogenic/xenogenic tendon grafts is the main prohibitive factor for their use in tendon reconstructive surgery. A hypothesis is that their antigenicity can be reduced/minimized if they are made acellular. Tendon grafts of allogenic/heterogenic origin were collected from the abattoir. These grafts were made acellular by chemical treatment and the technique for making graft acellular was standardized. During *in vitro* and *in vivo* biocompatibility testing, these acellular grafts were less immunogenic and imflammogenic. The acellular grafts were used to repair 2 cm long defect of flexor tendon in buffalo calves. Clinically, the grafts were acceptable. Gross observation revealed absorption of graft by day 90 and replacement by neoformed tissue. Histological observation did not reveal any untoward reaction.

Modalities for the prevention of adhesion formation after tendon surgery

Different modalities were evaluated for preventing the adhesions. They were evaluated on the basis of clinical, radiological, angiographical, gross, histological and scanning-electron microscopic observations. Administration of autogenous synovia and 1% hyaluronic acid at the reconstructive site of tendon twice weekly on 4 occasions was effective. Therapeutic ultrasonic therapy starting from day 3 post-operatively was also effective in preventing peritendinous adhesion formation following tendon surgery.



Showing creation of 2.5 cm defect in superficial digital flexor tedon. (*top*)

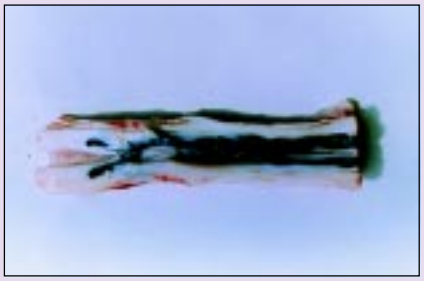
Repair of defect with plasma preserved allogenic graft.(*second-from-top*)

Repair of defect with two strands (each strand containing 6000 filaments having diameter of 7.5 micron each) of carbon fibres (*middle*)

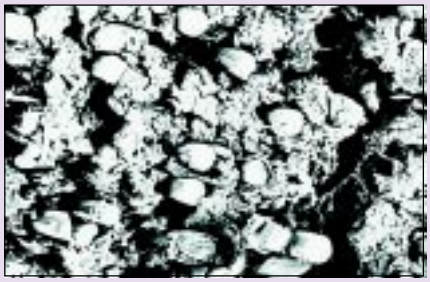
Longitudinal split section of neoformed tendon around fibres on day 30 post repair. (*bottom-but-one*)

Neoformed tendon on day 90 post repair having similarities with tendon.(*bottom*)

Split section of figure 5.



Scanning electron microscope photograph showing neo tendon growth between carbon fibre filaments. X1000.



- Feedbase-2001CD—provides information on feed resources and feed balance sheet.
- Vitamin supplementation improved oxidative stability of milk.
- Bypass protein value of feeds prediction possible.
- Barley proved a better energy ration for ruminants.
- Formaldehyde treatment of mustard-cake reduced degradation of glucosinolates in rumen.
- Lysine content highest in silk pupae-meal.
- Area specific mineral supplementation resulted in improved fertility in cows.
- Complete feed blocks insured proportionate intake of roughage and concentrates.
- Complete feed was prepared for camel using *guar phalgati* and *ardu.*
- Foxtail millet can replace 57% maize in broiler starter ration and 67% in finisher ration.
- Higher aflatoxin resulted in certain pathological changes in poultry.
- Propionic acid, *neem* leaf and *neem* seed-cake prevented mould infestation of poultry feed.

ANIMAL NUTRITION AND ANIMAL PHYSIOLOGY

ANIMAL NUTRITION

National Information System on Feed Resources

- The information system on availability and requirement of feed resources and feed balance sheet for all the states in the country, was brought out in a compact disc—Feedbase 2001. It comprises NIANP, Feed Resources, Animal Resources and Balance Sheet modules. It provides information on availability of feed resources in terms of crop residues, greens and concentrates for all the states from 1985 to 2000. Assessment of the availability of desired feed resources in a particular year/period of years across the different states, would also be possible.
- Animal resources data provide information on animal resources availability for cattle, buffalo, sheep and goat for all the states individually, and the country as a whole. The information is provided for different categories of animals both in terms of absolute numbers and standard ruminant livestock units. This package provides information on changing trends in the population of different ruminants in the various states/regions, which is vital as the type of ruminant species has a important bearing on the quantity and quality of feed resources requirements.
- Based on the availability of feed resources and the ruminant livestock population in different states it would be possible to formulate production systems that are best suited to match the feed resources against the ruminant population. This would be a valuable tool for policy makers, planners, researchers and implementing agencies for formulating better livestock development activities.

Newer Feed Resource and Processing

Ricin content in castor-cake varied from 13 mg% in expeller castor-cake to 58% in dust deoiled castor-cake. Autoclaving, heating (100°C for 30 min) and ammonia treatments increased organic matter digestibility. Quantification of ricin in treated cake revealed that chemical methods are superior to physical methods in reducing the toxicity of cake.

COMPLETE ECONOMIC RATIONS FROM SUGARCANE

Complete diets prepared at the IVRI, Izatnagar, having ammoniated bagasse pith could be successfully fed to adult animals without any adverse effect on intake and digestibility of nutrients. For ammoniation of sugarcane baggasse, 4 weeks incubation with 4% urea at 40% moisture level was the most viable and effective treatment. The best combination for the ammoniation of sugarcane tops (chopped) was 3 weeks incubation with 3% urea at 40% moisture. Feeding of sugarcane tops as a sole feed had adverse effects on the performance of animals particularly on Ca and P metabolism. It requires to be supplemented with a concentrate mixture or UMLD to meet requirements of animals. Supplementation of sugarcane tops with lentil *chuni* and concentrate mixture gave better performance as compared to wheat bran and urea molasses mineral liquid diet, respectively.

CATTLE

Supplementation of α-tocopherol and ß-carotene in the cow's diet improves oxidative stability of milk: Supplementation of 1,000 mg dl-tocopheryl acetate and 1,000 mg dl-tocopheryl acetate + 300 mg ß-carotene/cow daily during 120 days of lactation, improved oxidative stability of milk. In non-supplemented group 64% of milk samples were susceptible. Non-susceptible milk samples contained higher α-tocopherol (46.36 vs 36.46 µg/g fat, ß-carotene 4.42 vs 3.83 µg/g fat) and retinal (5.93 vs. 5.10 µg/g fat) than susceptible milk.

Leucaena leaf protein–a rich source of bypass protein for ruminants: Leaf-meal from K-8, K-28 and Peru varieties of subabul (*Leucaena leucocephala*) had mimosine content ranging from 2.94 to 5.56%, 2.54 to 5.56% and 4.06 to 4.19% respectively. The effective degradability of CP was lower in K-28 (34.80%) followed by K-28 (31.61%) and Peru (28.82%). The RDP and UDP values were lower in Peru than that in K-8. The UDP (g/kg LLM) was the highest in K-8 (57.9), medium in K-28 (53.8) and the lowest in Peru (40.2). Nutritional quality of K-28 was the highest followed by K-8 and Peru leaf-meal.

Prediction of the bypass protein value of feeds: Effective protein degradability by *in sacco* method showed that maize gluten-meal had the best bypass protein value followed by cotton seed-cake, soybean-meal, sunflower-meal, *Leucaena*

lucocephala and fish-meal. Barley, wheat and wheat bran had low bypass value, whereas, maize grain was quite resistant to microbial proteases. Laboratory methods of N-fractionation could be used to predict the effective protein degradability of feeds, which may be adopted by the feed industry (using prediction equations to calculate RDP and UDP value of feeds).

Barley–a good energy source in ruminant rations: Better dry matter and organic matter digestibilities were observed in diet comprising barley than that in maize along with groundnut-cake as protein source. A similar response was also observed in rumen fermentation in terms of total protein TVFA concentration. *In vitro* dry matter digestibility and *in vitro* organic matter digestibility of complete feed, containing barley with soybean-meal, were also better than that containing maize grain with soybean-meal. Barley proved better than maize as an energy source, irrespective of the protein sources used.

Feeding of formaldehyde treated mustard-cake to ruminants: Formaldehyde treatment of mustard-cake and groundnut-cake resulted in protection of their proteins from ruminal degradation thus making these cakes as artificial source of bypass protein. This treatment also prevents the degradation of glucosinolates of the cake in rumen to a more toxic form ie thiocynate, which disturbs the animal thyroid metabolism and also gets excreted into milk.

Protected Nutrient Technology for High Producers

Limiting amino acids: High yielding cattle and buffaloes require about 40% of crude protein of their diet in the form of rumen undegradable protein (UDP) bypass protein, and fraction should contain essential amino acids methionine and lysine. Highest lysine was in silkworm pupae (1.71%) followed by pearl millet grain and maize gluten-meal. The lysine of other feedstuffs ranged from 0.85 to 1.48%. Maize gluten-meal contains the highest methionine (1.25%) followed by silkworm pupae (1.08%). The methionine of other feedstuffs ranged from 0.11 to 0.44%. The bypass protein fraction of silkworm pupae contained highest amount of lysine followed by safflower-cake, copra-cake, maize gluten-meal-60, maize gluten-meal-40, pearl millet and groundnut-cake. The lysine and methionine of groundnut-cake protein get extensively degraded in the rumen and needs to be protected for feeding top high producing animals.

Buffalo

Ammoniation has already been advocated to the farmers as the best method for improvement of crop residues. However, there is a great economic loss of urea-N in the form of free ammonia, which escapes to the atmosphere polluting the environment. The modified technology of urea ammoniation would be more useful in fixing ammonia without affecting the improved digestibility of crop residues, and it will be utilized by the animal for its body functions, checking the double loss caused by urea ammoniation.

In the laboratory scale trials efforts were made to trap the excess ammonia during urea ammoniation of wheat straw (AWS) using boric acid, sulphuric acid, hydrochloric acid, phosphoric acid, acetic acid and formic acid. The palatability and nutritive value of commercial hydrochloric acid treated straw were the best. Feeding of AWS to growing male buffalo calves up to 258 days was superior to HCl–AWS feeding indicating that trapping of excess ammonia by adding HCl during urea ammoniation of wheat straw has no extra benefit. Feeding of AWS as well as HCl–AWS showed no adverse effect on clinico-nutritional aspect and buffer quality.

Sheep

At the CSWRI, Bikaner, several experiments were conducted using mustard straw (MS) (treated/untreated) and peal millet *kadbi* (BK) as major source of roughage in complete feed blocks (CFB). The ration of roughage to concentrate in CFB was

UNCONVENTIONAL AND AGRO-INDUSTRIAL BY-PRODUCTS FOR LIVESTOCK FEEDS

The unconventional feeds, tested and recommended as energy source in livestock ration, are mango seed kernel, sal seed-meal, *vilayati* babul pods,tomato waste, tapioca starch waste, *mahua* flowers, molasses, malt waste, etc. The important protein source are babul seed *chuni*, *kuvadia* seeds, *pilludi*-cake, *Isabgul gola* and lali, *ambadi*-cake, niger seed-cake, rubber seed-cake, neem seed-cake, etc. *Mahua*-cake, babul pods, sububal seeds, single cell protein, corn steep liquor, sorghum gluten, etc., are good energy and protein sources. Unconventional feeds

- decrease the shortage of feeds
- give employment to the rural poor, and
- being low cost decrease the cost of livestock feeds.

The BIS approved some unconventional feeds. Use of these feeds and crop residues in the form of complete feeds provide readymade, balanced, low cost ration for livestock.

Judicious use of these techniques will help sustain economically viable livestock production, which will provide opportunity to livestock owners to uplift their socio-economic status.

MICRONUTRIENTS IN LIVESTOCK FEED

- *Micronutrient:* Supplementation of deficient micronutrients through area specific mineral salts developed by the NIANP, showed highly encouraging results in overcoming the problems of infertility in dairy animals in the IVLP-adopted villages.
- Trace mineral requirements of crossbred cows producing up to 10 liters of milk/day, could be met through feeding good quality green fodder along with concentrate. However, animals may not be able to fulfil requirements of Ca and Mg so these need to be supplemented through specific mineral salts. The retention of minerals was better in cows supplemented with minerals through inorganic source.

MILK REPLACER FOR KIDS

Milk was replaced by providing three levels of protein (20,24 and 28% CP) in Barbari goats. Palatability of all three milk replacers was very good in Barbari kids. Final body weight of replacer fed kids in all three groups was comparable with that of milk fed control. Average daily gain was also similar in treatment groups. DM, CP and OM intake increased during last phase of the trial in replacer fed groups over milk fed control. In the middle phase also OM and CP intake increased in replacer fed group. Ruminal VFA, acetate, propionate, butyrate and A/P ratio in replacer fed groups were comparable with that of milk fed control at 3 and 6 hr of feeding. Hence, rumen fermentation was not adversely affected. The experimental animals specifically replacer fed kids sustained very harsh weather of extreme cold.The cost per litre of reconstituted milk replacer in all three types is lesser than market price of goat milk.

Precautionary measures to be adapted during milk replacer feeding are:

- milk replacer should be thoroughly mixed in lukewarm water (40°C),
- reconstituted milk should be prepared just before feeding,
- feeding bottles should be cleaned thoroughly after each feeding, and
- two-times feeding of milk replacer is sufficient.

MAIZE IS DISPENSABLE FROM POULTRY FEEDS

Maize has remained the principal source of energy in poultry feed for several years but the diversified utility of maize for industrial purposes limited its availability for poultry. The increased cost of maize and its scarcity often prohibited its use in poultry diets. At the Project Directorate on Poultry, Hyderabad, possibilities of alternative energy sources for replacing maize from broiler diets, were explored. Entire maize from broiler starter (57%) and finisher (67%) diets was effectively replaced by *korra* (foxtail millet) without adversely influencing their body weight, feed consumption and meat yield. *Korra* as energy source had the advantage of retaining low serum cholesterol level compared to maize. *Bajra* and *ragi* were also useful in partially (25%) replacing maize from broiler diets.

60 : 40 or 70 : 30. The block checked selectivity of ingestion of concentrate and insured a constant proportionate intake of roughage and concentrate. Dry-matter intake of animals fed MS based blocks, ranged from 827 g to 956 g/animal a day, and was optimum for adult sheep. Intake from CBF, based on BK, ranged from 1,036–1,350 g/day. Mustard straw based CBF contained adequate CP to maintain adult animals. Urea and NaOH treatment and AHP (H_2O_2) plus urea supplementation increased digestibility of fibre fractions and gross energy.

Goat

Economic feeding systems and feed processing technologies were developed for small holders and commercial goat farmers. Effect of different nutritional strategies on feed utilization, growth rate and meat production in goats, were studied. By-products of pulses, oil seeds along with coarse cereals grains were utilized for intensive goat production. Mineral status of feeds vis-à-vis goats, were studied.

Camel

At the NRCC, Bikaner, complete feed using *guar phalgati* (*Cyamopsis tetragonoloba*) as the basal feed was formulated. The complete rations could meet the protein and energy requirements of camel calves. *Ardu* was the cheapest (Rs 270/q) and *khejri* the costliest (Rs 290/q) due to inclusion of higher tree leaves quantity in the complete ration.

Mithun

Survey and evaluation of feed stuffs eaten by mithun: A survey was conducted to identify the green forages of jungle consisting of tree leaves, grasses, herbs and shrubs, which are normally consumed by mithun in hill tracts of Nagaland. Survey was carried out pre-monsoon, monsoon and post-monsoon period at high and low altitude hill areas. Thirty-three feed stuffs from low hilly area and 26 from high hill area were identified and analysed for nutritive value. Maximum growth rate of 610 g/day could be achieved in mithuns on feeding of high energy and high protein diets. Growth rate and nutrient utilization improved on feeding of cultivated grasses, tree leaves and jungle grasses along with balanced concentrate feeds. A complete diet was formulated by using locally available green forages and cereals byproducts. A growth rate of 517 g/day was recorded on feeding of this complete diet.

Yak

Locally available tree fodders were identified and analyzed for different nutritional parameters, and comparative status of 12 different tree fodders as source of macro- and micro-elements was studied.

Poultry

Utilization of phytate phosphorus in poultry diet: Maize and soya products contain approximately 4.72 g phosphorus/kg, which is available to chicken lesser than 1.11 g/kg as it is present in phytate forms. A significant improvement (up to 38%) was achieved in utilization of phytate phosphorus in broiler chicken by reducing the levels of supplemental calcium from 11 to 60 g/kg diets. By increasing the utilization of phytate phosporus, the need for supplementation of inorganic phosphorus was reduced by about 33% (from 4.5 g to 3 g/kg diets). The proper utilization of these findings in practical feed formulations, may result in a net savings of Rs 150/ton broiler feed besides minimizing the environmental pollution through reduced excretion of Ca, P, Mn, Zn, Cu and Fe by 25 to 52%.

Synthetic colour broiler breeders perform well even on low-density diets: At the PD on Poultry, pure lines responded well to low protein (18.5%) and low energy (2,650 kcal ME/kg) diets up to 6 weeks of age. The performance of broilers for

body weight, feed conversion and meat yield was optimum with 18.5% in the diet. It was also supportive in maintaining low serum cholesterol and low fat deposition. The lowest (0.3%) level of methionine was as efficient as higher levels for growth and feed intake for pure lines. But, by increasing methionine level to 0.4% in the diet containing 18.5% protein, a significant improvement in feed conversion efficiency, and size of bursa, and decrease in abdominal fat were achieved. The broiler breeder lines need low concentration of energy, protein and methionine in diets implying minimization of cost on feed, which is the key for economical poultry production.

COMPLETE FEED–AN INNOVATIVE SYSTEM OF FEEDING ANIMALS

Complete feeding is a system that provides concentrate and roughages together in blended form, and except water all dietary essentials are supplied through it. It is advantageous against conventional system of feeding because of reduced labour cost, maintenance of uniform roughage concentrate ratio, uniform feed intake favouring uniform supply of nutrients and maintenance of rumen environment. Complete feeds based on crop residues and un-conventional feeds were evaluated for growing, lactating and adult cattle.

Growing Animals

- 30.0% wheat straw, 18.0% groundnut-cake (deoiled), 20.5% rice polish, 19.0% wheat bran, 1.0% salt, 10.0% molasses and 1.0% mineral mixture supports the growth rate of 435 g/day. It provides 12.0% DCP and 56.0% TDN.
- 30.0% sugarcane bagasse, 8.5% maize gluten, 20.0% *Prosopis juliflora* pods, 12.0% corn steep liquor, 0.5% urea, 8.0% molasses, 1.0% salt and 1.0% mineral mixture supports the growth rate of 497 g/day of growing calves. It provides 12.0% DCP and 58.5% TDN. It is 44% economical in terms of feed cost/day and 33% more economical in terms of feed cost/kg gain than conventional system of feeding.
- 40.0%wheat straw, 19.5% deoiled groundnut-cake, 8.0% wheat bran, 10.0% mango seed kernel, 10.0% mineral mixture and 10.0% molasses resulted in growth rate of 450 to 500 g/day in growing calves. It provides 11.0% DCP and 54.0%TDN. The feed cost is Rs 15/animal per day.
- Complete feed/TMR based on 52.0% wheat straw, 23.0% deoiled groundnut-cake, 9.0% *Prosopis juliflora* pods, 8.0% corn steep liquor, 5.0% molasses, 1.0% salt and 2.0% mineral mixture supports the growth rate of 468 g/day in growing calves. The feed cost/kg gain decreased by 46.35 and 36.84% in complete feed and TMR (total mixed ration), respectively, over the conventional rations.

Lactating Animals

- 30.0% wheat straw, 20.0% *Prosopis juliflora* pods, 6.5% rice bran, 5.0% wheat bran, 26.0% deoiled groundnut-cake, 0.5% urea,1.0% salt, 2.0% mineral mixture, and 10.0% molasses could be used as ration of lactating cows without any adverse effects on milk yield and milk fat%.
- 45.0% wheat straw, 25.0% deoiled groundnut-cake, 14.0% *Prosopis juliflora* pods, 3.5% babul seed *chuni*, 10.0% molasses, 1.0% salt, 1.0% mineral mixture and 0.5% urea could be used as ration of lactating cows without any adverse effect on production performance of cows. Total mixed ration is 8.66% economical than complete feed in terms of feed cost/kg milk yield. It decreases the feed cost/kg milk yield by 36.58% over conventional system of feeding.

AFLATOXIN DETOXIFICATION

Aflatoxin production was maximum in flake (ungrounded) form of feed as compared to meal (ground) form. Storage of feeds in open containers increased the aflatoxin production. Feeds stored in HDPE bags developed brownish green discolouration due to anaerobic conditions. Among the several antifungal agents screened propionic acid, copper sulphate, ammonia and sodium hypochlorite were most effective in preventing the growth of *Aspergillus* fungi.

AFLATOXIN EFFECT

No harmful effects on growth and feed intake in broilers were noticed when the aflatoxin level was maintained below 100ppb in feed. At 200 and 400ppb levels a significant depression in growth (19 and 40.6% respectively) and feed intake (16.4 and 38.2% respectively) was observed. The broilers fed 200 and 400ppb levels of toxin revealed marked pathological changes by enlarged liver (31.6 and 79.5% respectively) and kidney (38.6 and 116.3% respectively) besides a reduction in the size of thymus (14.5 and 39.1%, respectively). Skin pigmentation assessed against shank colour was poor with increased toxin level.

COMMERCIAL COMPLETE FEEDS

Various centres of the Network Programme have already launched the programme for promoting the use of complete feed in various villages in their state. About 250 million tonnes of complete feed was supplied to farmers at production cost (Rs 4.20/kg) in summer when there was scarcity of green fodder. In this season the farmers get remunerative price of milk. The milk production increased by 1 to 2 litres/day an animal. Complete feed will be the best option for feeding dairy cows during periods of scarcity/drought. The pilot scale plant for producing complete feed pellets installed as a part of the ICAR project has a capacity to produce 4.5 tonnes of complete feed per day in one shift. The technology for complete feed formulation is available for commercialization.

HERBAL AND BIOLOGICAL AGENTS PREVENT MOULD INFESTATION OF POULTRY FEED

Neem leaf, neem seed-cake, propionic acid and cultures of *Trichoderma viridae* produced positive response in controlling fungal proliferation in poultry feed. Neem leaf depressed fungal proliferation for 2 weeks, when added @ 800 g/ton feed, but not for a prolonged period of storage. A reduction of 47% in fungal growth was obtained with neem seed-cake on its inclusion at 100 g/ton feed. However, propionic acid (0.1%) in feed was highly effective with no trace of fungal growth.

Adult Animals

- 55.0% wheat straw, 22.0% *Prosopis juliflora* pods, 20.0% corn steep liquor,1.0% salt, 1.0% urea and 2.0% mineral mixture provides 6.7% DCP and 61.2% TDN. It forms an economic balanced ration for livestock.
- 60.0% wheat straw, 22.5% deoiled groundnut-cake, 5.0%, *Prosopis* pods, 10.0% molasses, 0.5% urea, 1.0% salt and 1.0% mineral mixture, provides 9.7% DCP and 54.2% TDN which is adequate for maintenance of adult cattle.

Processing and Utilization of Poultry Waste in Ruminants

The deep stacked poultry litter could replace 30–50% of concentrate mixture on N-basis when supplemented to quality roughage like naturally fermented straw, preparation as complete diet depending the production status of buffalo.

ASSESSMENT OF MICRONUTRIENT STATUS IN ASSAM, KARNATAKA, KERALA, MADHYA PRADESH, TAMIL NADU AND WEST BENGAL

Status of soil, plants, feeds, livestock was evaluated to assess the micronutrient availability to livestock in various agro climatic zones of these states. Trends of deficiencies in these agro climatic zones were ascertained. The bioavailability of the micro- and macro-elements, which hampers production of milk, meat, egg and other animal products was studied. Area specific mineral and trace element supplements were planned for raising livestock productivity and to check unnecessary loading of micronutrients.

Assam: Upper Brahmaputra Valley zone and North Bank Plain Zone were surveyed. Ca, P, Mg and Cu were observed below critical level in some fodder. Deficiency for Cu, Fe and Mn was above the critical level in 100% fodder in both districts. Mo was recorded below toxic level. The serum inorganic phosphorus concentration was below critical level in lactating animals of all categories of farms. Calf, heifers and pregnant animals belonging to small, medium and large farms also showed deficiency in Dibrugarh district. Cu was also observed below critical level in certain group of animals in this district. In Tinsukhia district all categories of animals showed below critical level for serum inorganic phosphorus except pregnant animals of organized farms. Other minerals were observed well above the critical level.

In North Bank Plain Zone Ca, P and Mg were observed below critical level for few fodders, whereas, Cu was observed below critical level in all fodder samples. The other mineral samples were well above the critical level.

Karnataka: After assessing the micronutrient deficiency in different agro climatic zones of Karnataka, area specific mineral salts were advocated. For cows yielding up to 10 liters of milk/day most of the trace mineral requirement could be met through feeding good quality green fodder along with concentrate. However, requirements of Ca and Mg could not be met, and had to be supplemented through specific mineral salts. The overall minerals retention was better in cows supplemented with minerals through inorganic source. Strategic supplementation of micronutrients through locally available green fodders, which are good source of most trace minerals could be a cost effective approach. The survey work revealed that the major deficiency is of Ca, P, Cu and Zn in animals. Region specific mineral supplements were formulated on the basis of these results. Cataloguing of locally available feeds and fodder was done based on the micronutrient status, for strategic supplementation in deficient zones.

Kerala: The surveyed areas revealed normal serum mineral concentrations in animals except for a marginal deficiency of Mg in certain areas, scattered deficiency of Ca in soil samples, and Cu and P levels in a few fodder samples. The lower

dietary intake of Ca in certain areas probably is because of the differences in the type of feeds and quality of mineral mixture provided to animals. Survey and analysis of soil, feeds, fodder and biological materials did not reveal any specific mineral deficiency in all the 14 districts of the state. The higher incidence of low production and reproductive disorders may be either due to marginal deficiencies of minerals/ vitamins which may go undetected, lower utilization of minerals due to interaction or imbalances or mainly deficiencies of major nutrients particularly energy.

Tamil Nadu: In North West agro climatic zone the growing and lactating cattle and buffaloes had lower plasma P level. The Ca to P level was wide in growing animals may be because of difference in the feeding practices adapted to raise growing cattle (grazing alone). In lactating cattle and buffaloes, the mineral deficiency/imbalance minimized due to additional supplementation of green forage/ feed/feed ingredients. The mineral status of fodder/feed supports this view.

Sheep in north eastern zone had lower plasma copper level. The forage species in pastures also had similar low level of Cu. As growing and lactating sheep in this region are maintained exclusively on grazing, there was no variation in the plasma mineral status of sheep. Goats in this region had lower plasma P level. The tree leaves, which they generally browse also had low P content. The study clearly indicated a need to supplement P and Cu in this region. The low level of minerals did not show any critical systems in this hilly zone.

West Bengal: Micronutrient survey studies in respect of soil, plant, feed and animals was completed in all the agro climatic zones of West Bengal. The dietary intake of Cu, Mn and Zn at 140% of the NRC recommended levels could enhance the digestibility of organic nutrients significantly.

MINERAL STATUS OF SOIL, PLANTS AND ANIMALS IN TAMIL NADU

In Cauvery delta and high rain fall zones no incidence of mineral deficiency symptoms was observed. The P level in four taluks in western zone was lower in growing HF crossbred cattle and in lactating cows in three taluks. Cu was below critical level for growing HF crossbred cattle in three of the taluks surveyed and lactating cattle in two taluks, while Zn and Fe concentration was above critical limits. None of the taluks surveyed in Southern zone revealed mineral status below the critical level in cattle. Studies on correlation between soil and plant revealed that even though Cu was above critical limit in soil the grasses/herbage grown on these soils were below critical level. However, Ca was below critical level in most of the unfortified soil, the herbage/ native grasses also have Ca concentration below critical level. Similar to soil and plant relationship, a positive correlation exists between plant (native grasses) and animals for P level. However, the Ca and Cu in animals did not appear to be influenced by the respective mineral concentration in native grasses.

ANIMAL PHYSIOLOGY

Cattle and Buffaloes

The area specific mineral salt provided with copper and cobalt, developed for Karnal area, were when supplemented @ 1 g/day an animal, improved anoestrous in dairy cattle and buffaloes.

A highly sensitive and specific second antibody enzyme immunoassay (EIA) on microtitre plates for oxytocin determination in bovine plasma was developed. This study opens the prospects of exploring the role of this hormone in various processes associated with reproduction and lactation which will provide reasons of low reproductive efficiency in bovines. Enzyme immunoassay for LH determination and FSH in buffalo plasma were also developed at the NDRI. Maximum heat symptoms were observed during winter (November to February) and lowest heat symptoms from March to August.

Multiplication of Elite Buffalo Germplasm through IVF Technology

The technique of IVF is being assessed for its practicability in buffaloes and the different steps were standardized using slaughterhouse oocytes. Next step is aimed at collection of oocytes from live animals through ultrasound guided aspiration technique to make the technique applicable for multiplication of elite germplasm and to accelerate the progeny testing of bulls.

Development of buffalo embryos in vitro *using complex and defined media*: The cleavage rate of 60% and transferable embryo yield of 25% were achieved in oocytes/ embryos cultured in complex media, as against the cleavage rate of 40% and transferable embryo yield of 12% in chemically defined media. The use of complex media containing serum resulted in more blastocysts per cleaved embryo compared to defined media. The post-thaw morphology and survivability rate of morulae culture in defined media was higher than those cultured in complex medium. The overall post-thaw viability of *in vitro* produced buffalo embryos was poor because embryos are highly sensitive to cryo temperature.

- Buffalo embryos were developed *in-vitro* using complex media.
- Carting potential of camels was studied.
- Camel semen processing and AI studied.
- Biofreezer used for freezing of goat semen.
- Pregnant mare serum gonadotropin was isolated, purified and characterized for the first time.
- Behavioural studies were carried out in mithun.

MITHUN

The maintenance and social behaviours of mithuns were recorded both quantitatively and descriptively under semi-intensive system of management. The ethogram revealed that the mithun spent more time in grazing and/or browsing followed by rumination. The mithun usually followed a definite biological clock. The elder mithun cow generally took the leadership of an all-female social group. Their respective mothers usually take care of mithun calves.

Sheep

Nulliparous ewes, multiparous ewes and both combined (control) were separately penned out of sight of rams for 4 months. About 39% nulliparous ewes and 69% multiparous ewes came in to estrus, after 15 days of introduction of ram. None of the ewes in the control group exhibited signs of estrus.

Plasma progesterone remained undetectable/low during estrus and parturition in Malpura ewes. Average plasma progesterone was 1.17 ± 0.36 ng/ml and 0.2 ± 0.0 ng/ml on the day of estrus during autumn and spring, respectively. The pattern of individual sheep breed suggested the random occurrence of peaks throughout the luteal phase of estrus cycle. The average progesterone and estrus levels were significantly different between parturition day.

Semen from 17 rams were processed for freezing. Doses of ram semen were stored in 0.25 ml (218) and in 0.5 ml (250) for use in laparoscope aided intrauterine AI or transcervical AI (TCAI), respectively. Evaluation of fertility and lambing rates were done following TCAI of native sheep with frozen semen using needles of different shapes. Lambing rates achieved were 30% with bent type needle, 30% with straight round tip and 30% with bent round tip. The conception and lambing rates with fresh and frozen semen achieved were 40, 30% and 40, 30% respectively. The conception and lambing rates followed by AI frozen semen through os-cervical, laparoscope aided intrauterine (IUAI) and TCAI methods, were 36.3,60, 30% and 27.3, 40, 30% respectively. The conception and lambing rates followed by AI using fresh and frozen semen through os-cervical methods, were 50 and 36.3%, 33.3 and 27.3% respectively. The overall conception and lambing rates followed by TCAI using frozen thawed semen from Malpura ram, were 90 vs 60% and 50 vs 40%. Conception and lambing rate following TCAI of native sheep with froze semen were 90 and 50%, whereas in epidosin (dilating agent) treated group the conception and lambing rates were 80 and 30% respectively. The overall conception and lambing rate with 0.5 ml and 0.25 ml dose of frozen semen by TCAI method, were 90 vs 80% and 50 vs 30%. The conception and lambing rate with fresh and frozen thawed semen with TCAI were 71.4 vs 57.1 and 57.1 vs 28.6% respectively.

Goat

Protocol for automation of semen freezing for higher post-thaw motility and fertility in goats, was standardized. The latest improvement in the field is the freezing of semen through biofreezer using controlled rate freezing. Caffeine addition in diluter was superior for achieving higher percentage of intact acrosome, progressive motile sperms compared to addition of ascorbic acid of control group in frozen buck semen. Work on development of a non-invasive technique of embryo collection and transfer in goats was initiated. Five kids were born through embryo transfer technology during the year. Physiological basis of thermoadapatability of goats was studied. Blood metabolic profiles of goats in different environmental periods were quantified. Package of management practices for commercial goat farming was developed. Hormonal and biochemical profiles of goats during different physiological stages were studied.

Camel

Carting potential for Jaisalmeri camels: A cart load equivalent to 300, 350 and 400% of their body weight could be successfully pulled by 80, 40% and 0% Jaisalmeri camels on a *kachcha* desert track of 20 km in 3.5 hr without any sign of stress.

Camel semen processing and artificial insemination: Regular carting has adverse effect on rutting activity, libido and semen donation efficiency. Out of 100 semen samples kept for refrigerator preservation 46, 35, 18, 10 and 2 could maintain motility respectively, for 24,48, 72, 96 and 120 hr in Tris dilutor while a commercial dilutor was not able to sustain sperm motility. None of the 10 female camels inseminated with diluted liquid semen conceived while 40% females could successfully be

impregnated with whole semen deposited into uterus. This indicated some important role of gelation of semen in sperm banking in genital tract and fertility.

Camel behaviour: Neonatal behavioural study in loose housing system revealed that the average time taken for the calf to stand on leg was 56.23 ± 10.44 min whereas the range was 25 to 90 min. The average time taken for first suckling attempt was 80.26 ± 8.53 min whereas the time interval for suckling varied from 1 to 3 hr. In 90% cases the locomotary movement of newly born calf was normal within 12 to 24 hr after parturition but 10% calves took more time to normalize their locomotary movement. Maximum calf (90%) could properly walk after 6 to 7 days of parturition but in some cases (10%) calves walked properly before 6–7 days. The study will be very useful in proper management and increasing survivability of newly born camel calves.

Pregnancy diagnosis in a jenny after AI using frozen semen

Equine

The results of defatted fresh jenny's milk as diluter for freezing semen were not encouraging and post-thawing sperms motility was less than 20%. Performance of citrate EDTA as centrifuge media and lactose-glucose-EDTA-egg yolk as freezing media, was satisfactory and achieved up to 55 to 60% post-thawing sperm motility. Conception rate of 45.4% in jennies was achieved at the farmer's door using frozen semen technology developed by the NRCE, Hisar.

Equine chorionic gonadotropin also known as pregnant mare serum gonadotropin (PMSG) was isolated, purified and characterized from serum of pregnant mares for the first time in India. This purified glycoprotein hormone was isolated @ 2.8 mg/ litre of serum with biological activity of 13,500 IU/mg. This hormone have dual hormonal activity, i.e., FSH and LH type activities, and is generally used for superovulation and synchronization of estrous cycles in animals other than equines.

Work was initiated on the development of ELISA based test for pregnancy diagnosis in equines and cryopreservation of stallion semen and perfection of artificial insemination for Marwari horses.

Yak

The baseline data on mineral profile in yak blood and milk were generated, and comparative elemental distribution in hair of yak, cattle, goat and pig was studied. Sexual behaviour of yak bull during usage of artificial vagina and natural mating was studied. Seminal characteristics were studied in summer and winter. Estrogen and progesterone in a ratio of 1 : 3.5 successfully inducted lactation in yaks.

The Jai Vigyan Project on Household and Nutritional Security for Tribal, Backward and Hilly Areas: Improved Livestock Productivity in Tribal, Backward and Hilly Areas

Migratory sheep, integrated piggery and backyard poultry were studied to develop sustainable livestock systems of higher monetary return, which should not only provide all the needs of life support system but also nutritional security to the households for these areas.

MIGRATORY SHEEP PRODUCTION SYSTEMS

Migratory sheep production systems were studied in cold and arid regions of Jammu and Kashmir and Himachal Pradesh and hot dry conditions of Rajasthan, to

- improve productivity of migratory sheep by applying scientific technologies of breeding, nutrition and health cover, and
- to provide livelyhood security to the farmers round the year by giving the inputs on their migratory routes of three states.

IMPACT OF MIGRATORY SHEEP PRODUCTION

- Pasture improvement was linked with sheep improvement programme to overcome poor lambing rate
- Supplementation of minerals, trace elements
- Narrowing down the male : female ratio from 1 : 100 to 1 : 50
- Control of ecto- and gastro-intestinal parasites
- Management of intervention points of migratory routes for giving inputs, checking the health status; and grassland, pasture land and range land improvement programmes should get a priority. Tropical and temperate pasture species of grass and legumes should be introduced on migratory routes.

IMPACT OF INTEGRATED PIGGERY PRODUCTION

The biggest impact of the project is development of self-help group for sustained piggery production by establishing "Breeding Unit" and "Fattening Unit".

- This programme had biggest impact in Mizoram, Nagaland and Jharkhand, where farmers realized that this programme can sustain and multiply in wider areas if two-tier system of breeder unit and fattener units are established having close link among the units.

- Farmers agreed to return the surplus piglets from first generation for distribution to next group of farmers.
- Farmers realized the importance of feeding pigs according to their age group and health status.

Rajasthan: Rajasthan migratory sheep start facing the fodder shortage from November, and so move to Diggi, Tonk, Bharatpur, Agra, Etawah and finally reach Kanpur. They start return movement on the same route after the onset of monsoon in July. Fourteen intervention points were identified on these migratory routes two in Uttar Pradesh and rest in Rajasthan. These intervention points are for providing services by State Governments of Rajasthan and Uttar Pradesh. During migration high mortality was recorded due to pneumonia, gastro-intestinal parasites, and protozoan infestation. Ectoparasites were also the cause of low production in most of the flocks. The number of rams in flock of 250 to 350 ranged between 2 to 4 only.

Himachal Pradesh: The three migratory routes namely Unna to Chamba (route 1); Chamba to Bilaspur (route 2); and Lahaul to Sirmaour (route 3) have 13 intervention points (4+5+4). Approximately 8 to 12 g mineral mixture with common salts were supplemented. No other feed supplement was given from the project. Heavy infestation of stongyle, amphistomes, coccidiosis in young sheep was observed. Sheep body coats were having tick infestation also. Dipping tanks were constructed to disinfect migratory sheep on these intervention points. The groups receiving health coverage and mineral supplement gained better body weight as compared to the group receiving only one input. Route 3 from Lahaul to Sirmour was better as compared to reoute 1 from Chamba to Unna, and route 2 from Chamba to Bilaspur in terms of gain in body weight, lambing per cent and wool yield in sheep flocks. Treatment-wise and route-wise variation in wool growth was not different significantly. Maximum abortions (8.3%) were recorded in flocks on route 1. Number of lambs born on three routes were 2,759, and 351 aborted.

Jammu and Kashmir: In the first year of the programme, migratory routes for undertaking studies were identified in the districts of Srinagar and Badgaon.

INTEGRATED PIGGERY DEVELOPMENT PROGRAMME

Development programme on piggery, a very important enterprise for tribal communities of northeastern hilly region, is in operation at Meghalaya, Nagaland, Mizoram and Jharkhand (Ranchi) to

- demonstrate the economic benefits of scientific management of pig husbandry by providing quality pig germplasm and inputs like feed, health cover, and other services,
- study the impact of the programme through modified service support system like linking pig germplasm unit (breeding unit) with fattening unit under self controlled rural mechanisms, and
- to demonstrate the benefits to attract other farmers for adopting similar programmes without support from out side.

Improved germplasm of Hampshire and local crosses at Meghalaya and Nagaland, Yorkshire at Mizoram, and Tamworth and local crosses at Jharkhand, were distributed among farmers. It is a two-tier programme linking pig breeding unit with fattening unit. The programme was undertaken in 35 villages of four states. Fattening units (269), breeding units (31) and farm families (302) were covered. Litter size at birth ranged between 4 and 9 in three states but at Mizoram it ranged between 7 and 8. Litter size at birth was more uniform in Large White Yorkshire in Mizoram.

BACKYARD POULTRY PRODUCTION

Backyard poultry production suits to the conditions of tribal farmers of remote and backward areas. The main objectives of this project are to

- demonstrate the benefits of rearing specially designed poultry birds (Vanaraja) under the backyard system of low input, and
- to provide food and nutritional security through consumption of surplus eggs and meat.

"Vanaraja" a multicolour medium sized dual purpose bird was developed for

rural and backyard systems at the Project Directorate on Poultry. For the first time in four North Eastern States of the country, Vanaraja was introduced for the benefit of tribal people. The significant achievement of the project are

- Chicks achieved a body weight ranging from 750 to 882 g in 6 weeks in all the four states. Feed conversion ratio also ranged between 1.63 and 2.55.
- Performance of Vanaraja adults was also satisfactory — age at sexual maturity 160, 180 and 176 days in Manipur, Arunachal Pradesh and Mizoram; body weight varied between 2.52 and 3.22 kg in males and 1.78 and 2.52 kg in females; layer performance 9.3, 14 and 11.5 egg/month a bird, which was more than 2-times of local birds.

Nutritional Security Studies

- Egg consumption in high income group farmers and low income group farmers improved. This backyard system provided high degree of nutritional security in one of the remotest villages in the country on China boarders.
- At Manipur Centre, 20 week-old Vanaraja birds weighed 2,360 g and 2,520 g under open and semi range conditions and local birds weighed 1,895 g. Under two range conditions number of days Vanaraja laid eggs was 168 days, which was 20 days lesser than local birds.
- Another important innovation of Manipur farmers was use of broody hens instead of government hatcheries. The chicks hatched under broody hen mechanism were in very high demand by the tribal people both for rearing and self-consumption.

IMPACT OF BACKYARD POULTRY FARMING IN MANIPUR

- At household level, these birds were fed on surplus grains, kitchen wastes, worms, insects, leaves, etc., with no cost involved on feeding.
- The eggs were sold, consumed and hatched. The twin objectives of egg consumption and generation of supplementary income were well achieved.

STUDIES ON PASTURE BASED ANIMAL PRODUCTION SYSTEM

Objectives of Network Programme on 'Crop Based Animal Production System' are to compare the different grazing management practices, and suggesting the best possible alternative for livestock systems dependent upon this system. The livestock system under this study consisted of cattle, buffalo, sheep, goat and camel.

IGFRI, Jhansi: Pasture improvement, forage evaluation, nutrient losses, and water conservation aspects were studied. Rotational grazing proved to be a good practice for *Cenchrus ciliaris* and *Sehima nervosum*, and under continuous grazing the vigour of *Cenchrus ciliaris* and *Heteropogon contortus* decreased considerably while *Dichantium annulatum* flourished well in deferred rotational system. As a whole rotational grazing promoted the vigour character of range grasses and continuous grazing system hampered these to some extent. Total forage production ranged from 7.9 to 9.5 tonnes/ha in continuous and deferred rotational systems respectively. *Heteropogon contortus* was the main forage producer in all the four systems and its production varied from 321.2 to 511.1 g/m^2 in cut-and-carry to deferred rotational system, which is more than 45% of total production.

CIRG, Makhdoom: Biomass production was more in the cut-and-carry system but cost of fodder production is higher under this system because it is more labour intensive. Rotational system grazing is mot economical on account of lowest rate of cost of fodder production. Livestock productivity is more under deferred rotational system of grazing. By integrating both livestock and fodder production the deferred rotational system seems to be more economical over other system of grazing.

CSWRI, Avikanagar: Economics of sheep and goat rearing under different grazing systems was worked out. The cost of grazing, fodder, shearing and prophylaxis and treatment for 16 animals in each group for 1 year under continuous, rotational, deferred rotational and grazing plus supplementation system was Rs 10,482, 5,990, 1,000, 238 and 316 respectively. The cost of concentrate feeding in continuous, rotational, deferred rotational and grazing plus supplementation system was Rs 2,809, 2,805, 2,819, and 7,533 respectively. Thus the total expenditure on 16 animals in these group was Rs 20,835, 20,859, 20,834 and 25,548 accounting grazing charges

Economics of goat sheep rearing under different grazing system was studied

and cost of fodder consumed by these animals from the pasture under continuous, rotational, deferred rotational and grazing plus supplementation system, respectively. However leaving aside the expenses on account of grazing charge and fodder cost, the total rearing expenditure under the four systems will be Rs 3,363, 3,387, 3,362 and 8,076 respectively. The total receipt in terms of value addition from lambs/kids, wool and manure was Rs 8,309, 7,702, 7,268 and 10,147 under continuous, rotational, deferred rotational and grazing plus supplementation systems respectively.

DAIRYING AND ANIMAL PRODUCTS TECHNOLOGY

MILK AND MILK PRODUCTS TECHNOLOGY

- Low cost processed cheese prepared.
- Conical process vat for viscous dairy products improved.
- Fruit *dahi* preparation technology developed.
- *Dahi* prepared from camel milk.

Value Added Products/Processes/Technologies

Developed low cost processed cheese (PC) preparations: The PC preparations substituting milk fat completely with vegetable fat were lower in costs and with a quality comparable to that of conventional processed cheese.

Process for micro-filtered milk with extended shelf life: The shelf life of the micro-filtered milk and that of the pasteurized micro-filtered milk was more than 1 month while it was 4 days for raw milk and 14 days for the pasteurized milk at 46°C.

Improved the conical process vat for viscous dairy products: This unit can be adopted by dairy plants handling viscous milk products.

Adoption of continuous paneer making machine: The unit can easily be adopted for other acidic coagulated milk products.

Developed technologies for fruit dahi*:* Fermented milks have been developed with the improved shelf life and acceptability. The plain *dahi*, had a shelf life of 18 days and the fruit *dahi* of 26 days at a storage temperature of 6 ± 1°C.

Standardized process of camel milk fermentation, viz., dahi: Its sensory evaluation test indicated 85% acceptability. The texture of camel curd (fermented milk) is loose and requires longer incubation period (18–22 hr) as compared to cattle milk curd. Camel milk curd has positive influence on digestive systems.

- Synergistic action of anti-microbial components was observed in goat milk.
- *Campylobacter jejuni* isolates from milk and milk products were characterized
- A multiplex PCR was developed for detection of *Listeria monocytogenes* in milk and milk products
- Beneficial effect of camel milk on glycemic control and diabetic quality of life in type I diabetes mellitus

MEAT AND POULTRY PRODUCTS TECHNOLOGY

- Dehydrated instant chicken soup mix developed using spent hen.
- Egg crepe, a convenience egg-rich item, developed.
- Food-borne pathogens testing methods developed.
- Red chili inclusion in chicken meat products improved storage stability.

Processing and Value Addition

- Technologies were developed for chicken nuggets, sausages, tandoori kababs, fried tenders (breast muscle-minor) from broiler-spent hens and enrobed meat products with high consumer acceptability.
- Complementary technologies were developed for chicken *samosa*, stuffed chicken *paratha* and chicken gel (stock for chicken soup) to improve the commercial viability of spent hen utilization and low cost improved chicken meat chips and curls.

Developed dehydrated instant chicken soup mix from spent hen meat: To widen the avenue for efficient disposal of less desirable spent (culled) hens, efforts were made to formulate dehydrated instant chicken soup mix from cooked (1 kg/cm^2; 15 min) and oven-dried (70 ± 1°C; 12 hr) spent hen meat stock (40%) in combination with refined wheat flour (30%), skim milk powder (15%), hydrogenated vegetable

oil (7%), common salt, seasonings and permitted food additives. Chicken soup mix packed aerobically in LDPE film (300 G) pouches or under vacuum in aluminum foil-LDPE laminated pouches revealed a gradual decline in pH and a progressive increase in TBA value of the product during 90 days of storage at mean ambient temperature (24ºC). The rate of lipid oxidation was, however, much faster in aerobically than that in vacuum packed sample. The product had low (0.53) water activity (aw) initially, which did not evince much change during storage. Similarly, moisture (5.6–6.1%), crude proteins (60.8–61.2%) and ether extract (13.9–14.5%) of the product during storage did not change. Both bacterial (log 2.5–3.6 cfu/g) and yeast and mold (log 1.0–1.4 cfu/g) counts remained fairly low throughout the storage regardless of packaging treatments. A few anaerobes were encountered in vacuum packed samples but no coliforms or staphylococci were detected. Sensory quality tended to decline with storage time but vacuum packed samples were preferred organoleptically over aerobically packed group throughout the storage.

Egg crepe preparation: Egg crepe, a thin, flat, circular egg-rich product, can be popularized as a convenience egg-rich item at growing fast food outlets and at homes. The most acceptable standardized formulation consisted of 60% homogenized liquid whole egg and 40% mixture of blended whole white rice and dehusked black gram splits. Besides skimmed milk powder (5%), salt (0.5%) and seasonings were incorporated in the formulation. Storage studies of most acceptable egg crepes at refrigerated (4 ± 1°C) and frozen (–18 ± 1°C) temperatures showed progressive increase in weight loss and TBA values and decrease in moisture content with storage time, but changes were slower in vacuum than that in aerobic packaging and at frozen than that at refrigerated storage. The bacterial counts gradually increased under refrigerated and the same tended to decrease during frozen storage. Although sensory quality evinced a gradual decline, the product remained sensorily acceptable for up to 22 days in vacuum and 20 days in LDPE packaging at refrigeration (4 ± 1°C) temperature. At frozen temperature (–18 ± 1°C), the crepes remained sensorily acceptable and microbiologically satisfactory for up to 60 days in both packs, but the vacuum packed crepes consistently received higher ratings over air-packed samples during storage. The ingredient cost of formulating 1 egg crepe (cooked weight about 46 g) was calculated to be Rs 1.37.

Quality assurance and monitoring of foods of livestock and poultry origin: Standardization/improvization of immunological and molecular methods for certain food-borne pathogens was carried out at the IVRI, Izatnagar. SDS-PAGE profile and immunoblotting of cell surface proteins of 30 different isolates of *Listeria* spp revealed that 28 and 75 kDa proteins were immunodominant, as well as *L. monocytogenes*-specific. Antiserum was raised against these peptides and used for standardizing immunoassays. A PCR method for detection of *L. monocytogenes* targeted to hly A gene was standardized. The test was specific and sensitive. A PCR method was standardized for detection of *Salmonella* spp of 32 different isolates. A 32-kDa polypeptide was immunodominant and the antiserum was raised against this protein antigen. An indirect-ELISA was further standardized. A PCR protocol was also standardized targeted to invA gene for detection of *Salmonella* spp from foods. Different selective broths were also evaluated for use in PCR protocol, of which a newly developed *Salmonella* enrichment broth and tetrathionate broth were better than RV and selenite cystine broth. PCR protocols for detection of verotoxic *E. coli* targeting VT1, VT2 and Ehly genes and *S. aureus* targeting enterotoxin gene were standardized.

Evaluation and extension of storage stability of poultry meat products: Effect of incorporation of different levels (0.05, 0.1 and 0.2%) of red chili extract in chicken meat-skin (70 : 30 w/w) and chicken gizzard snack resulted in decline in pH, moisture and microbial counts with increasing levels of red chili extract. Frozen samples had lower microbial (TPC, anaerobes, yeast and moulds) counts than the refrigerated samples, regardless of the type of the product. Sensory quality declined with storage time. Both chicken skin-meat cutlet and chicken gizzard snack containing 0.05% red chili extract had microbiologically safe and organoleptically acceptable shelf-

EQUINE AND CAMEL HAIR BLENDS WITH WOOL

Indian camel and equine hairs are having unique characteristic of natural colours ranging from light to dark brown, grey and light black. However, the fibres are coarse. The fibre quality of fineness and stiffness changes with the age of the animal, i.e., younger animal produces better quality fibres. These hairs are not commercially utilized and there is no commercial marketing centre. To explore the possibility to utilize fibres in small and medium sector enterprises, it was tried to blend colour camel hair and equine hair with white fine wool in different proportion to obtain various shade ranges, i.e., from light grey to dark grey and brownish colours. These blends were processed on standard woolen spinning system into yarn linear density of 2 to 4 Nm. The furnishing

fabrics having weight per sq. metre of 300 to 400 g/sq. metre were developed on handlooms. The various camel and equine blended products, which have exclusive natural colour resistant to fading on washing and sun exposure and also have higher drape and attractiveness over the traditional furnishing fabrics which are generally dyed. Moreover, these hair-blended products are low cost and unique fire extinguishing property. Exploitation of these non-conventional hairs for commercial products will enhance the marketability of fibre and enhance the income of hair producers. Moreover the rural artisan may get employment for manufacturing such unique products using handloom in rural areas thereby helping in development of rural economy.

life of 14 and 28 days under refrigerated (5 ± 1ºC) and frozen (–18ºC) conditions, respectively.

Determination of BHC and DDT residues in spent hen tissues: The BHC level in muscle of spent hen carcass ranged from 0.1–0.3 ppm while in liver and adipose tissue it was 0.1–0.2 ppm and 0.5–1.2 ppm, respectively. Adipose fat was store house of BHC. The level of DDT was recorded to be 0.1–0.2 ppm in muscle and liver while it was higher (0.4–2.1 ppm) in fat tissue. BHC was also higher in adipose fat (68%) followed by muscle (50%) and liver (34%). On the other hand, DDT occurred at higher rate in all tissues compared to BHC.

WOOL AND WOOL PRODUCTS TECHNOLOGY

Processing Technology of Hand-made Felts

Hand-made non-woven felted products were developed using camel wool, coarse sheep wool and their blends. The product thickness ranged from 2 to 5 mm and area density 300 g to 500 g/sq. m. The products have unique feature of natural colour, warmth, and strength.These can find application in floor coverings, jackets, etc. Embroidery and colour designing through patchwork would enhance the quality of felt.

Light Weight Hand-made Felts

These felts were prepared by using Angora hair in blends with fine quality sheep wool and have area density of approximately 100 to 200 g/sq. m. These products have unique whiteness, and can be dyed with natural and synthetic dyes.

Fish Production and Processing

CAPTURE FISHERIES

MARINE SECTOR

The marine fish production, in India, during 2001 has been estimated at 2.33 million tonnes, a decrease of 13%, as compared to 2.69 million tonnes of the preceding year. The pelagic, demersal and crustaceans group formed about 51%, 27% and 17%, respectively, of the total landings. The mechanized and motorized sector constituted 67.7% and 24.6%, respectively, of the total landings. The percentage contributions of north east, south east, south west and north west regions are 7.3, 22.2, 32.0 and 37.0 respectively.

- Marine fish production was 2.33 million tonnes.
- Management guidelines prepared for Rajasthan reservoirs.
- Induced breeding and larval rearing of medium carps achieved.
- Crossbreeding of freshwater prawns was attempted.
- Growth rate of Jayanti rohu was better in lower stocking density.
- Lysine and methionine supplementation induced early maturation in Indian major carps.
- Aquatic pollutant resulted in reproductive incompetence.

INLAND SECTOR

Inventory and mapping of large water bodies of West Bengal

A complete inventory and mapping of larger water bodies above 10 ha in the West Bengal have been done through digital image processing technique by using satellite data (IRS-IC & ID) acquired from National Remote Sensing Agency, Hyderabad. Analysis techniques were also developed to extract brightness (value), hue (colour) and saturation (colour purity) for each pixel which are correlated with actual on-site data on water quality. Multiple correlation coefficient has been computed for regression of these water quality parameters on reflectance of four bands. The significant values have been observed for water temperature, pH, chlorinity, salinity, NO_3, total N, silicate, Ca, GPP and respiration.

Assessment of production potential of Rajasthan reservoirs

Ecological investigations with major thrust on the evaluation of production potential of four southern Rajasthan reservoirs, viz., Jawai, West Benas, Nandsamand and Gambhiri were conducted. Based on biogenic production potential management guidelines have been formulated for these reservoirs.

CULTURE FISHERIES

FRESHWATER AQUACULTURE

Diversification of carp culture with medium carp

To diversify freshwater aquaculture, successful induced breeding and larval rearing of *Anabas testudineus, Clarias batrachus, Heteropneustes fossilis, Ompok pabda, Mystus vittatus, Labeo fimbriatus, Puntius gonionatus, Channa striatus* and *Pangassius pangassius* were achieved.

The medium carp *Puntius gonionatus* was evaluated as a candidate species for monoculture in three stocking densities of 5,000, 10,000 and 15,000/ha ponds. After eight months of culture the mean growth and survival levels recorded were 331 g and 94.3%, 259 g and 82.2% and 183 g and 77.3% gross and the respective net.

- Ornamental fishes identified in north and north-eastern states.
- Riverine resources were assessed in Garhwal, Uttaranchal.
- Immunostimulant technique developed for health management.
- Lightweight boat with strength and durability for backwater and coastal fishing was developed.
- Ready-to-consume fried mussel developed.
- Protocols developed sperm cryopreservation of fishes.

The production was 1,562.5 and 1,527.5 kg; 2,128.3 and 2,053.3 kg and 2,115 and 2,009.7 kg/ha respectively.

Large-scale breeding of giant freshwater prawn

Breeding and seed production of *Macrobrachium rosenbergii* was carried out in a semi-closed two phase larval rearing system. Twenty-one batches were reared till metamorphosis. Intensive rearing of the post-larvae in outdoor cement cisterns revealed that they could be reared @ 735/m^2 in one month. In the monoculture trials of the giant freshwater prawn, an yield of 658 kg/ha/7 month was recorded.

Crossbreeding of commercially important freshwater prawns

Crossbreeding was attempted between Mahanadi river stock of *Macrobrachium malcolmsonii* and Padma river stock of *M. gangeticum*. Hatched zoea larvea were reared in salinity range of 12–18 ppt. The larvae of F_1 generation were more or less similar in characteristics to those of *M. gangeticum*. However, the red chromatophores found on entire region of merus of second chelate legs from stage 16–11 of *M. gangeticum* larvae were absent among the hybrids.

Multi-locational testing of improved Jayanti rohu

Under multi-location field testing experiments, Jayanti rohu was cultured at Jallandhar (Punjab), Rahara (West Bengal) and Vijayawada (Andhra Pradesh). Results indicated higher growth efficiency of improved rohu over control in all the three testing centres. The culture of improved rohu was also carried out at stocking densities of 100 and 150 fingerlings in 10 m^2 cages for six months. The growth rate was higher in lower stocking density as compared to those reared under high stocking.

Early maturation of Indian major carps reared on lysine and methionine supplemented diet

The CIFA has achieved success in advancing the maturity of the Indian major carps by supplementing the semi-balanced diet with lysine and methionine broodstocks of the Indian major carps were reared on the 5 mm pelleted semi-balanced diet. Natural spawning took place in the cemented tank after 6 hr of the ovaprim administration.

Cage culture of fish

Cage culture experiment has been initiated to demonstrate the possibilities of fish production in cage from an open water system. A cage having dimension of 12 m^3 made of 5 mm Netlon screen was used to grow fishes in Mathura beel and West Bengal. The cage was reinforced by framed acrylic pipes. Fish growth increment in 45 days has been recorded as 50 g in *Catla catla* and 44 g in *Labeo rohita*.

Fish health

Experiments conducted on reproductive physiological response of fish *Rita rita* to aquatic pollutants revealed accumulation of ovarian and hepatic cholesterol and reduction in hormone 17ß estradiol level indicating reduced steriodogenesis and consequent reproductive incompetence.

Survey and breeding of the ornamental fishes

A survey was conducted to identify ornamental fish species in north and north eastern states. More than 100 species of ornamental fishes were identified. Captive breeding of *Carassius auratus*, *Puntius conchonius* and *Colisa fasciata* were standardized. A total of four variants in body colouration and caudal fin formation were recorded in gold fish.

Seed of *Ompak pabda* being reared in the hatchery

Hatchery produced seed of *Mystus vittatus*

Broodstock of rosy barb, *Punitius conchonius*

Ornamental fish Danio devario

COLDWATER FISHERIES

Riverine resource assessment in Garhwal region of Uttaranchal

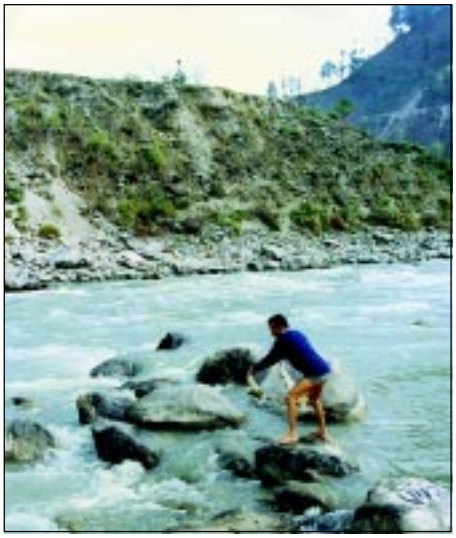
Ecological investigations were conducted on glacier and spring fed streams of Garhwal Himalayas to generate biodiversity database for developing conservation action plan. Most of these streams are in the oligotrophic state. The water quality was quite congenial for sustaining fish and benthic food chain. The main fishery comprised *Schizothorax richardsonii* (57–58%) followed by *Tor putitora* (5–15%). The other species recorded were *Labeo, Barilius, Glyptothorax, Pseudecheneis* and *Nemacheilus*. The catch per unit effort was extremely low in these systems. Potential site for conservation of both mahseer and snow trout were located in these streams.

Characterization of mahseer stock

A study was undertaken to characterize the population of commercially important mahseer in riverine and lacustrine ecosystem of Uttaranchal. Significant variation in the size and fecundity of mahseer stock in riverine and lacustrine was noticed. The study will be useful for stock improvement programme in the coldwater sector.

Fishery potential in Nainital lake, Uttaranchal

Ecological investigations were taken up to know the fisheries potential in the



A typical hill stream in Kumaon Himalayas

Farm reared brood fish of Rainbow trout at Chirapani

Nainital lake. Based on the conversion efficiency between primary production to fish biomass, it was estimated the lake has high production potentiality and fish production to the tune of 35–70 kg/ha/year could be achieved.

BRACKISHWATER AQUACULTURE

Prevention of seepage in brackishwater ponds

Laboratory studies were conducted to measure the seepage rate of different soil groups and to test lining materials to control seepage using the extended type LYNX falling head permeameter. These tests were repeated in field conditions in ponds with a variety of lining and fibrous materials like biocrete, sand cement plastering clay blanketing compaction using roller, polythene lining, lime, sea shell and sand plastering. Based on modified Penman method the evaporation rate was worked out to be 0.48 cm/day. Among the materials tested biocrete (mixture of cement, sand and natural fibre including bamboo frames) and cattle manure were found effective in controlling lateral seepage in ponds.

Identification of dietary cholesterol level in mud crab

To determine the dietary requirement of cholesterol for the juvenile of mud crab *Scylla tranquebarica*, feeding trials with six purified diets containing 0 to 1.4% cholesterol levels were conducted. The results indicated that juveniles crabs fed with 0.5% cholesterol diet gained highest weight with good moulting frequency and maintained natural colouration.

Diet for sea bass

A compounded diet with indigenous feed ingredients like soybean meal, squid meal, shrimp meal, trash fish and cereal flour was formulated for larva of sea bass. The seabass fry were successfully weaned on the formulated diet for 15 days. The performance of the formulated diet in terms of growth and survival was quiet high.

Kit for detection of White Spot Virus in Shrimps

Shrimp disease

To tackle shrimp disease problems, an immunostimulant has been developed for health management. A field trial with a Vibrio whole cell immunostimulant has been conducted with *P. monodon* in farmers fields in Tamil Nadu and West Bengal. The trial was successful and the shrimp exhibited better growth and the production was significantly high in immunostimulated pond as compared to control ponds.

A Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) technique was perfected for detection of yellow head virus which causes the devastating yellow head disease, in farmed shrimp.

MARICULTURE

Broodstock development, breeding and larval rearing of damselfish *Chrysiptera unimaculata* and grouper *Epinephelus malabaricus* was achieved in captivity. Juveniles of *Sepia pharaonis* were reared up to 10 mm size in captivity.

FISH HARVEST AND PROCESSING TECHNOLOGY

An improved design of a FRP boat which has light weight, strength and durability for backwater and coastal fishing was developed. Similarly a design was developed of a sail system for use on-board medium class fishing vessels for reducing fuel consumption during free running mode. Two canoes were constructed for marine and backwater fishing from rubber wood.

Canoe constructed from rubber wood

Harvest of healthy Penaeus monodon from on immuno stimulated pond

Technology for the production of ready-to-consume fried mussel in flexible retortable pouch with shelf life of more than a year at room temperature was developed. The technology for production of battered and breaded balls from small squids as raw material which otherwise not suitable for export was standardized.

Chitin and chitosan incorporated isinglass films were found very effective in maxillofacial surgery.

FISH GENETICS RESOURCES

Polymorphic microsatellite loci were identified from nine prioritized species through cross species amplification of primers obtained through bioinformatic tools. By using the identified microsatellite and allozyme markers for genetic stock of *Labeo rohita, Catla catla, Tor putitora* and *Labeo dero* across the natural range of their distribution were identified.

Using the developed protocols, sperm cryopreservation for wild accessions of *Horabagrus brachysoma, Labeo rohita, Catla catla* and *Cirrhinus mrigala* were made. Protocol development for sperm cryopreservation of *Labeo dyocheilus* was also done and viable progeny produced using frozen milt.

A comprehensive bibliography on pathogens and diseases of native and existing exotic fishes, shrimps and molluscs have been prepared.

A National Strategic document 'Plan and Guidelines' on 'Exotics and Quarantine of Aquatic Animals' has been finalized.

Genetic characterization of *Labeo* spp. viz., *L. rohita, L. calbasu, L. bata, L. fimbriatus, L. dyocheilus* and *L. gonius* was performed using RAPD profiling. Fifteen selected RAPD primers were used for profiling. The mean intraspecific genetic similarity (GS) values were 0.86±0.04, 0.88±0.04, 0.74±0.05, 0.88±0.05, 0.82±0.06 and 0.86±0.05 for *L. bata, L. calbasu, L. dyocheilus, L. fimbriatus, L. gonius* and *L. rohita* respectively.

Immunoglobulins were purified from BSA immunized *Cirrhinus mrigala* serum by affinity chromatography. The purity was confirmed by the presence of a single band in native gradient PAGE of 2.8-22.5% acrylamide. In SDS-PAGE the purified immunoglobulins showed one heavy and one light chain, the molecular weights were determined to be ~ 84kD and ~ 28 kD respectively.

HUMAN RESOURCE DEVELOPMENT

The academic programmes at Masters' and Doctoral levels, offered by the Central Institute of Fisheries Education, Mumbai, Central Marine Fisheries Research

FORMULATION OF CIFELOSTRESS TO REDUCE STRESS AND MORTALITY OF FISH SEED

The CIFE, Mumbai has developed CIFELOSTRESS, a combinational antistress formulation which reduces stress and resultant mortality of fish seed during transportation. The formulation has shown excellent results and there was satisfactory response from the users. The formulation is economically viable and help in ensuring high survival in long distance, transportation of fish seeds. The technology has been transferred to a private firm for its commercialization.

A fish farm women learning by doing in a training course organized at Madhubani

Institute, Kochi; Central Institute of Fisheries Technology, Kochi; and Central Institute of Freshwater Aquaculture, Bhubaneswar progressed satisfactorily as per schedule. A total of 85 students were awarded their Masters' Degrees and 22 Ph.D. degrees were also awarded, while 30 trainees successfully completed the one-year PG Diploma in Inland Fisheries.

Besides the three new Masters' Programmes, viz., Fish Pathology and Microbiology, Fish Nutrition and Biochemistry, Fish Genetics and Biotechnology, which were started during the last year, a new programme on Fish Business Management was also introduced from the current academic session. Ph.D. Programme on Post Harvest Technology commenced during the academic session of 2001. Students (47) including 2 foreign students enrolled under these 9 Masters' programmes, while 25 students, including 4 in-service candidates and one foreign student, enrolled for the Ph.D. programmes, 30 trainees were admitted to the one year PG Diploma in Inland Fisheries at Kolkata Centre.

Three training programmes, 8 Mass Awareness programmes conducted under DBT/NBDB Sponsored Programme on HRD in Coastal Bio-resource Development and Management besides Summer School sponsored by the ICAR on EIA and Management of Coastal Zones, and Indo-Israel International Training Programme on Advances in Aquaculture.

The CIFE, Mumbai conducted training programmes for the farmers of Andaman & Nicobar Panchayats at Mumbai and Powarkheda, Madhya Pradesh in collaboration with MPCON, the Academy of Scientists, Engineers and Technologists, and the DST, New Delhi.

SUCCESS STORIES

MANAGEMENT OF COASTAL AGRO-ECOSYSTEM AFFECTED BY SUPER CYCLONE IN INDIA

Seven ponds in super cyclone hit blocks of Ersama, Jagatsinghpur and Astarang (Puri) were taken up for composite fish culture along with prawn *M. rosenbergii* under poverty alleviation programme. Farmers were supplied with inputs like rice bran, rice polish, groundnut oil-cake, soyabean and advised to prepare supplementary feed by incorporating vitamins, minerals and probiotics. A partial harvest has shown 500–700 g size and 30–45 g size prawns in six months duration.

Mussel farming in Kerala

The technology for farming edible mussel (*Perna viridis*) developed by CMFRI is being adopted on commercial scale in the villages of northern Kerala. With the financial assistance from state Government under the SGRY (Swamajayanthi Gramaseva Rosar Yojana) and Co-operative Banks, more and more Women Self Help Groups (SHG's) are coming up for mussel farming in the backwaters adjacent to their houses. By adopting this production technology aquafarmers are producing 0.8 to 1.0 tonne of mussels in their farms.

PCR kit for WSSV in shrimp

A diagnostic PCR kit for identification of dreaded White Spot Syndrome Virus (WSSV) has been developed by CIBA Chennai. This PCR kit has a sensitivity of detecting 10 copies of virus. The PCR kit is economical and it has been transferred to a private firm for commercialization.

FRP canoes for coastal fishing

The CIFT, Kochi has developed a small size FRP canoes by using fibre glass reinforced plastic especially for use in backwaters and near-shore waters. Till now six such canoes have already been constructed for the Chellanam Village SC/ST Co-operative Society under the scheme of Special Central Assistance to Special Component Plan. The fabrication cost of each FRP canoe is about Rs 23,000.

Agricultural Engineering and Technology

FARM IMPLEMENTS AND MACHINERY

Tractor-operated Laser-controlled Land Leveller for Wetlands

A commercial design of the tractor-operated laser-controlled leveller was field tested at the ANGRAU, Hyderabad.

Based on the feedback from the testing of the above leveller, a new leveller has been designed by the ANGRAU, Hyderabad centre, for wetlands by adopting a commercial laser-beam sensor on it, which can be operated by a tractor-hydraulic system. In this, the angle of the blade can be changed to control the depth of the cut. The rotating laser-beam when touches sensor, activates hydraulic system to change the depth of the cut automatically. Field trials were carried out in 8 hectares, and the results were very encouraging for the precision levelling in wet conditions. Its field capacity has been found 1.8–2.5 ha/day at 3–4 km/hr speed.

ANGRAU tractor-operated laser-controlled wetland leveller. This has given encouraging results for precision levelling in wet conditions. Its field capacity is 1.8–2.5 ha/day at 3–4 km/hr speed

Rotavator Attachment for Self-propelled Reaper Unit

A rotavator attachment for the self-propelled reaper has been developed by the CIAE, Bhopal, from the available standard power-tiller rotavator components. The rear portion of the self-propelled reaper was removed and engine was shifted to the front of the power unit. The rotavator attachment was hitched to the drawbar of the power unit at the rear. The rotavator has 12 C-shaped blades, fitted on a rotavator-axle of 45 cm. The drive for the rotavator transmission system was taken from the PTO (power take-off) of the power unit through sprocket and chain-drive. Rotavator blades speed was set for 200 and 110 rpm with peripheral velocities of blades as 4.7 and 2.7 m/sec. To avoid injury to operator, a hood made of metal sheet has been provided at the top with a rubber cover at the rear. The depth of the cut can be adjusted with the rear wheel. The rotovator attachment was tested in the field, and the field capacity of the rotavator has been found as 0.06 ha/hr at a field efficiency of 65%.

Power-tiller-operated Wetland Leveller

A power-tiller-operated wetland leveller, developed by the ANGRAU, Hyderabad, has been tested in black cotton soils, red soils and chalka soils. Its operation speed varied between 1 and 1.2 km/hr, field capacity between 0.16 and 0.18 ha/hr and field efficiency between 60 and 65%.

- Developed a rotavator attachment for self-propelled reaper. With this, the depth of the cut can be adjusted with the rear wheel.
- Developed a power-tiller-operated wetland leveller with a field capacity varying between 0.16 and 0.18 ha/hr and field efficiency between 60 and 65%.

FARM IMPLEMENTS AND MACHINERY AT A GLANCE

Wheat raised-bed planter. Its cost of operation with 45-hp tractor for fresh beds is estimated at Rs 200/hr. With this, wheat yields obtained were 4.48 tonnes/ha, compared to 4.08 tonnes/ha of flat sowing

Modified PAU self-propelled rice transplanter. The estimated cost of the machine is Rs 70,000 as against Rs 120,000 of the imported unit

Tractor-mounted sugarcane trash-shedder. Its soil-mixing blades dig soil from the sides of the ridges and mix it with chopped trash. Due to its soil digging, fibrous roots of stubbles could be removed; which is useful for the ratoon-crop

Tractor-mounted hydraulically-opeated hoist for harvesting mango, guava, sapota and coconut. It is safe and stable in operation, and easy to transport, and its cost of operation is Rs 336/hr

Modified sprouted rice transplanter. Seeding of sprouted rice with 4-row seeder has been found 70.8% labour-, 87.11% energy- and 83.67% cost-effective compared to mechanized trans-planting of seedlings

FARM IMPLEMENTS . . . AT A GLANCE (*continued*)

Tractor-mounted turmeric digger. It could dig turmeric bulbs from 12-cm depth with 4% bulb damage

A commercial straw combine for straw harvesting has been field evaluated. It is recommended for faster collection of chopped straw from combine-harvested wheat field

Tractor-operated straw-chopper-cum-spreader. For rice-straw management, a tractor-operated, straw-chopping machine has been developed. The machine chops straws of 5-cm length and spreads it in the field. Its capacity is 4 ha/day

Raised-bed Planter for Planting Wheat

The effective field capacity of the raised-bed planter for fresh beds was 0.2 ha/hr, and its cost of operation with 45-hp tractor was Rs 200 per hour. And its time, cost and operational energy used per hectare with preparatory tillage were found 17.61, 22.83 and 19.70% higher than flat sowing. Three rows of wheat were planted shallow (depth of planting = 40 mm) at the inter-row spacing of 150 mm on each bed with 80 kg/ha seed rate and N : P : K at 90 : 30 : 15 kg/ha, based on the soil test. The peformance of the bed-planted wheat was found superior to flat sowing in respect of growth, active tillers and yield. The yield of the bed-planted wheat was 4.48 tonnes/ha compared to 4.08 tonnes/ha in flat sowing.

Wheat planting on permanent beds was more advantageous than fresh beds with preparatory tillage and flat sowing with conventional tillage.

RAISED-BED PLANTER *VERSUS* SEED-CUM-FERTILIZER DRILL FOR WHEAT SOWING

	Bed planting using raised-bed planter			Flat sowing with seed - cum-fertilizer drill		
	Preparatory tillage	Bed planting	Total	Preparatory tillage	Flat sowing	Total
Time required, hr/ha	8.40	5.00	13.40	8.01	3.03	11.04
Cost of operation, Rs/ha	1,512.00	1,075.00	2,587.00	1,441.80	554.49	1,996.29
Direct (operational) energy requirement, MJ/ha	1,576.59	1,005.02	2,581.61	1,504.14	568.98	2,073.12
Soil condition	Moisture content=23.16%db Bulk density=1.18g/cc MWD of clods=17.42 mm Depth of tillage=138 mm			Moisture content =23.82%db Bulk density=1.26 g/cc MWD of clods=21.42 mm Depth of tillage=110 mm		

PLANTING OPERATION ON PERMANENT BEDS/FRESH BEDS/ CONVENTIONAL FLAT SOWING

	On permanent beds	On fresh beds with preparatory tillage	Conventional flat sowing
Time required (hr/ha)	4.00 (70.1)* (63.8)ᵃ	13.40	11.04
Cost of operation (Rs/ha)	860 (66.8)* (56.9)ᵃ	2,587	1,996
Operational energy used (MJ/ha)	804 (68.9)* (61.2)ᵃ	2,582	2,073

*Figures show% saving over planting on fresh beds

ᵃFigures show% saving over conventional flat sowing

Refinement of PAU Designed Self-propelled Rice Transplanter

Design of the self-propelled rice transplanter has been refined at the PAU, Ludhiana centre. Machine's estimated cost is Rs 70,000 as against Rs120,000 of the imported unit. Its performance has been found at a par with that of the imported unit; commercial, available in the market. Production of this is being taken up in collaboration with a local manufacturer.

Sprouted Rice-seeder Refinement

A four-row manually-operated rice-seeder has been developed and refined at the CIAE, Bhopal, based on the feedback from the field tests.

Its metering mechanism is of gravity drop-type, consisting of 2 seed-containers with diverging ends. On the outer periphery of each container 8 holes of 12 mm diameter are provided. The length of the seed container is 220 mm; the diameter is 220 mm at both ends and 160 mm at the centre. The container is provided with an opening of 60 mm × 60 mm with a cover for filling seeds. The capacity of each container is 2-kg sprouted seeds. The seeder containers (2 no.) are mounted on a shaft connected to 2 lugged wheels. One frame-handle as marker and for pulling is provided. The drive wheels with lugs are made to function as support/transport wheels by providing mild steel round-ring over lugs. The support/drive wheels at both the ends could improve stability during operation compared to single wheel at the centre. The row markers spaced 200 mm apart have provision for changing depth of operation, suiting to height and convenience of the operator. The seeder

required 20-kg pull and dropped 6 seeds per hill with a spacing of 12 cm. The effective field capacity of the drum seeder was 0.08 ha/hr and its field efficiency was 85%.

Seeding of sprouted rice with the 4-row seeder has been found 70.8% labour-, 87.11% energy-and 83.67% cost-effective compared to mechanized transplanting of seedlings.

Tractor-operated Aero-blast Sprayer

The sprayer was tested in mango (0.82 ha), sapota (0.14 ha) and jackfruit (0.15 ha) orchards at the CIAE farm. The penetration of the spray into mango-canopy was measured by spraying red-coloured solution on 50 pieces of white card-sheets of 15 cm × 7.5 cm, mounted at the various locations in the canopy. Deposition of discharge was 84.25% at the periphery. Penetration efficiency of the sprayer reduced with increase in depth of the canopy, resulting in 44.95% deposition at 1-metre depth and 32.42% at 2-metre depth from the canopy surface. The deposition was found negligible beyond 2 metres. The operator felt uncomfortable to manoeuver tractor and sprayer beyond PTO speed of 411 rev/min.

The manually-operated rocker-sprayer had low cost of operation, low application rate and moderate field capacity, but tractor-operated aero-blast sprayer had highest field capacity, lowest manpower requirement, highest reach of discharge but high cost of operation.

Multi-crop Harvester for Intercrops in Rainfed Areas

Self-propelled vertical conveyor-reaper for paddy has been redesigned for harvesting safflower and sorghum. The prototype of multicrop harvester was tested with a 5.4 hp-diesel engine and with a 3.5-hp bi-fuel kerosene engine for harvesting

SUCCESS STORY

MANUALLY-OPERATED LOWLAND RICE-SEEDER

During peak rice-transplanting season, labour is scarce, and this results in delayed transplanting, which in turns affects productivity. To overcome this problem, a manual pre-germinated-rice-seeder has been developed by the TNAU, Coimbatore centre. It has eight rows with 200 mm row-to-row spacing. A lugged wheel is provided for giving drive to an agitator in the drums to facilitate easy flow of pre-germinated seeds. The machine floats on two skids. Pre-germinated rice seeds are kept in 4 drums, which have peripheral openings at two ends for seed discharge. The seed flow can be cut-off by closing holes with rings, provided over the drums. The seeder is manually drawn and requires two persons, one for operating the unit and the other for helping operator for filling seeds and turning at headlands. The overall dimensions of the unit are 1,650 mm × 1,600 mm × 690 mm and it weighs 11.2 kg. Due to maintenance of rows at required spacing, the weeding and interculture can be carried out easily using long-handled tools.

Manually-operated lowland rice-seeder

Field trials at the Research Farms at Coimbatore, Madurai and Bhavanisagar recorded average effective field capacity of the rice-seeder at 0.12 ha/hr with 63% field efficiency. Average seed rate of the seeder in the field was 85 kg/ha. The germination of rice-seed is not affected by the continuous seed-drum rotation. Rice Research Centres of the Tamil Nadu Agricultural University, at Coimbatore, Madurai, Aduthurai, Tanjore, Ambasamudram and Bhavanisagar had assessed performance of the lowland rice-seeder with transplanted rice and broadcasting method, and found grain yield higher with rice-seeder at all locations.

IIT, Kharagpur centre, had carried out prototype feasibility testing of the seeder. The seed rate for B 7029, Lolat, IR 36 and Shankar rice varieties during trials varied from 42 to 60 kg/ha. The field capacity of the seeder was found in the range of 0.1–0.14 ha/hr with the labour requirement of 15–20 man-hr/ha.

It was also tested at the ANGRAU, Hyderabad; CIAE, Bhopal; UAS, Raichur and KAU, Tavanur centres. Seeder field capacity varied from 0.08 to 0.14 ha/hr. The average field efficiency was 75%. The initial cost of machine is Rs 2,500 and its cost of operation is Rs 600/ha.

safflower. The field capacity of the harvester was 0.176 ha/hr, indicating 11.7 times more coverage than manual harvesting by a single person . The field losses were minimum, 0.86, within the permissible limits for the mechanical harvesting, though higher than manual harvesting. The physical comfort rating with harvester was quite high in terms of freeness from thorn-picking and tiredness from continuous work. It was 94 as compared to 27 points with manual sickle in 100 points score. Its harvesting efficiency and field efficiency were 98.2 and 97.0%, respectively.

The machine could not harvest chickpea as shattering losses were high due to poor conveying of the harvested crop due to shorter crop height.

The field capacity was 0.24 ha/hr at a forward speed of 3.0 kph for a non-lodged erect crop. Performance of the harvester for harvesting wheat was found good.

Tractor-mounted Turmeric Digger

MPKV, Pune centre, has developed a tractor-mounted turmeric digger. It consists of 2 cutting-blades mounted 32-cm apart, which cut ridges from both the sides. It can dig turmeric-bulbs grown on both sides of the ridges. The blades are fitted with lifting rods to separate soil from turmeric-bulbs. The preliminary trials conducted on 4 hectares of turmeric, grown on raised beds, have showed that it could dig turmeric-bulbs from the depth of 12 cm with 4% bulb damage.

Combine for Harvesting Wheat and Soybean

Combine harvester use was assessed by the CIAE, Bhopal, in Central Narmada Valley, Vindhya Plateau and Malwa Plateau of Madhya Pradesh. Its maximum use was in wheat harvesting (69.5%) in Central Narmada Valley, followed by Vindhya Plateau (45.9%) and Malwa Plateau (10.6%). Out of the three zones, highest percentage of soybean area harvested was in Vindhya Plateau (40.6%), followed by Central Narmada Valley (35.9%) and Malwa Plateau (1.71%). Combine use was directly related to crop yield in wheat but this was not true for soybean.

Tractor-mounted Hydraulically-operated Hoist

TNAU, Coimbatore centre, has developed a tractor-mounted hydraulically-operated hoist for harvesting mango, guava, sapota and coconut. It is ideal for tree-lopping, pruning and for spraying on the tree-canopy and for oil-palm harvesting. It is safe and stable in operation, and easy to transport. It consists of 600 mm × 600 mm aluminum ladders made of U-section as frames and round-hollow pipes as cross-members. The lowering and raising of the hoist platform is by the hydraulic motor, run with auxiliary hydraulic system of tractor. This helps as a safety frame for the person standing on the platform, and the ladder platform height can be varied from 5.8 to 9.8 m. Its cost of operation is Rs 336/hr.

Tractor-mounted Sugarcane Trash-shredder

MPKV centre has modified tractor-mounted sugarcane trash-shredder by replacing 'C'-shaped blades by power-tiller, rotary-type blades. Sugarcane-trash height lying in the field after harvesting was 15.30 cm. Dry leaves (trash) of 118-cm length were reduced to a length of 13.34 cm. The soil-mixing blades were able to dig soil from the sides of ridges and mixed it with chopped trash. The field capacity of the machine was 0.21 ha/hr. In addition to this, due to digging of soil on both the sides of the ridges to a depth of 7 to 8 cm, fibrous roots of the stubbles could be removed; which was useful for ratoon-crop.

- Wheat planting on permanent beds found more advantageous than fresh beds with preparatory tillage and flat sowing with conventional tillage.
- Modified 4-row manually-operated rice-seeder found cost-effective compared to mechanized trans-planting of seedlings.
- Evaluated tractor-operated aero-blast sprayer for orchards. It showed highest field capacity, lowest man-power requirement, highest discharge rate but its cost of operation was high.

Straw Harvester for Combine-harvested Wheat Field

Harvesting rice and wheat with combine leaves considerable straw and stubbles in the field. At an average straw : grain ratio of 1.50 : 1.00 for wheat and 1.00 : 1.00 for rice (about 5–7 tonnes of straw) are available per hectare after crop harvest.

A commercial straw combine for straw harvesting has been evaluated at the

CIAE, Bhopal. The machine was hitched to rear of the tractor on the draw bar-link.

Loose straw and stubbles left on the field after grain-combining gave an overall mean of 581 g/m^2. During field operation of straw harvester only 52% of the total straw/stubble available on the field could be harvested and the rest remained beyond the reach of the cutter-bar and the straw-collection unit of the harvester. Straw/stubbles 20% and 6% were broken and bent, being suppressed under the wheels of the grain-combine and tractor. Therefore, out of 5.81 tonnes of straw/stubbles/ha, straw harvester could recover only about 3.02 tonnes of straw/ha at the straw output of 1,027 kg/hr.

With 52% recovery of the straw and partial collection of the left-out grains from the field, the net income gains were Rs 1,690 per hectare. It is recommended that straw harvester may be used for faster collection of chopped straw from combine-harvested wheat fields. When straw is not to be collected, machine may be used to blow-out and spread chopped straw on the field for incorporation, and it may facilitate unimpaired drilling of the subsequent crops in straw-mulch cover.

- Prototype feasibility testing done on tractor-mounted rotavator, pulverizing roller attachment, ANGRAU Hydrotiller, zero-till drill and light weight power-weeder.
- Evaluated self-propelled vertical conveyor-reaper for rice and wheat. The saving in cost by this was 24% in harvesting and 60.5% in labour requirement.

Tractor-operated Straw Chopper-cum-Spreader

To solve the problem of rice-straw management, for its incorporation in the soil, the PAU, Ludhiana centre, has developed a tractor-operated, straw-chopping machine. The machine harvests straw and chops it into pieces for spreading in the field in a single operation. The chopped and spread stubbles are buried easily in the soil by traditional disc-harrows in 2 operations. The straw chopper can be operated by a 40–45-hp tractor, and can chop straw to 5-cm length and spread it in the field. The field capacity of the machine has been found as 4.00 ha/day.

PROTOTYPE FEASIBILITY TESTING

Tractor-mounted Rotavator

The machine has showed promise for seed-bed preparation in a single or double pass compared to 3–4 operations in the conventional method of the seed-bed preparation.

Tractor-mounted Pulverizing Roller-attachment

PAU, Ludhiana centre, has developed a pulverizing roller-attachment to 9-tine cultivator. It is suitable for puddling as well as for dry seed-bed preparation. Performance of equipment at higher speed of 4–5 km/hr is better because of churning action of the soil. The equipment could cover 2.5–3.0 ha/day with 70–90% of field efficiency and saved one-third of the irrigation water, because of better puddling. It saves 40% in labour requirement and 20% in cost of operation over the traditional method.

A pulverizing roller attachment to 9-tine cultivator has been developed at the PAU centre. It saves 40% on labour and 20% over cost of operation

ANGRAU Hydrotiller

It churns wet soil and levels field thus reducing labour (6 man-hr/ha) for levelling puddled soil. Its field capacity was 0.18 ha/hr with field efficiency of 94% and cost of operation was Rs 311/ha compared to 0.15 ha/hr, 81% and Rs 516/ha, respectively, of the power-tiller. The cost of puddling operation by this was 40% lesser than power-tiller.

Light weight power-weeder for interculture. It is found suitable for weeding with 40-cm rotavator and rotary wheel. There is a net saving of Rs 1,070/ha with this, compared to traditional method of interculture

ANGRAU Animal-drawn Puddler in NEH Region

The ANGRAU animal-drawn puddler was operated by the ICAR Research Complex for NEH Region, Barapani centre in the valley lands of watershed in Mawpun village of Ri-Bhoi district of Megyalaya. This puddled soil was better than the soil puddled with local plough. It saved 80% in labour and 72% in operational cost as compared to bullock-drawn country plough. The field efficiency was 65%.

Tractor-mounted Zero-till Drill for Peas

The sowing of pea for seed-grain purposes under the sodic saline soils could be advanced by 9–12 days with the zero-till drill. The net profit of Rs 17,670/ha could be achieved by using zero-till drill as against of Rs 7,436/ha with 3 operations of tillage (two cultivator + one *patela*) and of Rs 2,066/ha by broadcasting in the well-prepared field.

Light-weight Power-weeder for Interculture

The light-weight power-weeder has been found suitable for weeding with 40-cm rotavator and rotary wheel. The interculture was conducted in 9 hectares of sugarcane, 4.5 hectares of maize and 2 hectares of tobacco. Field capacity and field efficiency of the weeder for the crops were 0.2 ha/hr, 0.11 ha/hr and 0.2 ha/hr and 90%, 77.5% and 95%, respectively. And there was a net saving of Rs 1,070/ha with the use of the weeder compared to traditional method of interculture.

Self-propelled Vertical Conveyor-reaper

Evaluated the reaper at the AADU,Allahabad centre, for rice Pant 10 and wheat PBW 245 and UP 262, covering 42.85 ha and 18.5 ha. Machine capacity was 0.19 ha/hr and its efficiency was 59%for rice. For wheat PBW 245 and UP 262, machine capacity ranged between 0.16 and 0.22 ha/hr and its efficiency between 63 and 68%. Manual harvesting required 144 man-hr/ha and another 84 man-hr/ha were required for crop collection and bundling. Thus, harvesting manually costed Rs 1,900/ha against Rs 1,442 (including crop collection and bundling) per hectare by the reaper. There was the saving in the cost of harvesting by reaper of 24% and in labour requirement by 60.5%.

POST-HARVEST ENGINEERING AND TECHNOLOGY

Pre-milling treatment and recovery of *dal*

Whole pigeonpea grains (Asha variety) were treated with 4% soil, followed by 4% CIRCOT enzyme. The pitted and cleaned samples were soaked in water for 75 min and later dried up to 10% moisture. The samples were milled for 20, 25, 30, 35 and 40 seconds. The results showed enhanced recovery of *dal* due to applied enzyme. The *dal* yield was 80.56 to 84.04% with 6.02–7.24% broken material.

Post-harvest Losses Reduction in Strawberry

GA_3, NAA, 2,4-D, TIBA, $CaCl_2$ and Ca $(NO_3)_2$ were sprayed at 4 and 2 weeks before harvesting strawberry. Calcium nitrate (1%) reduced PLW, GA_3 (25 ppm) favoured TSS retention during storage; 2,4-D (40 ppm) arrested acidity; NAA (75 ppm and 25 ppm) preserved more sugar and vitamin C contents respectively during storage. Calcium chloride, ascorbic acid and calcium nitrate were used after harvest. Ascorbic acid at 0.2% and at 0.05% was found better for minimum PLW and higher vitamin C retention. Calcium chloride at (0.1%) was effective in arresting acidity

ANTI-NUTRITIONAL FACTORS MINIMIZED FROM SOYBEAN

Soak soybean seeds inoculated artificially with *Rhizopus oligosporous* and *Aspergillus oryzae,* followed by blanching them for 10 and 40 minutes. This results in 68% reduction in phytic acid. The blanching for 10 minutes was done at 15 psi or 1 atmosphere and for 40 min through open-boiling at 100°C.

during extended storage. No chemical proved better over control for higher TSS and reducing sugar retention in storage (up to 9 days)

Enhancement of Shelf-life of *Ber*

For room storage of *ber*, polyethylene bags and waxing of fruits should be preferred to minimize decay losses (24.31%) after 9 days of storage. Gunny bags were best packaging material for zero-energy cool chamber storage, as it minimized decay losses (16.91 and 17.22%) in waxed and unwaxed fruits in 9 days of storage. Storage of *ber* was not economical beyond 9 days.

OSMOTIC DEHYDRATION FEASIBILITY STUDIES OF SOME VEGETABLES

Parameters	Commodity		
	Cauliflower	Mushroom	Greenpeas
Initial moisture content (% weight basis)	89 - 91.2	90 - 92.3	84 - 86
Best suited osmotic solution	10% sugar + 10% salt	10% salt	10% sugar + 10% salt + 0.1% $MgHCO_3$
Moisture loss due to osmosis (% points)	42.5	49.3	38.7
Optimum time for osmosis (hr)	4	4.5	6
Solids gain (g/100g wet material)	8.6	6.2	6.7
Maximum dehydration ratio	4.2	2.3	3.1
Texture g (load)			
Fresh	116.8	1756.1	24.4
Dehydrated	46.6	48.9	45.3
Colour (LAB scale)			
Fresh	88.3, 7.8, 26.2	80.9, 4.03, 17.7	44.94, – 9.47, 25.23
Dehydrated	92.2, 6.7, 28.6	57.31, 7.96, 27.07	42.4, – 8.28, 26.25

Storage of Jaggery-chocolate

Technology for jaggery-chocolate production has been standardized. Equilibrium moisture content (EMC) of unwrapped jaggery-chocolate stored at room temperature was more than wrapped samples at different relative humidities. Wrapped chocolate could be stored at higher temperature and even at higher relative humidity.

Preservation of *Rab* (Liquid Jaggery)

The plastic and stainless steel-pots have showed their suitability for storing *rabs*. Citric acid (0.04%) and potassium meta bi-sulphite (0.1%) helped in preventing inversion, bacterial growth and also crystallization.

Jaggery-based Extruded Product

Raw materials for jaggery-based extruded products are wheat-flour and broken rice-flour. The flours were roasted separately and added to melted jaggery. This paste was extruded through 3-mm-size orifice of extruder, oven-dried at 60°C, packed

- Recovery of *dal* from pigeonpea enhanced in milling with the application of 4% CIRCOT enzyme.
- Antinutritional factor, phytic acid, reduced from soybean seeds artificially inoculated with *Rhizopus oligosporous* and *Aspergillus oryzae*, and blanching them for 10 and 40 minutes.
- Okara, by-product of soymilk, found suitable for making high fibre nutritious soy-cereal snacks with rice, wheat, maize, *jowar* and *bajra*.
- Technology for jaggery-chocolate production standardized.
- Plastic and stainless steel pots proved promising for storing *rabs* (liquid jaggery).

OKARA FORTIFIED SOY-CEREAL SNACKS USING WENGER EXTRUDER

Okara is a by-product of soymilk process. From 1 kg of soybean about 1.1 kg of okara is obtained, having 75–78% moisture. On the dry basis, soy okara contains 22% protein, 10% fat, 27.5% carbohydrates, 34.5% insoluble fibres and 3.5% ash, and hence is suitable for making high-fibre nutritious soy-cereals-based snacks. Okara was added to rice, wheat, maize, *jowar* and *bajra* at 6, 14,and 18% fortification level. The highest expansion was obtained when okara was fortified with *jowar,* followed by wheat and rice.

PROBLEM AREAS IN *KHANDSARI* UNITS

The major problems in *khandsari* (sugar) industry include poor juice recovery, open-pan system of manufacturing, crushing, inversion losses due to uncontrolled heating and lack of mechanization of different unit operations. The total losses of sugarcane in *khandsari* mill with open-pan system ranged from 3.7 to 6.2% and with vacuum-pan system losses were only from 1.65 to 2.9%. The study suggested use of vacuum-pan system, mechanization of various operations, improvement in juice recovery through imbibition system, and crop management through varietal schedule.

ECONOMICS OF PILOT PLANT FOR SOY-BASED ICE-CREAM

Four pilot plant equipments, pasteurization tank, homogenizer, refrigerated ageing tank and softy ice-cream machine were procured to produce 100-litre soy ice-cream per day. Experiments were conducted by replacement of milk with 100% soymilk in common ice-cream to compare it with a commercial ice-cream plant. Hundred per cent soymilk ice-cream was found inferior in quality compared to commercial dairy milk ice-cream. However, when compared with ice-cream of 100% over-run, as obtained by commercial plant, the ice-cream from the pilot plant with 60% over-run was more acceptable. The working capital investment was Rs 287,925 for 100 litres per day capacity plant. The cost of production per litre and net profit were Rs 25.40 and Rs 1,180,800. The break even point was 33 days/5,209 litres.

and subjected to sensory evaluation. The product obtained from broken rice-flour and wheat-flour and jaggery in 1 : 2 : 0.25 attained the highest score on 9-point hedonic scale, and was most liked due to texture, taste, appearance and overall acceptance.

- To prepare grey-cotton fabric for dyeing, plasma treatment, developed at the CIRCOT, can substitute fully or partially the conventional wet chemical process.
- Developed a new bio-chemical scouring technique for cotton and P/C blended fabrics. This process can be coupled with Hand-processing unit, and can reduce pollution by 25% and save 30% in energy needs.

COTTON TECHNOLOGY

Eco-friendly and Cost-effective Means to Strengthen Cotton-Yarn

Cotton-yarn wetting brings about many changes in its properties. A recent investigation conducted at the CIRCOT has revealed that subsequent to swelling in water if the yarn is stretched and dried in taut state (referred to as treatment), permanent structural transformations could be brought about. This increases yarn strength by 20% and brings about considerable improvement in various moduli values, making it more “elastic”. The treated yarn does not exhibit any changes in its properties on wetting in water.

Bio-chemical Scouring Technique for Cotton and Blends

In this method, employing a mixed microflora, the fabric was subjected to an anaerobic treatment at the room temperature, followed by boiling in the mild alkali. While the properties of bleached and dyed fabrics were at a par with the conventionally processed ones, but their colour value was found higher. This process can be easily coupled to existing Hand-Processing Unit, and can result in reduction of pollution load by 25% and lead to energy saving of 30%.

Plasma Treatment for Improving Cotton Fabric Dyeability

Plasma treatment can substitute either fully or partially the conventional wet chemical process used to prepare grey-cotton fabric for dyeing. Grey and bleached fabrics indicated increased absorbency by about 68–75%; the longer was the plasma treatment time, the better was the absorbency, and absorbency values were on a par with those of bleached fabric, normally used for dyeing.

LIPASE FROM *CANDIDA CYLINDRACEA* FOR WAX REMOVAL IN GREY-COTTON FABRICS

Candida cylindracea lipase and the commercial lipase could remove sufficient wax in the moderate conditions of treatment. The weight loss in enzyme-treated fabric samples was lesser than chemically scoured fabric.

JUTE TECHNOLOGY

Simultaneous Alkali Treatment and Bleaching of Jute Goods

The novelty of the present method lies in achieving multiple advantages by prior alkali treatment and then bleaching in alkaline conditions. The pretreatment with alkali in controlled way improves softness and dye uptake of the product. There is no need to drain alkali, and the softened material may be bleached in the same bath, without additional heating to get satisfactory whiteness and brightness index. Thus in this process not only the effluent disposal problem has been overcome to a

significant extent but consumption of energy for bleaching can also be avoided. This single-bath processed material can then be conveniently dyed with reactive dyes to get better dye uptake and colour yield. With Procion Red M8B and Remazol yellow FG dyes, colour yield could be improved by 18% and 42%.

Microwave-induced Biomethanation of Jute Waste

Methanosarcina barkeri (DSM 804) is a methanogenic and strictly anaerobic bacteria, capable of accelerating biogas production from cellulosic wastes. Methane content of biogas can be improved further by inducing bacteria with microwave, and it was established that irradiation of bacteria with a microwave of 31.5 GHz frequency of 10 dbm power for 2 hours could boost methane content of gas up to 76%, as against 55% achieved with the use of non-induced bacteria.

- Developed a novel method for jute bleaching. In this jute is given alkali treatment, and then bleached in alkaline conditions. This single bath processed material can be dyed with reactive dyes, Procion Red M8B and Remazol yellow.
- Improved methane content of biogas by inducing *Methanosarcina barkeri* (DSM 804), a bacteria, with a microwave irridation at 31.5 GHZ frequency of 10 dbm power for 2 hr.

LAC TECHNOLOGY

Quality Brood and Sticklac Production on *Ber*

A sustainable technology has been developed for good quality brood and sticklac production under three-coupe system. Two coupes consisted of kusum plants and one of *ber*. The technology offers 40 to 50% increase in productivity and profitability, as compared to on kusum only or on *ber* only.

Bioactive Compounds Synthesized from Aleuritic Acid

From aleuritic acid, a component acid of lac resin, 10-carboxy methyl-Z decenoic acid has been synthesized and tested as plant growth regulator (PGR analogue) on *in-vitro* shoot-tip culture of *Flemingia macrophylla.* At 5 ppm concentration of the PGR analogue, root-initiation was observed after 45 days of inoculation. This initially suggests presence of auxin-like activity in the PGR analogue.

EXTRACTION OF FIBRES FROM BANANA PSEUDOSTEM

The applied compressive stress during fibre extraction from banana pseudostem should be more than what non-fibrous tissue can withstand, but at the same time lesser than the fibre-breaking stress so that non-fibrous tissues get ruptured and fibres can be extracted without damage.

ENERGY IN AGRICULTURE

RENEWABLE SOURCES OF ENERGY

Drying, Enrichment and Handling of Biogas Plant Spent Slurry

To study the effect of slope on slurry filtration, a variable slope slurry filtration system was developed, which provided 2° 4', 5°3' and 7°5' slopes to the filtration unit. The slope of 2° 4' was found optimum. Composting pits of 2 m × 1.5 m × 1 m each were constructed and polyethylene sheet was laid on the bottom of the pits to check any possible seepage and moisture depletion. The rice straw and soybean straw were evenly spread on the bottom of the separate pits in 10–15-cm thick layers and the colloidal filtrate, from the filtration of the biogas spent slurry, was poured in such a fashion that filtrate moisture is absorbed by the layer of the selected absorbent. The filtrate absorption capacity of rice and soybean was 11 to 8 times of the initial weight. And the total solids content of filtrate and rice straw and filtrate and soybean straw varied between 8 and 11% and 12 and 14%. This practice was followed on the daily basis. After completion of one layer, another layer of absorbent was prepared. The composted mass was left undisturbed for 60 days for composting, and temperature inside the pits was monitored periodically. The temperature gradually increased after twelfth day and reached maximum on the 25 day. Then slowly decreased to ambient temperature. The leguminous straw decomposed faster than the cereal straw. The mixture containing soybean straw and biogas plant spent slurry was nutritionally 22–27% more enriched as compared to mixture of rice straw and spent slurry.

Groundnut-shells-based Open-core Gasifier. The fuel used for the system is dry groundnut-shells and groundnut-shell briquettes. In the system, every 4 kg of groundnut-shells replaced 1 litre of light diesel oil

- Compared to rice straw and biogas spent slurry mixture, soybean straw and spent slurry mixture was found 22-27% nutritionally more enriched.
- Developed a family-size, solid state anaerobic digester for agro-residues.
- Developed a biogas plant of 6 m^3 capacity and of floating dome-type, suitable for high water-table regions.
- Developed groundnut-shell-based Open-core Down Draft Gasifier. In this, every 4-kg groundnut-shells replaced 1 litre of LDO.
- Upscaled model of the CIAE Natural Draft Gasifier refined to achieve a thermal output of 92,000 kcal/hr, and it was evaluated on wood chips and groundnut-shells.
- Developed a simple electronic temperature controller for use on the natural convection solar dryers.
- The solar-water heater for paddy parboiling compared to traditional paddy parboiling saved 50% coal requirements, besides lessening time for parboiling.
- All blends of HSD fuel and ethanol tested for engine-fuel found with the similar power-producing capability as HSD fuel alone.

A Family-size, Solid-state Anaerobic Digester for Agro-residues

The available solid-state digester of 1.18 m^3 capacity has been used. A mild steel perforated leachate re-circulation tray was developed and stationed over the top of the digester under the gas holder for solving the problem of uneven moisture and microbial flora distribution inside the digester. The leachate percolated at 4 litre/min through the digester substrate-bed and accumulated in the built-in leachate collection chamber, having 78.5 litres capacity for the next 24 hours. For easier emptying of digested mass, a cylindrical sieved structure suiting to available digester was designed. The feasibility of the fabricated system has been tested by charging mixed substrate in the perforated cylinder, and the system has been found workable. The generated gas was removed from gas plenum and conveyed through flexible/rigid pipe for introducing at the bottom of the digester near the leachate-accumulation chamber.

Biogas Plant for High Water-table Regions

A biogas plant of 6 m^3 capacity and of floating dome-type, suitable for high water-table regions such as tarai of Uttaranchal, has been developed. Its digester depth is lower than (diameter to depth ratio is 1 : 1) the conventional KVIC design. This design plants have been installed in 4 rural houses in Nainital and Udhamsingh Nagar at Rs 32,000 each. The average biogas yield varied between 4.2 m^3/day in summer and 2.2 m^3/day in winter. The families did not require LPG cylinders, excepting for December to February.

Natural Draft Gasifier for Rural Community Application

The SPRERI Natural Draft Gasifier (85 kW) has been put under operational research project trials for boiling forest produce (*bael* and *amla*) at village Khori in Sheopur district. A boiler having a capacity of 400 kg of forest produce, designed and developed by the MPSTEP and IIFM, has been retrofitted with SPRERI Natural Draft Gasifier, and modifications have been incorporated for guiding the flame. Its initial testing was conducted at the CIAE, Bhopal, for about 20 hr. Its steam initiation time was 30-40 minutes and biomass consumption varied from 22 to 27 kg/hr. The PHU of the system was 33.4 to 39.2%. The gasifier has been installed at 1.6 m below the ground and a chain-pulley system has been installed for easy loading and unloading of the forest produce in the boiler, placed above the gasifier.

Groundnut-shells-based Open-core Gasifier

Groundnut-shells-based Open-core Downdraft Gasifier has been developed by the SPRERI, VallabhVidyanagar. It consists of a well-insulated, open-top cylindrical reactor with a manually-operated cast-iron grate, a blower for producing appropriate draft and a naturally aspirated producer gas-burner. The fuel used for the system is dry groundnut-shells (moisture content around 8%) and groundnut-shell briquettes. With loose groundnut shells, fuel consumption rate varied between 44 and 50 kg/hr, and gas's calorific value ranged between 900 and 1100 kcal/m^3 after stabilization of the operation. The gasifier efficiency varied from 55 to 60%. When the gasifier was loaded with 133 kg groundnut-shell briquettes, system operated continuously for 3 hr. The flame temperature was found consistent, varying from 870° to 929°C. Every 4 kg of groundnut-shells replaced 1 litre of LDO (Light Diesel Oil) i.e. a saving of approximately Rs 13 per litre of LDO replaced. Payback period has been computed around 1,000 hr of operation.

100-kW Natural Draft Gasifier for Wood and Crop Residues

Upscaled model of the CIAE Natural Draft Gasifier was refined to achieve a thermal output of 92,000 kcal/hr, and it was evaluated on wood chips and groundnut-shells. The flame temperature varied from 850 to 1090°C with wood chips and

from 810 to 1021°C with groundnut-shells. The calorific value of the gas generated ranged between 980 and 1,276 kcal/m^3 with wood chips. The biomass consumption was recorded at 38–43 kg/hr and at 19–22 kg/hr for wood chips and groundnut-shells. The temperature profile of the gasifier was 1,238–1348°C and 1080–1232°C near the grate for wood and groundnut-shells. The present gasifier has faced problems of fly-ash moving along with the producer gas and of falling of partially burnt groundnut-shells from the grate.

Agro-industrial Application of Gasifier

Performance of the modified CIAE Portable Updraft Gasifier (25-kW capacity), installed at the menthol-oil-extraction plant, situated at village Khajuri in Bhopal, was monitored.

Economics and energy audit analysis of the plant were carried out based on the monitored data. The energy expenditure per hour for gasifier system was 433 MJ/hr as compared to 615 MJ/hr in the conventional system. The energy saving was 29.6% over conventional system. Batch-process time increased by 8.9%, as more time was required for steam initiation. Plant's operational cost was 4.3% less than conventional system. The study revealed that gasifier system fitted with the plant was energy-efficient and cost-competitive.

High-efficiency Solar Air-heater

Design for packed bed-type, solar air-heater has been developed. This design is similar to the commercially available solar air-heaters, excepting upper surface of the air-duct is made up of a transparent glass-sheet, which is packed with blackened

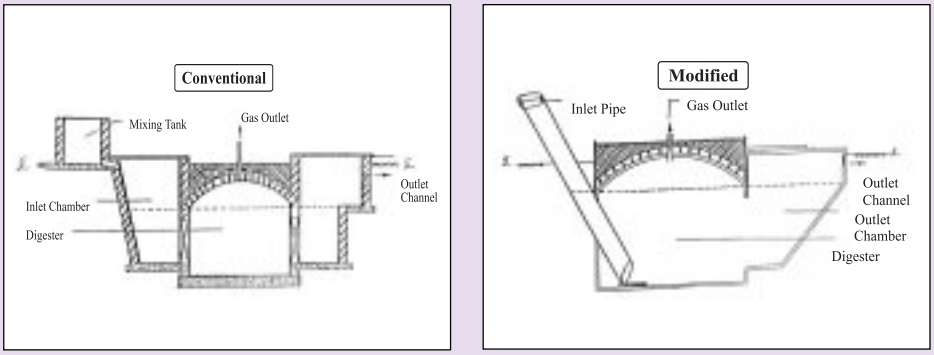
SUCCESS STORY

MODIFIED BIOGAS PLANT FOR SOLID-STATE DIGESTION OF CATTLE-DUNG

The CCSHAU Hisar centre has modified 2 m^3 capacity family-size fixed-dome-type biogas plant (popularly know as Janta design) for use of cattle-dung in solid-state as substrate (TSC around 16%).

Main modifications in the biogas plant are as follows.

- The inlet feed chamber is replaced by a RCC pipe of 30-cm inside diameter. The upper end of the pipe extends above ground by about 1.2 m.
- The outlet chamber is enlarged suitably to accommodate total volume of slurry displacement from digester.
- The step-type construction of outlet chamber of Janta plant has been changed to an inclined wall for streamlined flow of digested slurry and outlet has been widened for easy discharge of the digested slurry on to ground.



Line diagrams of conventional (*left*) and modified (*right*) Janta Biogas plant

The modified plant was commissioned as usual with 1 : 1 mixture of cattle-dung and water. The plant operation was stabilized over a period of about two months. Thereafter, the required quantity (50 kg) of the fresh cattle-dung, having TSC 16%, was poured everyday straight into the inlet plant pipe. The effective retention period for the plant was thus increased to 100 days. The modified plant consistently produced around 30–40% more gas yield compared to the conventional design. Besides, water requirement was negligible and digested slurry handling had become much easier.

Modified plant cost has been estimated approximately similar to that of the conventional biogas plant of 2 m^3 capacity. The hydraulic retention period for the plant has been optimized as 80 days for winter and 60 days for summer. Operational research trials for the design are under progress at many centres.

iron-chips. Iron-chips act as absorber of solar radiations and glass-sheet acts as glazing. The duct is insulated with glass-wool at the bottom and at the sides. Each module of the solar air-heater has an aperture area of 1.25 m^2. Even at low air-flow rates, packed-bed solar air-heater gave high efficiency, because of better heat transfer due to turbulence created by the iron-chips and volumetric absorption of the solar radiations. The optimum length of the packed heater has worked out to be 1 m compared to 2 m for the available solar heaters. The payback period for the heater is computed as 260 days and 310 days, depending on whether it replaces electrical energy and LDO/furnace oil, respectively. Comparative evaluation, carried out at the SPRERI Vallabh Vidyanagar centre, for air-flow rate varied between 35.0 and 65.7 m^3/hr, and revealed higher thermal efficiency of 35.7 and 49.9% for the packed-bed heater and 25.0 to 39.1% for the commercial air-heater.

Electronic Temperature Controller for Solar Dryers

A simple electronic temperature controller for the use on the natural convection solar dryers has been developed. The device controls temperature within the desired range, suitable for the products being dried. It consists of a thermister sensor circuit to detect hot-air temperature, has a differential amplification unit, a buffer circuit for impedance matching and a controller circuit to actuate exhaust-fan. The controller unit is fixed at the bottom of the solar collector. The temperature probe is placed on the middle-plate collector and a 50-Watt domestic exhaust-fan is fitted across the chimney. The controller is available commercially.

Solar Water Heater for Paddy Parboiling

For parboiling paddy, improved CRRI Cuttack method includes soaking of paddy in hot-water at around 70°C for 30–45 minutes. The solar-parboiling system consists of a solar water-heater of 200-litre capacity/day and an improved mini paddy parboiling unit of 50-kg holding capacity. The advantage of the solar system over the traditional is 50% saving in coal requirement and lesser time for parboiling. Total system costs about Rs 35,000 and cost of parboiling 100-kg paddy has been estimated at Rs 63.

Alcohol as Fuel for Diesel Engines

Extensive studies were carried out on the use of anhydrous and aqueous ethanol of different proofs for blending with high-speed diesel fuel for operation of a 7.5-kW constant speed diesel-engine. Distinct phase separation was not observed in 80 : 20 blend of HSD fuel and ethanol, provided moisture content of the ethanol was up to 10% (180° proof ethanol). For ethanol of 170° proof (moisture content 15%), the blend should have a maximum of 15% of ethanol by volume. All blends of HSD (High Speed Diesel) fuel and ethanol tested for engine fuel are found to have similar power-producing capability as that of HSD fuel. Up to 20% of 180° or 190° proof aqueous ethanol can be blended with HSD fuel for satisfactory operation of the CI (Compression Ignition) engines.

Anhydrous 1-butanol was used as a surfactant to increase miscibility of aqueous ethanol with HSD fuel. The performance of a 7.5-kW constant speed-diesel engine using emulsified fuels revealed that the power of the engine was almost same as that for the HSD fuel. CO emission was lower but NO_x and unburnt hydrocarbons were higher with micro-emulsion fuels than HSD fuel. CO and NO_x were, however, found lower in fuel containing 20% ethanol in the blend. The study concludes that up to 38.9% of HSD fuel can be replaced by 170° proof ethanol and 1-butanol for CI engines.

Electronic temperature controller fixed with a natural convection solar dryer. This is now commercially available.

ANIMAL ENERGY

Improved Animal-drawn Equipments

Thirteen animal-operated zero-till-drills were fabricated and provided to the farmers of the hilly and tarai regions. Also, ten sets of matching implements of increased size, mould-board plough, disc harrow, cultivator and *patela*, were provided to farmers. Use of increased size implements gave 20–30% of higher area coverage with the same pair of animals.

Bullock-owning farmers extensively used wedge plough for interculture operations. Wedge plough was modified and fabricated for attachment of 2 and 3 rows. Five sets of increased size bakhar blade, Nagpuri yoke, three row seed-cum-fertilizer drill, wedge plough and sweep cultivator were provided to farmers of Udaipura, Ghana and nearby villages of Goharganj Tehsil of Raisen district. They found these equipments superior to traditional ones.

Under the ORP trials, the Udaipur centre provided camel-drawn matching package of implements, blade harrow, bund former, disc harrow, 3- and 5-tyne cultivator, multipurpose tool frame with seeding attachment, CIAE inclined plate planter and groundnut digger to the farmers of different villages of Bikaner and Sardarsahar in Churu district. The farmers found that these equipments gave about 30% more output than the traditional implements.

IRRIGATION AND DRAINAGE ENGINEERING

Artificial Groundwater Recharge through Bore-wells

An underground irrigation grid system has been designed, and installed at the CIAE, Bhopal farm, for recharging groundwater using harvested water. The pipe lines were of HDPE pipes with rated pressure of 6 kg/cm^2 to meet carrying capacity of 40 lps. The pipe-line was laid at 0.75-m depth. Depending upon the field requirement, risers with hydrants were provided at 66-m interval to take out water through valve-opener for irrigation. At all water sources, water meters were fitted with non-return valves in grid system for recharging the groundwater. Before non-return valve, a hydrant was provided so that water from the tube-well/open-wells could be pumped into the grid system. The pipe-line could be used for irrigation as well as for recharging groundwater.

The fluctuations in water-table were measured at fortnightly interval in 3 observation wells. These indicated approximately a fall of above 10-m in water level in February in all observation wells compared to water-level in rainy season. An abandoned tube-well at the Institute farm was tested for recharging, and intake rate was found to be 8 lps, indicating a very good potential for recharging.

Automated Surge-flow System Developed for Irrigating Furrows

The system consists of an inlet water-tank and a surge irrigation pipe with 10 outlets spaced 60-cm apart. Portable multi-outlet irrigation system has been designed to apply water in furrows. It was designed to operate 5 outlets at a time for a prefixed surge-cycle time and number of surge cycles. The combination of 1.5 lps (litres per second) stream size, 0.5 CR and 15 min CT (cycle time) was found optimum for surge irrigation system. Multiple outlet size was 25 mm dia to deliver 1.5 lps discharge into furrows. The velocity of the flow in furrows (36 cm/s) was found within permissible limits of non-erosion for vertisols. Main pipe was 100 mm in dia, selected for carrying a total of 7.5 lps supplied discharge with an allowable velocity of 2.5 m/s in the PVC pipes.

Automation system for the surge irrigation system includes surge timer, surge counter, inlet solenoid valve (75 mm dia), 10 solenoid valves (25 mm dia) for outlets, water-level sensor and electronic hooter. When water level in supply tank reaches

EFFICIENT FILTER AND TAR-CRACKING DEVICE FOR THE ENGINE-QUALITY PRODUCER GAS

Tar-cracking device

The system has been developed to achieve the desired residence time of the gases in the cracking unit (10 seconds) and also for maintaining its temperature at 900°C. The device is a rectangle of 150 mm × 150 mm × 450 mm. Electrical heaters of 5.2-kW rating were fitted on the device. The gases from the gasifier were analyzed for tar level before their entry either to tar-cracking unit or to filter. Gases leaving tar-cracking unit or filter were passed through another condenser for measuring tar present in the gases coming out from the cracking or filtering system. Gas temperature is monitored after tar-cracking system and condenser outlet.

Evaluation of tar-cracking device

The selected Downdraft Gasifier was tested on wood chips for analyzing its tar output. The wood used was 20–30 mm in length. The moisture content of the wood was found between 10.1 and 10.9%. The tar generated from gasifier varied from 1.7 to 2.1 g/m^3. The tar-cracking unit fitted with electrical heaters and insulated from outside for preventing heat loss was tested. The electrical power consumption was found to vary from 4.7 to 4.9 kW. The gasifier and tar-cracking unit were connected to assess catalysts used for tar-cracking.

Evaluation of tar filter

A sand-filter has been developed. The filter is of 80 mm dia and consists of a sieve for holding sand-bed of 50-mm thickness. The water below the sieve was kept for 50 mm height to impregnate gases in the water column. The effectiveness of the tar filter for tar absorption was assessed by drawing part of the gases generated from gasifier to filter. Tar content after tar-cracking unit varied between 28 and 44 mg/m^3, which was considered on the higher side. Tar reduction up to 89.2 to 91.9% could be achieved in the filter.

SUCCESS STORY

AGRO-INDUSTRIAL APPLICATION OF SOLAR TUNNEL DRYER

A walk- in-type solar tunnel dryer in an industry producing di-basic calcium phosphate (DCP) near Udaipur city has been designed, erected and commissioned. DCP produced has moisture content of 35–40%, which is mechanically dried to 5% in two stages. In the first stage, the moisture content is reduced to 15% in the diesel-fired tray dryers. The tray drying operation has been replaced by the solar tunnel dryer.

Salient features of the Solar Tunnel Dryer

- It is a hemi-cylindrical-shaped walk-in-type and has base area of 3.75 m × 21.00 m and maximum ceiling height of 2.0 m.
- Metallic-frame structure of the dryer has been covered with UV stabilized semi-transparent polythene sheet of 200 micron thickness. A gradient of 10–15° has been provided along the length of the tunnel to induce natural convection air-flow.
- Cement concrete floor has been painted black for better absorption of solar radiations. Glass-wool of 5-cm thickness for insulation has been provided to reduce heat loss. Black polythene sheet has been provided on the northern side to reduce heat loss.
- Inlets for fresh air have been provided along the periphery of the tunnel near the ground level.
- Two chimneys of 20-cm diameter and 75-cm height have been provided on the top of the curved surface to exit hot moist air. Besides, an exhaust fan of 1,000–1,200 m^3/hr air-flow rate capacity and 0.7 kW-power rating has been provided on the upper end of the tunnel. The humidity sensors and controller are fitted inside the tunnel to maintain maximum relative humidity as per the requirements.
- Upper end of the tunnel has been provided with a door of 1.60m × 0.75 m size to facilitate loading and unloading of the material.
- Wet DCP is spread in thin layers of approximately 4-cm thickness in trays of 40 cm × 80 cm. Twenty-four trays are packed on to a trolley. Ten trolleys containing 1.5 tonnes material are loaded into the tunnel dryer in the morning.

The drying time varied between 2 and 3 solar days depending upon the solar insulation. On an average 4–6 kW of electricity was consumed in operating exhaust fan for drying one batch.

The total cost including cost of materials and of labour worked out to be around Rs 50,000. The average cost of drying one batch of DCP of 1.5 tonnes has been worked out at Rs 470. For the same quantity of DCP, cost in the existing diesel-based tray dryer worked out at Rs 1,739. The payback period for the solar tunnel dryer has worked out as 100 working days.

20-cm depth, water-level sensor activates operation of solenoid valves fixed to outlets. These valves are operated in a sequence (5 at a time) with on-and-off cycles for a selected time and number of surge cycles. After fixed cycles are over in irrigation, an electronic hooter gets activated to draw attention of user for checking completion of furrow irrigation. The label massage is provided on the control panel for the user to operate the system again by adjusting counter value if irrigation is not sufficient in furrows. The system runs on 220 V AC power supply.

Surface Drainage Field Experiment in Vertisols

Field experiment on surface drainage system for soybean comprising five drain spacings of 15 m, 20 m, 25 m, 30 m, 35 m and control with 3 replications of each drain spacing was conducted second time during *kharif* 2001 at the CIAE farm. Surface drains having bottom width of 35 cm, depth of 50 cm and side slope of 1 : 1 were laid out using tractor-drawn ditcher. Spacing treatments indicated that variations in grain yield of soybean were significantly higher in all compared to the control at 5% level of significance. Surface drains at 15 m to 20 m spacing are sufficient to remove excess runoff water from fields for soybean-crop in vertisols.

Sub-surface Drainage System Field Trial

For the subsurface drainage (SSD) system, drainage coefficient for the soybean-

- Designed an underground irrigation grid system and installed it at the CIAE, Bhopal farm.
- Designed a portable, automatic multi-outlet irrigation system to apply water in furrows.
- Surface drains at 15 m to 20 m spacing found sufficient to remove excess runoff water from soybean fields in vertisols.

crop was obtained; it was 5.34 mm/day through the analysis of the meteorological data.The designed SSD system consists of a corrugated perforated PVC pipe of 72/80 mm diameter installed at 20-m drain spacing and at 1.0-m depth on 1.0-ha field for effective drainage discharge. The sub-surface drains enveloped with geo-textile filter material were laid manually in trenches of 1.0-m depth × 0.5-m width in longitudinal direction of the field by maintaining a bed gradient of 0.2%. To maintain water level below sub-surface drains, a sump of 1.2-m diameter with an automatic pumping and measuring system of drained water was constructed. Grain yield of soybean under SSD system during *kharif* 2001 increased by over 50% compared to control.

TECHNOLOGY TRANSFER

- An industrial prototype of SAF-750 thresher has been fabricated for its commercial production. The design modification and testing were carried out as per the guidance of the CIAE. The machine has performed satisfactorily for wheat-crop.
- Rural soymilk enterprises by the CIAE, Bhopal, have been initiated under the NATP activity on the Household Food and Nutritional Security; in which village-women produced soymilk and distributed sweetened milk to rural children.The health benefits of soy-products were explained to rural people, and they were exhorted to take up soy-based entreprises.
- Prototypes (449) of 10 equipments were prepared and supplied through the NATP on the Prototype Manufacturing by the CIAE, Bhopal; 177 prototypes and 18 manufacturing drawings were supplied to various organizations and entrepreneurs.
- Adaptive trials for zero-till drilled, strip-till drilled and raised-bed planted wheat were conducted by the CIAE, Bhopal, at three villages, Kardhel, Chached and Pipaliya Gajju, on farmers' fields in the participatory mode. The farmers could raise good crops with recommended cultural practices.
- CIRCOT variable speed Double Roller Gin technology has been commercialized to convert conventional DR gins for productivity increase on an average from 45 kg/hr to 65 kg/hr through M/s U.D. Patel & Co, Mumbai.
- CIRCOT has successfully transferred to M/s Hanjer Agro and BioTech Energies Co-operative Society Ltd, Surat, the technology of converting textile mill waste into compost. The firm is currently producing around 100 tonnes of compost per month and selling it at the rate of Rs 2,000/tonne.
- Technologies know-how for preparation of Melfolac, a wood-varnish composition, gasket shellac compound, water-soluble lac, spiritless varnish, air-drying insulating varnish, FRP sheet-based as two different compositions, were transferred by the ILRI, Ranchi.
- The MPUAT, Udaipur centre, had installed smokeless durable improved cookstoves in 50 houses in 5 selected villages. The models of the durable stoves included were single-pot stoves called Chetak and double-pot stoves called Udairaj. The thermal efficiency of Chetak and Udairaj stoves with *desi babul* (*Acacia nilotica*) was found around 22% and 28% in the laboratory. The cost of the single-pot stove was estimated at Rs 175 and of double pot at Rs 230. All beneficiaries were of the opinion that there was substantial reduction in smoke level inside the kitchen; and 80% agreed that there was significant saving in fuel-wood consumption compared to traditional stove.

- An industrial prototype of SAF-750 thresher fabricated for commercial production.
- The technology of converting textile mill waste into compose transferred from the CIRCOT to a society at Surat.

Agricultural Human Resource Development

CAPACITY DEVELOPMENT

STATE AGRICULTURAL UNIVERSITIES

Assam Agricultural University, Jorhat

- A new degree programme in Agri-business Management to run as a professional course was introduced.
- Admissions were made open to candidates from other states including the north east states to discourage inbreeding and encourage competitive spirit.
- AAU website was launched during the year. The information bulletin and the application forms for admission are now available on line.
- Faculty of Home Science implemented the revised M.Sc. curriculum.
- Tea Industrial Work Experience Programme (TIWEP), Rural Agricultural Work Experience Programme (RAWEP) for Agriculture, Rural Home Work Experience Programme and In-plant Training (RHWEP) for Home Science and Fishery Work Experience Programme (FWEP) for Fishery implemented for the students pursuing UG programmes.

Acharya NG Ranga Agricultural University, Hyderabad

- Internal and external evaluation system for B. Tech (Dairying) and B.FSc were introduced.
- Educational tours were made compulsory for undergraduate programmes.
- Short-term certificate courses with duration ranging from 3 weeks to 1 year for those who cannot afford higher education, but still have an aptitude for learning practical skills, entrepreneurship and self employment were launched.

Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli

- An MoU was signed with Maharana Pratap University of Agriculture and Technology, Udaipur, (Rajasthan), University of Agricultural Sciences, Dharwad and Aspee Agricultural Research and Development Foundation, Mumbai for fostering academic programmes and to encourage inter university working and garner private support for education.
- RAWE, Rural Home Work Experience Programme (RHWEP), FWEP were remodelled to harmonize with new UG curricula in Agriculture, Horticulture and Forestry.
- In order to build self-reliance and self-confidence counselling and guidance were provided to students for competitive examinations for JRF/SRF/IFRIE.
- With financial help from the ICAR, some steps/changes were initiated in the direction of upgradation in educational reforms and achievements.
- Central Instrumentation Cell established at the College of Agriculture, Dapoli and College of Fisheries, Ratnagiri became functional during the year.

Chandra Shekhar Azad University of Agriculture and Technology, Kanpur

- Three new Departments of Home Science, Extension Education, Human and Child Development and Clothing and Textiles were established in College of Home Science.

- Financial support was provided to support the State Agricultural Universities for development and strengthening of UG and PG programmes to expand, develop and improve the quality, relevance and utility of agricultural education and training.
- Support was provided for instructional farm development, computerization, internet facilities, educational technology cells, HRD of faculty and non-faculty members and for construction of Girls hostels.
- Rural Agricultural Work Experience is now being effectively implemented in most of the SAUs as an integral part of degree programmes. Adequate support was provided for this programme.

- Remodelled RAWE programme in tune with the new UG course curricula was launched.
- New laboratories viz. Multimedia laboratory, Central Instrumentation Laboratory and Plant Clinic Laboratory were set up.

Students at Computer Laboratory

Ch. Charan Singh Haryana Agricultural University, Hisar

- Course curricula for all the undergraduate and Post-graduate programmes were updated.
- Centre of Food Science and Technology was established to encourage value addition to staple food item.
- Diploma course in Food Science and Technology was started.
- Two months training schedule was implemented for agricultural graduates under the Ministry of Agriculture sponsored programme in Agri-clinics and Agri-business centres.
- Schemes on Women in Agriculture, Plant Clinic, Farmer Service Centre and toll free Agriculture helpline for farmers were set up.

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

- New programme on Biophysics initiated in the College of Basic Sciences and Humanities from the academic session 2002–03.
- Revision in various degree programme have been made as per the guidelines of the ICAR.
- Practical oriented programme on the lines of practical crop production developed by the university main campus were introduced in other Colleges of the University.

- AHRD Phase II: Dr J.C. Katyal DDG (Education) informed on the ICAR concept paper on AHRD Phase II for World Bank support. Both DEA and World Bank have agreed in principal to support the project.
- To inculcate cultural fellowship and sportsman spirit arrangements have been finalized to hold All-India Inter Agricultural University cultural meet (AGRIUNIFEST) and Fourth All-India Inter University Games and Sports meet.

Maharana Pratap University of Agriculture and Technology, Udaipur

- Course curricula for various teaching programmes were revised to support country's needs and emerging international scenario.
- State of the art educational technologies were introduced for curriculum delivery.
- University organized 8 summer/winter schools/short courses benefiting 199 faculty members in their career advancement pursuits.
- Two hundred and twenty faculty members were deputed for various Summer/ Winter Schools, Workshops, Seminars and Conferences held across various SAUs and ICAR institutes.

Marathwada Agricultural University, Parbhani

- Academic blocks which were in dilapidated conditions were renovated through catch up support of ICAR.
- Ninety-eight faculty members were deputed for different national and international trainings.
- Around 130 faculty members were trained in Teaching Technology by conducting workshops.

Scene of AGRIUNIFEST

Sher–e-Kashmir University of Agricultural Sciences and Technology, Jammu

- Being a newly established university, work of selection of site, preparation of site plan, and structural design were finalized during the year.
- Renovation of old laboratory buildings and old hostels at R.S.Pura was initiated.

Tamil Nadu Veterinary and Animal Sciences University, Chennai

- Syllabus finalized and adopted as per the VCI guidelines.

Veterinary students being trained under practical poultry production programme

University of Agricultural Sciences, Dharwad

- Following the recommendations of three Deans Committees, the University of Agricultural Sciences, Dharwad introduced development programme to make agriculture in education better.
- Under the revised curriculum, more emphasis was given to practical oriented courses. A few interdisciplinary courses were introduced to encourage multi-subject teaching-learning.
- University encouraged excellence among teachers by deputing 120 teachers to participate in the national and international conferences, seminars etc.
- University organized four Summer Schools and three training programmes to give impetus to develop intellectual skills in the area of agriculture and allied fields.
- The National Service Scheme introduced first time as a part of regular credit course curricula.

DEEMED-TO-BE-UNIVERSITIES

Indian Veterinary Research Institute, Izatnagar

- Twelve short-term training courses were organized for the benefit of faculty members.
- An International Training Course on Molecular Biology and Biotechnology in Animal Research (IGMBBTAR 2001) was conducted.
- Academic regulations of the Deemed to be University were compiled and released.

MANPOWER DEVELOPMENT

Accreditation of Agricultural Universities

In the continuing process of accreditation, 16 SAUs and 3 DUs have been under process of accreditation during the year. Out of them, peer review teams have visited 5 universities, namely KAU, Thrissur; UAS, Bangalore; PAU, Ludhiana; SKKV, Palampur and CIFE, Mumbai. The reports from the peer review teams are awaited. The visits of peer review teams for 3 SAUs namely, DYSPUHF, Solan; UAS, Dharwad and DBSKKV, Dapoli have been planned during December, 2002.

The remaining universities namely, CSUAT, Kanpur; GAU, Banaskantha; GBPUAT, Pantnagar; IGAU, Raipur; JNKV, Jabalpur; RAU, Bikaner; SKUAST, Srinagar; BAU, Ranchi; IARI, New Delhi; IVRI, Izatnagar and NDRI, Karnal have completed their self study and they are in the process of finalizing the Self Study reports of the university and constituent colleges. The self study reports are expected by March, 2003 and the entire accreditation process is planned to be completed by December, 2003.

Revision of PG curricula and syllabi

The exercise of revising PG curricula and syllabi has been completed with revision of syllabi of one more Master's degree program. Thus, the PG curricula and syllabi have been revised for major disciplines of Agriculture and Allied Sciences (excluding Veterinary and Animal Sciences), totaling to 44, which have been approved by the Accreditation Board.

During the year, 5 more course catalogues for Master's degree programs have been printed raising the number of such catalogues to 13. The printed catalogues alongwith revised academic regulations have been supplied to all Agricultural Universities for implementation from the academic year 2002-03. Most of the universities have started the process of approval and adoption.

ALL INDIA ENTRANCE EXAMINATIONS

Examinations were conducted by the ICAR during June 2002 for filling 15% seats in UG and 25% in PG for all the SAUs, DUs, CAU and three CUs (AMU, BHU and Viswa Bharti). For 10 programmes in 38 Institutions for UG, 14,288 candidates applied and 864 were admitted. For PG, there were 7,999 candidates in 19 programmes and 88 subjects at 37 institutions of which 1,129 were admitted. For allotment of seats, counselling was held during July 2002. The Council thus contributed in facilitating multicultural shade in educational institutions and provided opportunity to meritorious students for seeking education in an institution of their choice. The entire expenditure on this activity is being met from the Revolving Fund Scheme and the seed money has been refunded to the ICAR.

The conference of Vice-Chancellors of State Agricultural Universities for the year 2001 was held on 28–29 January 2002, in which three committees addressed the following issues:

- Efficient University Governance: Dr I.V. Subba Rao VC, ANGRAU Hyderabad, presented various aspects of efficient university governance. The report has been finalized for submission to ICAR.
- Financial health of the SAUs: Dr K.S. Aulakh VC, PAU Ludhiana, highlighted the concern on meagre financial grants to the SAU vis-à-vis expected output. Additional budgetary provisions have been made to SAUs for making agricultural education better.
- Approach towards X Plan support: Dr J.C. Katyal DDG (Edn) presented approach papers towards X Plan support. The need for infusing appropriate change in course curricula to address real life subjects and instruments of governance to create an enabling environment for enhancing faculty performance were highlighted as the central points of the plan proposal.

- Master's degree syllabi revised and implemented in 44 disciplines under 13 Broad Subject Areas.

Meetings of Accreditation Board and Sectoral Committees

The Accreditation Board and its Sectoral Committees on Accreditation Norms and New Institutions/Programs, and Governance and Personnel/Financial Policies met during the year and took several decisions. Some of the important decisions are as follows.

- Development of National Policy on Higher Agricultural Education keeping in view the present concerns and future thrust.
- Guidelines for starting of new institutions and programs.
- The accreditation process and eligibility criteria for financial and technical support to identified institutions and programs in agriculture and allied Sciences outside ICAR-SAU system.
- Amendment of rules pertaining to establishment and functioning of Accreditation Board.
- Check list for Peer Review Team report for accreditation of Agricultural Universities and Colleges.
- Starting of PG program in Post Harvest Processing and Food Engineering at OUAT, Bhubaneswar.

Peer Review Team for Accreditation visiting KAU, Thrissur

Accreditation Related Publications

During the year following publications came out:

- Curricula and Syllabi for Master's degree programs in Agricultural Engineering, Plant Protection, Dairy Technology, Fisheries Science and Forestry (5 nos)
- Academic Regulations and Degrees offered in Agriculture and Allied Sciences (1 no)
- Hands on Training Manuals on Self Study and Peer Review (2 nos)
- Information Brochure on Accreditation of Higher Agricultural Education Institutions and Programs (1 no)

The Accreditation Board recommended to provide technical and financial assistance to identified private college offering higher agricultural education, subject to fulfilment of eligibility criteria including accreditation and affiliation to SAU of the region.

However, affiliation clause is not applicable to college offering academic programmes not only in agriculture and allied sciences, but also in other fields like, science, art, commerce, etc.

Admission of Foreign Nationals

ICAR has developed a strong agricultural education system in the country. It is facilitating human resource development by offering undergraduate programmes in 11 major disciplines and postgraduate and Ph.D program in 65 disciplines to the students from 53 countries. In the year 2002-03, 121 students from 26 countries have been provided admissions in ICAR deemed-to-be Universities and State Agricultural Universities.

Accreditation Meeting held at New Delhi in July 2002

Summer/Winter School and Short Courses

To enhance the faculty competence in new and emerging areas as a part of skilled

Summer School

human resource development, this is in operation. Recognizing the need for training of large number of scientists, Council has increased the number of training programmes substantially.

This year, 82 Summer/Winter School and Short Courses have been organized in which approximately 2,050 scientists are to be trained. During this year special emphasis was on Managing Digital Libraries in Agriculture, Video Production for Technology Transfer, Computer Aided teaching, learning and Designing, Computer Multimedia application in Agriculture and Allied Sciences. A special course on Water Quality monitoring and surveillance was undertaken and many more in recent advances to update the Scientists/faculty for their respective area of specialization. Another highlight of the programme was development of excellent instructional material for effective curriculum delivery.

This year the efforts are being made to put up all the synthesized instructional material on ICAR website. This will facilitate all the scientists and the students to have easy accessibility of the latest literature in the specialised areas.

Perspective Plan for Agricultural Education and Human Resource Development

The mission of the agricultural education has been to harmonize agricultural education with excellence in science and technology output for livelihood security and sustainable development. The perspective Plan focusses at adopting utilitarian approach aiming at producing professionals and academicians who are self reliant, self confident and self-competing individuals and who are not white collar job seekers. The Perspective Plan envisages to strengthen the agricultural education system accordingly and take new initiative in the direction of better linking of education with entrepreneurship development, spread of distance mode of education for reaching and benefiting the unreached, export of agricultural education, and strengthening of inter-institutional linkages.

Fellowships/Scholarships

The ICAR conducts competitive examinations for entrance of students against 15% seats in various courses in Agriculture and allied subjects for pursuing Ph.D./ M.Sc. and B.Sc. During the year, 201 SRFs have been provided for pursuing Ph.D. 470 JRFs have been provided for pursuing M.Sc. The Governing Body has approved enhancement of the rates of fellowships at par with the rates prevailing in other science departments like DST, CSIR.

For the encouragement of talented students all over the country, National Talent Scholarships have been awarded to 230 students for pursuing undergraduate courses.

Merit-cum-means scholarships have been awarded to 7.5% of the intake capacity of the students in different colleges of SAUs. The SC/ST students have been provided scholarships/fellowships to the extent of 15% and 7.5% of the total intake.

Training Course on Advanced Plant Molecular Biology Techniques conducted by CAS in Biochemistry, at IARI, New Delhi

CENTRES OF ADVANCED STUDIES

Centres of Advanced Studies (CAS) scheme was launched to improve the quality of teaching in State Agricultural Universities. (SAUs) and Deemed Universities (DUs) of ICAR. The objective of the scheme is to identify the major discipline in SAUs/DUs which have developed facilities and faculty in the area of specialization and to make them capable of imparting advanced training to faculties of other SAUs/ institutes to enhance their teaching and research capabilities. As per recommendations of QRT, steps are being taken to open new CAS in Plant Biotechnology, Animal Biotechnology, Pharmacology, Veterinary Pathology and International Agriculture Trade and Marketing. During the year 2001–02, 72 trainings were organized in which 1,278 scientists from various institutions in different disciplines were trained and 72 manuals were prepared. Some of the

important areas of the trainings conducted are as follows:

- Multimedia in teaching of clinical medicine and therapeutics.
- Watershed management as an approach towards efficient resource use.
- Breeding heterosis and disease resistance of commercial vegetable crops.
- Emerging trends in functional foods.
- Brood stock management and genetic selection in fish seed production.
- Microbial transformations in soil.
- Demand-supply projections of agricultural commodities.
- Designing vortals for NARS.
- Social sciences in agro-biological research.
- Preservation of Ghee and fat rich dairy products.
- Diseases of wild life and their management.

PROFESSIONAL EXCELLENCE RECOGNITION

Best Teacher Award

In the year under reference following faculty members were awarded Best Teacher Awards. Dr S.S. Pahuja, Professor,COA; Dr Prem Singh, Associate Professor, COVS; Dr (Ms) Santosh Dhillon, Professor, COBS&H from CCS Haryana Agricultural University, Hisar; Dr P.B. Jha, Associate Professor, Department of Plant Breeding; Dr K.C.P. Singh, Associate Professor, Department of Veterinary Microbiology, Bihar Veterinary College; Dr V.K. Chawdhary, Department of Genetics; Dr P.H. Pandey, Associate Professor, Department of Post Harvest Technology; Dr Usha Singh, Assistant Professor, Department of Foods and Nutrition, College of Home Science from Rajendra Agricultural University, Pusa, Samastipur, Bihar.

University Level Text Book Writing

Out of the 33 titles finalized under AHRD Project for writing Textbook in Agriculture and Allied Sciences, 14 books have been completed and sent to Publication Division of ICAR for printing.

Dr L.K. Wader and Dr Murthy C. from UAS, Dharwad were awarded Book Writing Award on Agricultural Marketing Cooperation, which was completed this year.

National Professor and National Fellow

- In a study on the enhancement of yield through innovative genetic approaches in rice undertaken at DRR, Hyderabad, by Professor E.A. Siddiq, an advanced backcross population comprising 251 individuals from the cross involving the IC22015 of *Oryza rufipogon* and IR58025A and IR58025B was developed and utilized for linkage map construction as well as for identification and mapping of yield related QTLs. A total of 25 QTLs that influence 12 yield related traits were identified on five chromosomes.

- With the objective to generate transgenic rohu, restore a strain or species of fish from its preserved sperm and genome-inactivated surrogate eggs of another strain or species, and to generate triploids in selected Indian fishes, the ICAR National Professor project was given to Professor T.J. Pandian, Madurai Kamaraj University. Sexually mature *Puntius conchonius* were successfully restored using its preserved (–18°C) sperm and genome-inactivated surrogate eggs of *P. tetrazona.*

  To construct transformation vectors for the indigenous fishes, growth hormone genes of rohu, *Labeo rohita* and catfish, *Heteropneustes fossilis* were isolated, cloned and sequenced; their fidelity was confirmed in prokaryotic and eukaryotic systems. A vector was constructed with grass carp ß-actin promoter driving the expression of r-GH. The sperm

- The study by Professor E.A. Siddiq has led to the identification of suitable locations and seasons for indigenous temperature sensitive genic male sterile (TGMS) lines and hybrid seed production. Mode of inheritance of the TGMS trait sources was found to be monogenic recessive. Allelic relationships among the TGMS sources suggest existence of six putative genes designated as tms 1, tms 2, tms 3, tms 4, tms 5 and tms 6.

electroporation technique was standardized to ensure 25% hatchling survival and 37% presumptive transgenics without suffering any deformity. Genomic integration was confirmed in 15% of the tested individuals (Ti) belonging to family lines 2 and 3; another 25% of the juveniles (Te) were also proved transgenic but with the transgene persisting extrachromosomally for longer than 1 to 2 years.

- The comparative response of *Brassica juncea* cv 30 during *rabi* and *Oryza sativa* Basmati 1 and Pusa 677 during *kharif* was studied by Professor D.C. Uprety at IARI. The elevated CO_2 brought about 18% under OTC (open top chamber) condition and 37% in FACE ring in the dry matter accumulation (flowering stage) of the *Brassica* plant.

  In *kharif* season, elevated CO_2 brought about increase in grain yield, 25% increase in Basmati 1 and 19% in Pusa 677 under OTC conditions, whereas, the increase was 27% and 24% in Basmati 1 and Pusa 677, respectively, in FACE rings. The response was similar in OTC and FACE, however, intensity was greater in FACE conditions.

- A study on the identification and quantification of phosphatase hydrolysable organic P sources for plant nutrition and refinement of a non-destructive technique for phosphatase estimation conducted by Professor J.C. Tarafdar at the CAZRI, showed a strong linear relationship between intra versus extracellular fungal acid phosphatase (R^2=0.94), alkaline phosphatase (R^2=0.96) and phytase (R^2=0.97). Three-fourth of the phosphatases, generally present inside the fungal cells and only 25% were expected to release extracellularly within three weeks period. Extracellular enzymes were found 60% more efficient in the hydrolysis of phytin than their intracellular counterpart.

- Professor I.M. Santha, isolated and characterized the gene encoding acetyl CoA carboxylase from *Brassica juncea* var. Pusa Bold, using two-step strategy which includes the generation of probe and then identification of the positive clones by screening the genomic DNA library of *Brassica juncea* prepared in λEMBL-3 using the probe generated.

- Professor Renu Khanna-Chopra studied the interactive effect of Zn deficiency with water deficit in wheat. Zn deficiency (~50%) caused reduced growth, leaf area and size and caused significant reduction in dry matter accumulation in wheat var. Kundan. Root growth was promoted in Zn deficient plants leading to higher root/shoot ratio. Zn deficient leaves showed significant reduction in carbonic anhydrase and superoxide dismutase activity but hydrogen peroxide metabolising enzymes such as catalase and ascorbate peroxidase were not affected significantly. Peroxidase activity increased 1.4-times compared to Zn sufficient plants. Under severe water stress Zn sufficient plants exhibited reduction in superoxide dismutase activity coupled with higher catalase and ascorbate peroxidase activity while Zn deficient plants exhibited higher activity of superoxide dismutase, ascorbate peroxidase and lower catalase activity. Zn deficient plants exhibited leaf necrosis, as enhanced activities of antioxidant enzymes were insufficient to manage drought induced oxidative stress.

- Professor A. K. Sahu in a project on the enhancement of seed production of Asiatic catfish, *Clarias batrachus* using sustained hormone preparations under took large-scale seed production of magur using 260 females and 190 males at the CIFA, Bhubaneshwar. A total of 140,000 spawn were produced with a hatching rate of 40–50%. Finally, 50,000 advanced fry were recovered. Advanced fry have been sent to Punjab, distributed among farmers and also stocked for grow out culture.

DISTANCE EDUCATION

Despite a strong network of educational institutions in the country, a large number of young men and women are still deprived of availing the college education for various reasons. ICAR in collaboration with the Indira Gandhi National Open University (IGNOU) has been in the process of developing programmes in distance mode for agricultural education and extension. While ICAR and SAUs would provide the content and platform for education and extension, IGNOU would facilitate in programme delivering in distance places in the country through channels like 'Gyan Darshan'. Monitoring, evaluation and certification would be done jointly.

- Professor B.R. Yadav established genome analysis of indigenous breeds of cattle, buffalo and goats using molecular markers at DNA repository, NDRI.

  Markers revealed association with problems related with anatomy, stunted growth or reproduction, viz., intersexuality, late maturity, anoestrous, repeat breeding, irregular heat cycle, recurrent abortions etc. There can be various reasons for such cases, however, early detection of these animals is quite important.

- Professor M.C. Sharma studied macro and micronutrients in relation to deficiency/metabolic diseases and production in animals at the IVRI, Izatnagar. The mineral deficiency in soil, fodder and serum (animal) of Uttar Pradesh, Uttaranchal, Haryana, Punjab and Delhi and efficacy of various mineral supplements was observed during the therapeutic trials.

Emeritus Scientist

- Topworking technique using patch budding during May to September on the wild *Prosopis cineraria* trees of more than 3 years age was standardized by Professor O.P. Pareek with a success rate of 76%.
- Professor P.C. Thomas in a study conducted at the CIFA, Bhubaneshwar, standardized brood husbandry, health care and both indoor and out door induced breeding techniques for stripped Murrel.
- Professor A.C. Thakur studied the effect of management factors on increasing the productivity of *Sali* (winter rice) and *Boro* (spring rice) system for high productivity at AAU, station at Shillonani. The *Boro* season variety × planting date combination involving varieties Jyotiprasad and Bishnuprasad transplanted between February 10–14 led to higher system productivity of 12 tonnes/ha in 2001–02 and 9 tonnes/ha in 2001–02 in 141–143 days compared to yields 1 tonnes/ha lower than those planted 15 days earlier.
- Professor D. V. Singh studied the common scab disease of radish caused by *Streptomyces aureofaciens*, which was widely prevalent in all agroclimatic regions of Uttar Pradesh with the incidence up to 90% in severe cases and ranging between 3.9–19%. The disease management was possible by the seed treatment with *Pseudomonas fluorescens* and antibiotics like Streptocycline, Agrimycin 100, Agrobiotech and Paushamycin.

NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT, HYDERABAD

- The Academy organized 34 Training programmes and total of 833 participated in these programmes.

The National Academy of Agricultural Research Management (NAARM), is the premier Institute entrusted with the responsibility to achieve higher levels of professional management in agricultural research and education. Marking the 25 years of its establishment, the Academy organized a National Seminar on Management—A key for improved performance as a part of Silver Jubilee-Foundation Day Celebrations on September 1, 2002.

In the Academy's efforts to improve the foundation course based on the participants feedback, the FOCARS training was organized through a modular approach for the first time. It resulted in tangible gains in the form of learning outcomes. The Field Experience Training was organized on the priniciples of 'seeing is believing' and 'learning by doing' through multi-disciplinary participatory approach.

The Academy organized 34 training programmes and a total of 833 participated in these programmes. It conducted off-campus programme at the Postgraduate institute of Agriculture, University of Peradeniya, Sri Lanka. A three months International Programme on Agricultural Research Management was organized for Yemen scientists at the request of the Government of Yemen and the FAO.

A National Seminar on "Veterinary Drugs and Pharmaceuticals" was organized in collaboration with the Department of Science and Technology, New Delhi, to improve collaborative research with private sector.

One of the significant achievements of the year include Pilot Distance Training on the theme "Focusing Agricultural Research on Poverty Alleviation", under the ISNAR-NAARM collaborative project, which was implemented in five SAUs.

The Academy developed an on-line data base (http://icar.naarm.ernet.in) on institutions in Indian NARS and a district level agri-database, which was used to develop prioritization of rainfed research using GIS.

Under the NATP the Strategic Research and Extension Plan (SREP) guidelines were revised by strengthening the research component, and these are currently being utilized for developing effective SREPs.

The Academy provided policy support to ICAR on performance appraisal of scientists-a new methodology in conformity with the project based budgeting and training needs assessment for ICAR employees which is being implemented at ICAR headquarters.

AGRICULTURAL ECONOMICS

ASSESSMENT OF WATERSHED PROGRAMMES FOR PRIORITIZATION OF RESEARCH AND DEVELOPMENT

Watershed programmes have been specifically launched in the rainfed areas with the sole objective to improve the livelihood of poor rural households encountering disproportionate uncertainties in agriculture. The study is based on the meta-analysis. The available micro-level studies from 310 watersheds were amassed. Watershed programmes were launched to improve efficiency, equity and sustainability of natural resources in the rainfed areas. To document these benefits, few proxy indicators were chosen and analyzed. The benefit-cost ratio and the internal rate of return were used as proxy for efficiency-gains from watershed programmes. Additional employment generation in agriculture as a consequence of watershed activities was assessed for equity benefits. The sustainability benefits were demonstrated by four indicators (i) increased water storage capacity, which augmented the irrigated area, (ii) increased cropping intensity, (iii) reduced run-off, which enhanced groundwater recharge, and (iv) subsided soil loss.

Benefits of Watershed Programmes

Benefits derived from numerous studies are quite impressive. The watershed programmes performed reasonably well and the investment was logically justified in the fragile and uncertain environments. The mean additional annual employment generated were about 181 man-days. Watershed programmes are largely aimed at conserving soil and water to raise farm productivity. Augmenting water storage capacity contributed in (i) reducing rate of runoff, and (ii) increasing groundwater recharge. These have direct impact on expanding the irrigated area and increasing cropping intensity. On an average, the former increased by about 34%, while the later by 64%. Such an impressive increase in the cropping intensity was not realised in many surface irrigated areas in the country. These benefits confirmed that the watershed programme is a viable strategy to overcome several externalities arising due to soil and water degradation.

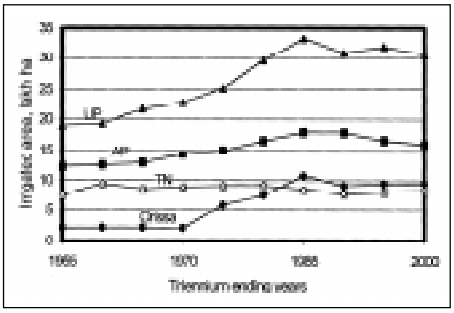
- Water runoff rate reduced by 34% in watershed management areas.
- Groundwater recharge increased by 64% in watershed management areas.
- Sustainability status of India's irrigation infrastructure studied.
- Decrease in transport and statutory charges may narrow down price band for rice and wheat.
- Buffer stock more useful in price stabilization than variable levies on external trade.
- Investment in agriculture must grow @ 7.91% per annum to realize target growth.
- Impact of research management process initiated under NATP being studied.
- Diversification of farming must to improve farmers' condition in western Uttar Pradesh.

Benefits from the sample watershed studies

Indicator	Particulars	Unit	No. of studies	Mean	Mode	Median	Minimum	Maximum	t-value
Efficiency	B/C ratio	Ratio	128	2.14	1.70	1.81	0.82	7.06	21.25
	IRR	Per cent	40	22.04	19.00	16.90	1.68	94.00	6.54
Equity	Employment	Mandays/ha/year	39	181.50	75.00	127.00	11.00	9000.00	6.74
Sustainability	Irrigated area	Per cent	97	33.56	52.00	26.00	1.37	156.03	11.77
	Cropping intensity	Per cent	115	63.51	80.00	41.00	10.00	200.00	12.65
	Rate of runoff	Per cent	36	–13.00	–33.00	–11.00	–1.30	–50.00	6.78
	Soil loss	Tons/ha/year	51	–0.82	-0.91	–0.88	–0.11	–0.99	39.29

HIGH PRIORITY TARGET DOMAINS FOR INVESTMENT IN WATERSHED RESEARCH

- Western Himalayan, Northeast Hills and Southern Zones
- Rainfall <500 mm and 1,000–1,500 mm
- Rehabilitation of degraded lands and soil-water conservation
- Poverty ridden areas



Performance of canal irrigation system

Targeting Watershed Research and Development

The patterns of benefits from watersheds vary depending upon the location, size, type, rainfall, implementing agency and people's participation. Target domains for investment on watershed development and watershed research were decided. Performance of watershed programme was the best in rainfall ranging between 700 and 1,000 mm, jointly implemented by state and central governments, targeted in low and medium income regions, and with effective participation of people.

HIGH AND LOW PRIORITY TARGET DOMAINS FOR WATERSHED DEVELOPMENT PROGRAMMES

High	Low
Western Himalayan Regions	Trans-Gangetic Plain and Western Plateau zone
Macro Watersheds	Micro Watersheds
Rainfall ranging between 700–1,000 mm	Rainfall < 500 and > 1000 mm
Rehabilitating degraded lands	Numerous activities
Joint programme by Central and State governments	Independent centrally sponsored
Poor income regions	High income regions
People's high participation	People's low participation

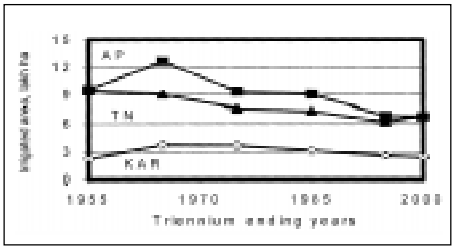
SUSTAINABILITY STATUS OF INDIA'S IRRIGATION INFRASTRUCTURE

Supply-demand management in water sector and efficiency in its every use is crucial for water-food security. Existing and expanding irrigation infrastructure has to be physically and financially sustained first. Surface irrigation infrastructure has deteriorated due to deferred maintenance. This has culminated in stagnating or falling irrigation coverage affecting agricultural growth in several regions. Area irrigated by major, medium and minor irrigation systems has been either stagnating or declining from mid 1980s or during 1990s.

Declining Irrigation Infrastructure

Currently canals in Uttar Pradesh are irrigating 3.06 million ha in the triennium ending (TE) 2000 as against 3.33 million ha in TE 1985. Similarly, in Andhra Pradesh, canals now irrigate 11% lesser area than what was irrigated 15 years back. Bihar, Orissa and Tamil Nadu also recorded similar decline in the canal irrigated area. On many irrigation commands, effective irrigated area has declined due to deterioration in the distribution infrastructure. Rapid depletion, salinization and pollution related problems threaten regions with sustainable groundwater balance, whose area is continuously shrinking. Administrative blocks categorized as 'dark' or critical increased @ 5.5% per annum during mid 1980s to mid 1990s. At this rate, 1/3rd of the blocks in the country would come under 'grey' category within two decades. Groundwater mining has resulted in fluoride contamination in north Gujarat and Rajasthan and arsenic contamination in southern West Bengal endangering the sustainable livelihood of the poor. In 1995, nearly 90% of the over exploited blocks were located in Gujarat, Haryana, Punjab, Tamil Nadu, Karnataka and Rajasthan.

Further, Andhra Pradesh, Tamil Nadu, Karnataka and Orissa, together accounting for 60% of the India's tank irrigated area, have lost about 37% of the area irrigated



Declining performance of tank system in south India

by tanks during 1965–2000. Physical strengthening and improvements of the inflow, storage and distribution systems are needed. Water users in tank commands need to be involved in planning and implementing the rehabilitation strategies.

Physical and Financial Sustainability

Currently, irrigation accounts for more than 1/3rd of states' revenue deficits. In Orissa, gross irrigated area from surface irrigation sources accounts for 64% of irrigation potential created. Average operation and maintenance (O and M) expenditure remained low at 30% of the desired level. Weighted water rate, based on revised water tariff in 1998, was low at Rs 104/ha. Current water rate demand from irrigation charges is 50% of potential demand. All these factors culminated in cost recovery of 25%. In Gujarat, actual O and M expenditure is one-fourth of the requirement. With average water charge remaining at Rs 165/ha, cost recovery is only 33%. Andhra Pradesh and Haryana have registered low cost recovery of 26% and 41%, respectively, under current account.

Physical sustainability of the irrigation infrastructure calls for need based O and M funding. Water user groups need to be empowered with the management responsibilities as well. Several states are in the process of finalizing state-water plans, institutionalizing farmer organizations in irrigation management and periodic review of water charges, improving assessment and collection procedures and prioritizing irrigation expenditures.

O and M cost recovery, TE 2000

Particulars	Orissa	Andhra Pradesh
Potential created (million ha)	2.5	48
Gross irrigated area (million ha)	1.6	22
Average annual plan outlay (million Rs)	6,190	893
Average O and M expenditure (million Rs)	600	265
Weighted water rate (Rs/ha)	104	398
Current water rate demand (million Rs)	190	116
Receipts, current account (million Rs)	150	69
Cost recovery, current account (Per cent)	25	26

GOVERNMENT INTERVENTION IN FOODGRAINS MARKET

Changing Context

Demand and supply scenario for agriculture in India has undergone profound changes during last 10–15 years. Farm price policy and policy for food management have to be changed to adjust to new situation and to check serious imbalances in production and several other problems like accumulation of huge grain stocks, increase in food subsidy bill, neglect of efficiency and quality, resulting in setback to private trade and regional bias in government support to agriculture.

Average availability of cereals has followed a decline in the recent years. The decline in per capita availability of cereals is neither a result of slack in production nor it is due to export of cereals. PDS prices during 1990s have increased in jumps and at a faster rate compared to open market prices, and prices of other food and other commodities which caused a decline in per capita PDS demand in the recent years. Diversification in consumption pattern, which is associated with improvement in per capita income and shift in food preference also possibly caused decline in per capita demand for cereals in open market. An important reason for high policy support to grains to continue, till recently, is that demand projections for grains did not take note of diversification in consumption pattern experienced in rural as well as urban areas. This has resulted in fast growth of the import of edible oils, while pulse deficit is reflected in both imports as well as in the increase in domestic prices of pulses. Hence there is a need for suitable policy to address these imbalances.

Price regulation

The regulatory mechanism should be used only when price movements are outside the desired price band representing width between the ceiling and floor price, which permits reasonable marketing margin for profitable public sector operations. The government intervention in foodgrains markets must allow and encourage active participation of private trade but check their exploitative tendencies. The study has prepared estimates of price band between farm harvest prices of wheat and paddy in surplus states and wholesale and retail price in subsequent months in all major states of the country, and these have required/justified participation of private trade in grain marketing.

PLANNING CUM METHODOLOGY WORKSHOP OF THE NATP PROJECT "WATER FOOD SECURITY ANALYSIS FOR 2025" (14–15 JUNE 2002)

Salient activities of the workshop are as follows:

- Base paper on water-food security representing four AERs presented.
- Methodology review of demand/supply projections for water/food discussed.
- Policy Interactive Dialogue Modelling (PODIUM) methodology discussed and adopted.
- Database needed for the existing PODIUM version identified.
- Four groups are formed to discuss and finalize refinements in the Consumption, Water balance and Area-yield-production modules of PODIUM model.
- Centre-wise work plan, milestones and expected outputs finalized.
- Policy Brief on 'Sustaining India's Irrigation Infrastructure' published.

NCAP OUTREACH PROGRAMME

The Centre in collaboration with an NGO, Society for Education and Social Welfare (SESW), Kandhla, initiated in 1999, a diagnostic study on constraints in agricultural Development in Western Uttar Pradesh. This study, covering five villages in the Muzaffarnagar district of Western Uttar Pradesh, revealed that major constraints are deteriorating soil nutrient status, declining profits from sugarcane-wheat farming, irregular and unreliable supply of power and canal water, falling water tables, and problems in marketing sugarcane due to delayed crushing season and delayed payments. There exists a broad consensus among all concerned that keeping in view the ecological and economic situations, farming in this area has to diversify. But lack of dependable advice on agriculture (technology, marketing, value addition) and lack of organizations that can support farmers have effectively blocked the prospects of diversifying to other crops or enterprises. Solving these constraints require co-ordinated effort at the field level by all agricultural development organizations of the district. The NCAP is presently playing a key role as a facilitator to bring the different agencies together and to provide necessary technical backstopping to farmers by linking them with different agricultural research institutes. This outreach activity is considered as a field laboratory by the Centre and the experiences with the implementation of this project are expected to provide lessons on how the recommendations of a research project gets translated into action in the field.

At existing structure of statutory charges/taxes, and transport and other costs, retail price for wheat in surplus states should be higher than farm harvest price by 36–60% in various months to attract private trade. In deficit state like Maharashtra, retail price before harvest need to be more than double the farm harvest price in surplus states to provide reasonable incentive to private trade. Similarly, the band suggests that retail prices of rice should be 96–213% higher than the farm harvest price of paddy to attract private trade to buy paddy and supply rice in various months and in several states. Price difference beyond this band would imply exploitation by private trade, which would need government intervention. Transport cost and statutory charges are the main elements of price spread and curtailing these costs can narrow down price band.

Buffer stocks vis-à-vis variable levies on external trade

The government has used buffer stocks as an important instrument for price stabilisation. However it is becoming fiscally unsustainable due to heavy cost of procurements, handling, carrying, storage etc. As an alternative it was suggested that the government should use the instrument of variable levies on external trade to stabilise domestic prices. A comparison of domestic stabilization measures and trade showed that selling and buying wheat in international market to stabilise domestic output does not result in large changes in international prices of wheat due to large volume of world trade in wheat. However, in rice, stabilising domestic supply through trade caused sharp fluctuation in international price of rice. Among the two options, viz. domestic stabilisation through buffer stock and stabilization through trade, the latter is costlier than domestic stabilization in most of the years though it also depends upon fluctuation in international price. If in future, relationship between domestic and international prices remains the same, as had been during the last 26 years, then policy of price stabilization through buffer stock seems to be a better option than trade.

Support price and deficiency payment

Minimum support prices (MSP) for various commodities must reflect the society's preference for the produce and should promote efficiency and quality. In the present form the guaranteed prices have given rise to several problems. As it is not feasible to ensure that prices would not fall below MSP in any commodity, only selected crops should be covered under MSP. Sometimes private trade turns out to be exploitative and farmers are paid price below MSP. A deficiency payment—a part of the difference between actual price received by farmers and MSP—may be made to farmer to avoid such situation. To check resale of produce the deficiency payment should be kept less than the charges (e.g., mandi fee, auction, labour charges etc.) involved in first sale of produce. This mechanism would check regional bias and commodity bias also. Government procurement should be selective. Its quantity should not exceed PDS requirement in a normal production year. Food security buffer stock should be maintained by purchasing grains during above normal production and releasing stock during low harvest years. A buffer stock of around 7 million tones would be adequate to meet supply shortfalls in most of the years.

CHANGING PATTERN OF CAPITAL USE EFFICIENCY IN INDIAN AGRICULTURE

Investments in agriculture resulted in improved agricultural production and made the country self-sufficient in food production. However, this pattern of growth is uneven across regions. Balanced growth requires uniform allocation of resources across regions so that total benefit is maximized due to equality in agricultural development. An analysis of incremental capital-output ratio (ICOR) in agriculture at disaggregated level would be of great help in this. It would be also useful for

estimation of capital requirements to achieve a target rate of growth in output, or to derive the expected growth rate once the capital position is clear. Therefore, ICOR values were calculated at the country and state levels for each year since 1969–70 to 1998–99. The study also assessed the adequacy of current level of investment by states for attaining the target rate of growth in the agriculture sector.

The realization of target growth rate in agriculture depends on the quantum of investment in agriculture, its regional pattern of deployment, and its use efficiency. The analysis of ICOR demonstrated considerable variability in the ICOR across the states and this variability has not reduced over time. Therefore, using a single ICOR estimate for the entire country by the Planning Commission has altered the normative allocation of resources for agricultural development across the states. Compared to the northern states, the ICOR is lower in eastern and southern states. These are the states where additional investment will have larger impact on agricultural productivity. The investment requirement in agriculture is much higher than that assumed by the Planning Commission on the basis of its much lower estimates for ICOR. With the current trend in investment growth, agriculture will grow only @ 3.01% per annum. This falls short of the targeted 4.5% level. To realize the target growth rate in the X Plan, the investment in agriculture should grow at an annual rate of 7.91%, as compared to the present level of 4.95%. Another dimension to this issue is its regional variability. The present trends in investment may result in negative growth in agriculture in most of the eastern and north-eastern states. Immediate attention is required to check further widening of regional disparity in agricultural development. These states would require special emphasis, because of their higher capital use efficiency, and higher concentration of rural poor. In hilly and large states, improvement in the capital use efficiency should be the priority. This requires more than proportional rise in the private investment and judicious use of the investment resources. For this, appropriate policy intervention may be made after careful monitoring of (i) institutional arrangements with which capital and other inputs are managed, and (ii) incentive framework for the agricultural sector.

Estimates of incremental output ratio in agriculture by states (1992–97)

Achievable growth in agriculture by states during X Plan (per cent/annum)

AGRICULTURAL STATISTICS AND COMPUTER APPLICATIONS

A pilot survey on Crop Yield Estimation at Blocks Level Using Farmers' Estimates in Karnal, Haryana, during 1998–99 in *rabi* season, on wheat crop to develop suitable block level estimates of yield using crop cut estimates and farmers' estimates was conducted. The sampling design of General Crop Estimation surveys (GCES) was followed. Accordingly, the crop cut data collected under GCES was utilized for the purpose. To develop block level estimates of average yield two different estimates were developed i.e. one based on simple average while the other was double sampling regression estimator utilizing the eye-estimated yields of the field as an auxiliary information**.** Nearly 20% reduction in the standard error of the estimate was observed in the double sampling regression estimator over an estimator based on simple mean values. The optimum values of sample size were obtained at various stages of sampling by fixing the standard error at 5% and minimizing the total cost. Overall 45% reduction in the total cost of the survey was obtained based on the optimum values of sample sizes in cases where there was high correlation between the farmers' estimate and the estimates obtained through crop cutting approach by adopting the double sample regression estimator. Also, cheaper the cost of obtaining the farmers' estimate compared to the crop cut estimates, the greater the percentage reduction in cost obtained by adopting the double sampling regression estimator over an estimator based on simple mean values.

Universally optimal block designs for both the direct effects of treatments applied to *rabi* crop and residual effect of the treatments applied to *kharif* crop were obtained for the experimental situations where the experimenter was not interested in the

- Method developed for estimation of crop yield at block level.
- Potato and ginger crop area and yield estimated in north-eastern states.
- Fodder tree sp., location of tree in plot, direction of crop around tree and distance of crop from tree affected yield of crop.
- Methodology developed for forecasting fish production from ponds.
- *Agricultural Research Databook–2002* released.

IMPACT OF RESEARCH MANAGEMENT PROCESSES INITIATED UNDER NATP

The NATP was launched to introduce major changes in agricultural research and extension in the country and to support agricultural research and extension in high priority areas. The main idea is to improve efficiency of the NARS, so as to: address effectively the national goals of alleviation of household food and nutritional insecurity and poverty, sustaining efficient and diversified growth, and conservation of environment and natural resources. This is being done through initiation of a number of new 'business processes', and funding research and extension activities. The study provides a mid-term assessment of the impact of NATP with particular reference to research planning, capacity development, competitive research funding, management issues and early socio-economic impact of promising technologies.

- There is a wider appreciation of the need for improved priority setting, monitoring and evaluation (PME) mechanisms in the NARS.
- The progress in multidisciplinary and multi-institutional research approach, though steady but is slow on account of some problems, which are considered as transitional. To accelerate this process further, there is much scope for improving reliability, functionality and efficiency of electronic connectivity in the system.
- Peer review of NATP projects is yielding good results and eco-regional approach in research planning and implementation is greatly appreciated.
- Human capital development is the greatest opportunity under NATP. Despite concrete outputs from previous training programmes, the progress is very slow. It will be a missed opportunity, if progress cannot be made under this soon.
- Competitive research funding is doing very well, though there is a scope to improve it further. The allocation of funds under NATP largely to support operational funds, and priority research (areas, ecosystems, themes etc.) is welcomed widely. But the progress in utilization at the project level is picking up at a slow pace. Reforms in financial management including simplification of rules and procedures hold the key.
- Another important determinant is decentralization of powers at all levels.
- Poor performance in utilization of funds are attributed to PIU (NATP) itself. Delays in release of funds, complexities in purchase of equipment, completion of audit and submissions of statement of expenditure (SOE) etc., are the important issues. Problems like delay in release of grants to principal investigators (PIs), completion of audit and submission of SOE, and compatibility with non-NATP projects, are within the organizations themselves.

It may be too early to track the socio-economic impact of the projects under NATP. But the early trends of expected impacts of selected technologies in all the agro-ecosystems are encouraging. There is a need to document and report the socio-economic information so that its quantification becomes easy later.

AGRICULTURAL RESEARCH DATA BOOK – 2002

The *Agricultural Research Data Book 2002*, the sixth in the series, comprises 195 tables, and eleven sections. List of important national and international Institutions associated with agricultural research and education along with their addresses and contact points are also given.

POTATO AND GINGER STATUS

The potato and ginger crops are the most important crops grown in Meghalaya so their reliable and stable estimates were calculated. The area under potato in East Khasi Hills was estimated as 3,124 ha. The average yield pooled over different varieties was 6,833 kg/ha. The ginger crop area was estimated as 1,240 ha. The average yield was estimated as 4,042 kg/ha. Entire potato growing area was benefited by manures and fertilizers and 47% of the area was benefited by plant protection chemicals.

interaction between direct effects and the residual effects of the two sets of treatments. In such experiments, either the treatments do not comprise complete factorial structure or have at most one replication of the complete factorial structure.

Evaluation of fodder trees with and without crops under rainfed arable farming for semi arid conditions, revealed that factors affecting the yield of the crops (barley and gram) were—trees (*siris*, neem, *babul* and *shisham*), location of the trees in the plot, direction of the crop on the either side of the tree and distance of the crop from the tree. The impact of *siris*, neem and *shisham* was more or less same on the yield of crop. The maximum returns were obtained from the plot consisting of *siris* and gram (Rs 16,688) followed by *babul* and gram (Rs 15,676). The stability analysis indicated that gram (grain and straw) was more stable under *siris* over years as compared to other trees. Land equivalent ratios were calculated for the system.

Methodology for forecasting fish production from ponds was developed for fitting non-linear forecast models under heteroscedastic error with auto-correlation. Models were validated and forecast model with 9-month fish weight was best fit for predicting 12th-month fish weight. Non-linear forecast models under heteroscedastic error structure were better than those developed under homoscedastic error structure.

Training Activities

The IASRI, New Delhi, organized training programmes/courses in Computer Application for the officials of SAUs, ICAR Institutes. Training programmes on 'Sample Surveys related to the Estimation of Area and Production of Fruits and Vegetables', 'Quantitative Techniques in Production Economics Research', 'Economic Accounts for Agriculture' and 'Development of Crop Statistics Methodology' were conducted.

Technology Assessment, Refinement and Transfer

The activities of Division of Agricultural Extension include technology assessment, refinement, and its dissemination. The council have established one National Research Centre for Women in Agriculture (NRCWA) at Bhubaneshwar (Orissa). At present, there are 261 KVKs, 8 TTCs, 70 IVLP Centres, and 44 ATICs in State Agricultural Universities, ICAR Institutes, NGOs and other institutions under frontline extension programmes of the council. The council have earlier strengthened 53 Zonal Agricultural Research Stations (ZARSs) to take up the additional functions of KVKs. During the year, 22 new KVKs and two TTCs have also been sanctioned.

KRISHI VIGYAN KENDRAS (KVKs)

The activities of KVK include skill training of farmers; on-farm testing; in-service training of extension personnel; and organizing frontline demonstrations to establish production potentials on farmers' fields and provide feed back.

Farmers' Training

A total of 18,461 training courses benefiting 0.43 million farmers and farm women were organized in various aspects of crop production, horticulture, plant protection, livestock production and management, home science, agricultural extension, agricultural engineering, fisheries, agroforestry, etc.

Training courses for farmers and farm women

	No. of courses	No. of beneficiaries		
		Male	Female	Total
Crop production	4,399	114,761	22,727	137,488
Horticulture	2,807	53,108	15,976	69,084
Home science	2,474	6,464	51,035	57,499
Livestock production and management	2,042	33,486	13,543	47,029
Plant protection	1,568	36,718	5,028	41,746
Agricultural engineering	967	17,625	3,785	21,410
Agricultural extension	811	10,394	3,805	14,199
Fisheries	345	5,280	1,412	6,692
Agroforestry	124	2,281	533	2,814
Soil fertility management	121	2,295	597	2,892
*Others	2,803	25,475	6,927	32,402
Total	18,461	307,887	125,368	433,255

*Mushroom production, rural crafts, sericulture, management of Self-Help Groups, etc.

Vocational Training for Rural Youths

The training courses for rural youths were organized in agricultural extension, agricultural engineering, agroforestry, animal science, apiculture, crop production, fishery, home science, horticulture, agri-business, mushroom production, plant

- KVKs organized 18,461 training courses for farmers, 3,237 vocational and skill-oriented training courses for rural youth, and 1,634 training programmes for in-service personnel.
- KVKs organized 17,969 extension activities to accelerate dissemination of technologies.
- Yield increased in oilseeds, pulses, cereals, fodder and horticultural crops through frontline demonstrations.
- KVKs identified 296 technologies for on-farm testing to evaluate and assess its impact on specific locations.
- KVKs produced 2816.2, 264.8, 563.9 and 160.3 tonnes seeds of cereals, oilsseds, pulses and vegetables respectively, in addition to 0.59 million fruits saplings, 11.32 million vegetables seedlings, 85,000 spices seedlings, and 0.61 million seedlings of forest species, ornamental and other plantation crops.
- Many KVKs started publication of quarterly newsletters in local languages.
- A total of 849 demonstrations were conducted on high-yielding and pest-tolerant varieties/hybrids of cotton. Training programmes (116) for 3,211 farmers and 15 training programmes for 430 extension workers were organized on various production technologies of cotton. KVKs organized 35 field days, 4 kisan melas, 4 radio and TV coverage, 28 conventions and 2 exhibitions.
- Under the collaborative programme with CIMMYT, the increase in yield varied from 9.15–10.79% over conventional tillage in Haryana, and 0.99–9.78% in various districts of Punjab. The density of *Phalaris minor* was lower in Haryana (20.50–29.32%) and in Punjab (44.30%).

Bicycle-run cocoon deflosser developed by a farmer who got training at KVK, Mysore (Karnataka)

protection, rural crafts and other income-generating activities. As many as 3,237 vocational and skill-oriented training courses were organized for 66,196 rural youths.

Training courses for rural youths

	No. of courses	No. of beneficiaries		
		Male	Female	Total
Crop production	456	7,457	1,914	9,371
Home science	808	1,966	14,658	16,624
Horticulture	620	8,700	3,577	12,277
Livestock production and management	426	6,310	1,847	8,157
Agricultural engineering	220	3,879	457	4,336
Plant protection	182	3,651	631	4,282
Agricultural extension	121	1,999	551	2,550
Fisheries	122	1,619	316	1,935
Mushroom production	68	1,273	360	1,633
*Others	214	3,538	1,493	5,031
Total	3,237	40,392	25,804	66,196

*Rural crafts, sericulture, aromatic and medicinal plants, soil fertility, women in agriculture, agroforestry, etc.

Training for In-service Personnel

A total of 1,634 training programmes were conducted covering 40,980 participants. The training was imparted through participatory training methodologies, field visits and other interactive methods.

Training courses for in-service personnel

	No. of courses	No. of beneficiaries		
		Male	Female	Total
Crop production	403	10,928	590	11,518
Horticulture	267	5,532	629	6,161
Home science	243	609	6,657	7,266
Agricultural extension	155	3,461	561	4,022
Plant protection	139	2,914	54	2,968
Agricultural engineering	131	2,613	218	2,831
Livestock production and management	124	2,164	292	2,456
Fisheries	48	409	52	461
*Others	124	2,708	589	3,297
Total	1,634	31,338	9,642	40,980

*Apiculture, mushroom production, soil fertility, agroforestry, etc.

Extension Activities

The KVKs organized 17,969 extension activities to accelerate the process of dissemination of technologies. These include kisan melas (320), field days (1,273), kisan gosthies (1,882), radio and TV talks (1,792), film shows (1,477), exhibitions (478), newspaper coverages (4,173), popular articles (879), extension literatures (1,338) and others activities (4,357) like advisory services and ex-trainees sammelans.

NEWSLETTERS

Many KVKs have started publication of quarterly newsletters in local languages for the benefit of the farming community. These newsletters contain information on agricultural operations for the coming three months, besides useful articles on crop production, vegetable cultivation, horticulture, animal sciences, home sciences, agricultural engineering, etc. The newsletters also carry the schedule of training programmes in the ensuing three months. These newsletters are widely circulated to the farmers, gram panchayats and line departments.

Extension activities

Zone	Kisan melas	Field days	Kisan gosthies	Radio & TV talks	Film shows	Exhibitions	Newspaper coverages	Popular articles	Extension literatures	*Others
I	19	162	133	173	128	101	449	321	194	516
II	41	186	82	233	18	224	122	52	136	2018
III	6	32	47	31	36	1	46	39	66	24
IV	44	233	365	202	924	19	719	-	-	-
V	101	226	136	269	164	18	642	176	252	536
VI	22	165	106	134	160	33	1,084	201	337	269
VII	54	138	442	179	47	82	420	90	182	92
VIII	33	131	571	571	-	-	691	-	171	902
Total	320	1,273	1,882	1,792	1,477	478	4,173	879	1,338	4,357

*Advisory services and ex-trainee sammelans

Frontline Demonstrations

The Frontline demonstrations (FLDs) were conducted to demonstrate the production potential of the newly released production technologies in a given farming system. The training and field days were organized for extension workers and farmers for dissemination of technologies.

Oilseeds: During the year, 11,195 demonstrations were conducted covering 4,543 ha on major oilseed crops including groundnut, mustard, sesame, soybean, castor, sunflower, linseed, niger and safflower. The percentage increase in yield varied from 34.6 in castor to 90.1 in niger.

Frontline demonstration on safflower hybrid DSH 129 at KVK, Jalna

Frontline demonstrations on oilseeds

Crops	No. of farmers	Area (ha)	Demonstration yield (tonnes/ha)	Local yield (tonnes/ha)	Increase (%)
Groundnut (*kharif*)	2,004	938.5	1.55	1.13	37.5
Groundnut (*rabi*)	1,394	595.9	1.90	1.42	34.6
Mustard	2,983	1,134.1	1.39	0.96	46.6
Sesame	1,389	510.3	0.61	0.42	51.6
Soybean	1,372	525.5	1.42	1.00	45.4
Castor	602	243.0	1.32	0.87	57.5
Sunflower	667	311.4	1.33	0.99	35.3
Linseed	239	78.0	0.93	0.65	51.3
Niger	407	134.3	0.48	0.30	90.1
Safflower	138	72.0	1.04	0.73	40.2
Total	11,195	4,543.0	–	–	–

Pulses: The demonstrations were conducted on bengalgram, redgram, blackgram, greengram, lentil, toria and field pea. A total of 2,587.5 ha was covered with 7,228 farmers. The percentage of increase in yield varied from 47.2 in redgram to as high as 97.8 in field pea.

Other crops: The KVKs organized FLDs on cereals, fodder and horticultural crops covering 3,125.7 ha benefiting 4,751 farmers. The demonstration yield *vis-à-vis* local check are given.

A bumber crop of Pusa Vishal greengram under Frontline demonstration programme

Frontline demonstrations on pulses

Crops	No. of farmers	Area (ha)	Demonstration yield (tonnes/ha)	Local yield (tonnes/ha)	Increase (%)
Bengalgram	2,098	807.4	1.41	0.91	55.4
Redgram	1,234	480.3	1.38	0.93	47.2
Blackgram	1,362	391.5	0.87	0.58	49.5
Greengram	1,110	484.6	0.86	0.58	47.6
Lentil	605	191.1	1.30	0.85	54.9
Toria	399	150.2	1.10	0.77	47.1
Fieldpea	420	82.4	2.36	1.19	97.8
Total	7,228	2,587.5	–	–	–

Frontline demonstrations on other crops

Crops	No. of farmers	Area (ha)	Demonstration yield (tonnes/ha)	Local yield (tonnes/ha)	Increase (%)
Paddy	1,329	460.3	4.84	3.46	43.2
Wheat	1,464	1,910.7	3.74	2.96	27.6
Barley	79	16.1	4.51	3.33	35.4
Pearl millet	141	56.2	2.09	1.43	45.6
Sorghum	105	51.6	1.91	1.42	74.9
Maize	427	142.6	4.00	2.62	56.7
Cotton	580	388.2	1.23	0.88	41.1
Okra	82	13.1	9.52	7.46	30.0
Clusterbean	48	14.5	3.48	2.90	24.9
Onion	200	28.0	17.06	13.03	34.4
Pea	75	11.0	5.45	3.71	61.3
Potato	138	20.5	23.74	16.79	43.8
Tomato	83	12.9	23.82	15.72	56.7
Total	4,751	3,125.7	–	–	–

On-farm trial on NDLR 8 rice at KVK, Yagantipalle

On-farm Testing

Technologies (296) were identified for on-farm testing by the KVKs to evaluate and assess its impact on location-specific basis in different farming systems including varietal trials (111), cropping systems (27), nutrient management (108), pest and disease management (35) and weed management (15).

Integrated management of Phalaris minor *in wheat:* On-farm trial was conducted in Gurdaspur, Punjab, with 3 dates of sowing and two varieties (PBW 343, WH 542), two planting patterns (15 cm, 22.5 cm) and two weed control treatments (un-weeded check, Isoproturon 0.94 kg/ha in sub-plots). Wheat sown on 25 October gave 16.1 and 38.7% higher grain yield over 10 November and 25 November respectively along with reduction in dry-matter accumulation by *Phalaris minor* over 10 November. The crop sown at closer spacing (15 cm) gave significantly more yield than sown at normal spacing of 22.5 cm due to more suppression of *P. minor*. The varieties PBW 343 and WH 542 did not show any difference in dry-matter production of *P.minor* and grain yield of wheat. Further, the crop sown on 25th October maintained superiority in suppressing the weed even without the application of isoproturon as compared to 10 November sowing with application of isoproturon 0.94 kg/ha.

Effect of foliage clipping on grain yield of Basmati rice: On-farm trial was conducted on effect of foliage clipping on the yield of Basmati rice, at KVK Gurdaspur, Punjab, during 2000–02 with different dates of sowing and varying levels of nitrogen. The clipping of Basmati 45 days after transplanting (DAT) along with application of 125 kg N/ha gave the highest average yield of 2.98 tonnes/ha which was 46.1% higher than the unclipped plots with normal dose of 62.5 kg N/ha. Foliage clipping only once at 45 DAT with 125 kg N/ha produced 17.8% higher mean grain yield than clipping the foliage twice at 45 and 75 DAT with same level of nitrogen.

Effect of Azotobactor on nitrogen economy in maize: A trial was conducted at KVK Kapurthala, Punjab, to evaluate the effect of *Azotobactor* on nitrogen economy in maize during 2001–02. The seed treatment with *Azotobactor* slightly increased the grain yield (0.085 tonnes/ha) cob length (1.1 cm) and plant height (32 mm). At recommended level of N, *Azotobactor* application increased the grain yield by 0.06 tonnes/ha, whereas with *Azotobactor* + ¾ recommended N treatment, the grain yield was 3.80 tonnes/ha.

Increasing productivity of tomato by minimizing the incidence of leaf curl virus disease in Sunderbans: Tomato leaf curl virus (TLCV) is a serious problem in cultivation of hybrid tomato in upland particularly irrigated situation of Sunderbans. Incidence of leaf-curl disease in tomato may sometimes affect 30–90% of yield. The trials were conducted by the KVK at Nimpith covering 50 farmers in 16 villages of 6 blocks, viz. Canning-II, Mathurapur I and II, Joynagar I and II and Kultali with four leaf-curl tolerant varieties, viz. Avinash-2 (commercial), Ramakrishna (KVK developed), Sarada (KVK developed) and Vivekananda (KVK developed). The yield of KVK developed hybrid varieties are almost at par with the commercial hybrid.

Leaf colour chart based nitrogen management in paddy: On-farm trials were conducted in Kaithal, Haryana, at five locations to introduce and promote application of nitrogen based on Leaf Colour Chart (LCC) in paddy (HKR 126) during *kharif* 2001. The application of nitrogen based on LCC with recommended plant population gave an average highest grain yield 5.91 tonnes/ha which was 7.7% more than the application of nitrogen at recommended level followed by the treatment of nitrogen based on LCC.

Similarly, trial was conducted on LCC based nitrogen management in paddy (HKR 126) at KVK farm. The highest yield of paddy (5.4 tonnes/ha) was obtained under LCC based N management @ 30 kg/ha compared with basal application of N @ 20 kg/ha.

Monitoring Mechanism

The Project is monitored through 8 Zonal Co-ordinating Units, located at Ludhiana (Zone I), Calcutta (Zone II), Shillong (Zone III), Kanpur (Zone IV), Hyderabad (Zone V), Jodhpur (Zone VI), Jabalpur (Zone VII), and Bangalore (Zone VIII). The Zonal Units monitor the frontline extension programmes by organizing Zonal- and State-level Workshop, Scientific Advisory Committee Meeting and Visits. During the year, eight Zonal Workshops were organized with the participation of the Incharges of all the KVKs to review the work done during the year and formulation of action plan for the next year. Similarly, 32 State-level Workshops were organized in order to review the frontline demonstrations on oilseeds and pulses. To upgrade the knowledge and skills of KVK staff, 15 workshops were organized under HRD programme.

SEED/PLANTING MATERIAL

The KVKs produced 2816.2 tonnes of seeds of cereal crops, 264.8 tonnes of oilseeds, 563.9 tonnes of pulses and 160.3 tonnes of vegetables. In addition, 0.59 million fruit saplings, 11.32 million vegetable seedlings, 0.085 million spices seedlings, and 0.617 million seedlings of forest species, ornamental and other plantation crops were produced. A total of 669.2 tonnes of sugarcane sets, 29.8 bottles of mushroom spawn and 39,123 fodder crops were also produced.

TECHNOLOGY EVALUATION AND IMPACT ASSESSMENT PROJECT

The Division jointly with the Division of Crop Sciences has been implementing an All India Co-ordinated Crop Improvement Project for multi-locational trials across various crop production ecologies in different parts of the country to identify superior-yielding varieties. The yield data revealed that wheat variety PBW 343 (5.717 tonnes/ha) and UP 2556 (5.717 tonnes/ha) recorded the highest yield at KVK, Patiala (Punjab) closely followed by CBW 14 (5.614 tonnes/ha) and PBW 502 (5.608 tonnes/ha). Another trial was conducted to identify the high-yielding genotype of durum wheat with broader adaptability in Faridabad, Haryana, the variety PBW 283 recorded highest yield. At Faridabad, the wheat variety PBW 502 recorded the highest yield of 5.863 tonnes/ha followed by variety PBW 492 (5.84 tonnes/ha). In another trial of pigeonpea, the variety V 30 gave 1.20 tonnes/ha and V 31 gave 1.14 tonnes/ha.

TRAINERS' TRAINING CENTRES (TTCs)

There are eight Trainers' Training Centres. In these centres, training is imparted through work experience, lectures, field visits, demonstration and discussions. During the year, 188 training courses were organized benefiting 2,893 participants and two more TTCs in the areas of vegetables and citrus have been sanctioned.

- TTCs organized 188 training courses benefiting 2,893 participants. Two more TTCs sanctioned in the areas of vegetables and citrus.

INTEGRATED PIGGERY DEVELOPMENT

The programme has been undertaken in 10 KVKs financed by the Department of Animal Husbandry and Dairying. All the 10 KVKs have completed their construction work and created other infrastructure facilities. The KVK, Ambala and Rewari have been imparting 15–20 days training programme to the farmers for establishment of piggery units. Out of 102 farmers trained by these two KVKs, 52 farmers have started their units. KVK, Bankura has selected 14 beneficiaries from scheduled tribe with an aim to upgrade the local stock in their backyard. Nine training programmes were conducted by KVK, Allahabad covering 164 farmers, of which, 21 farmers have started their piggery units. All the KVKs are providing technical information to the farmers for economic management of the pig along with clinical and vaccination services.

MISSION MODE PROJECT UNDER NATP

- A publication entitled *Inventory of Technical Knowledge in Agriculture document-I* has been brought out by Mission Mode Project under NATP.

Integrated Pest Management plot with focus on weed management and subsequently pest management

Groundnut plots of the farmers where Integrated Pest Management is practised under guidance of KVK, R. Mallavapuram, Renigunta Mandal

Collection, Documentation and Validation of Indigenous Technical Knowledge (ITK)

The project was launched under National Agricultural Technology Project (NATP) during 2000. Information on Indigenous Technical Knowledge (ITK) were collected from the primary sources through voluntary disclosures. A publication has been brought out entitled, *Inventory of Technical Knowledge in Agriculture-Document I.*

The information on ITK have been classified in various thematic areas, viz. rain water management (RWM), methods to check soil and water erosion (SWE), practices to check wind erosion (WE), crops and cropping system (CCS), soil fertility management (SFM), pest and disease management (PMD), methods of weather forecasting (MWF), horticultural crops (HOR), veterinary science and animal husbandry (VET), fisheries (FIS), farm implements (FIM), ethno-botany and agro-biodiversity (BOT), grain/seed storage (GSS), fuel management (FM), wood stove/ chullah and thermal efficiency (WSC), waste water management (WWM), garbage disposal and management (GDM), food product development (FPD), agro-animal-based yarns/natural dyes and weaves (YAM), low cost housing materials (LCH) and ethnic food (EF). In addition, some of the disclosers have provided information cutting across the themes. Out of 2,316 ITKs received through voluntary disclosures, 2,020 have been identified for documentation in various thematic areas.

Validation and Promotion of IPM Technology in Selected Crops in Different Agro-ecological Regions

The objectives of the project are to validate and refine the Integrated Pest Management (IPM) modules and evaluate its impact, and to develop a mechanism for creating an interface between IPM technology generation, verification and dissemination at village level among the stakeholders. Seven KVKs have been involved in implementation of the project.

At KVK Dausa, Rajasthan, the average groundnut pod yield in IPM field was 1.514 tonnes/ha as compared to 0.8 tonnes/ha in Non-IPM field with the cost : benefit ratio of 1 : 10.31. Similarly at KVK Kota, Rajasthan, the pod damage by *Helicoverpa armigera* in gram was found to be only 10.40% in IPM field as compared to 18.54% in Non-IPM field. The average yield of gram in the IPM selected field was 1.740 tonnes/ha against 0.98 tonnes/ha in Non IPM field. The mean per cent reduction of *Helicoverpa armigera* larvae in gram varied from 15.10 to 23.55. In IPM field the average number of nodule in gram was 13.65 per plant as compared to 6.27 in Non-IPM.

By adopting IPM technology in pigeonpea the farmers in Gulbarga district got an additional benefit of Rs 1,588/ha and Rs 1,667/ha at Samur and Fatahabad village respectively over Non-IPM village. Similarly, at KVK Ranchi, Jharkhand, the farmers

could harvest tomato crop with a cost : benefit ratio of 1 : 1.87. Because of the farmers interest towards IPM technology and achievement made so far, the State Agricultural Department of Jharkhand has declared one of the adopted village of KVK Ranchi (Barodi) as 'Bio-village'.

The farmers of Maharashtra normally used to spray cotton crop 6–10 times throughout the season, but on adopting the IPM technology demonstrated by KVK Nanded now the farmers are using only 2–3 sprays of insecticides. Due to the impact of the IPM project, the incidence of pest and disease has come down, the natural predators being conserved, the yield has increased from 0.25 to 0.77 tonne/ha. The KVK centres organized 52 training programmes covering 4,272 farmers, two field days covering 185 farmers, four kisan melas covering 500 farmers, 24 extension literatures and 142 newspaper coverages, and 107 advisory services.

AGRICULTURAL TECHNOLOGY INFORMATION CENTRES (ATICs)

The main objective of establishment of these centres under NATP is to create a single window support system linking various units of a research institution/SAU to provide technological products, diagnostic services and technology information to the farmers and other end user.

A total of 0.08 million farmers were provided with diagnostic services. The centres have provided 3,735 tonnes of seeds of improved varieties, 1.107 million nursery plants, and 3.81 million packets of biofertilizers and pesticides. Others activities were testing of 16,272 soil samples, diagnosis of 21,112 specimens of diseased plants; and treatment of 47,991 animals.

REMANDATED ZONAL AGRICULTURAL RESEARCH STATIONS (ZARSs)

The activities include (i) organizing vocational trainings for the farmers groups in agriculture and allied enterprises, (ii) on-farm testing of technologies related to crop, horticulture, livestock, fisheries, etc. (iii) frontline demonstrations on major cereals, oilseeds and pulses and other related enterprises and (iv) in-service training of field-level extension functionaries. Five training programmes on IPM was organized for scientists of ZARSs.

The ZARSs have conducted 1,654 training programmes for farmers and farm women (1,230), rural youths (137) and in-service extension personnel (287), covering 40,000 beneficiaries.

A total of 1,197 extension activities including kisan melas (78), field days (180), kisan gosthies (109) film shows (47), exhibitions (36) and ex-trainees sammelans (2), covering 86,000 participants were carried out. In addition, 553 radio and TV talks, 308 popular articles, 271 extension literatures, 329 advisory services to farmers and 1,209 newspaper coverages were also undertaken. A total of 809 tonnes of seeds of cereals, oilseeds, pulses and vegetables; and 0.55 million saplings/seedlings of fruits, vegetables and forest species were produced.

The ZARSs have conducted 2,836 frontline demonstrations covering 920.19 ha.

FRONTLINE DEMONSTRATION ON COTTON

A total of 849 demonstrations covering an area of 625 ha were conducted by 38 KVKs under FLD on cotton under Mini-Mission-II. These demonstrations were conducted on high-yielding and pest-tolerant varieties/hybrids of cotton.

A total of 115 training programmes for 3,211 farmers and 15 training programes

Monitoring of *Helicoverpa armigera* population by using phermone trap at KVK, Kota (Rajasthan)

- The ATICs provided 3,735 tonnes of seeds of improved varieties, 1.10 million nursery plants and 3.81 million biofertilizers and pesticides. Other activities were testing of 16,272 soil samples; diagnosis of 21,112 specimens of diseased plants, and treatment of 47,991 animals.
- ZARSs conducted 1,654 training programmes 1,197 extension activities, 553 radio and TV talks, 308 popular articles, 271 extension literatures, 329 advisory services to farmers and 1,209 newspaper coverages.
- ZARS produced 809 tonnes of seeds of cereals, oilseeds, pulses and vegetables. Also 0.55 million saplings/seedlings of fruits, vegetables and forest species were produced.

Training is being given on the maintenance of power tiller at Zonal Agricultural Research Station of the KVK, Udupi (Karnataka)

SETTING UP OF RENEWABLE ENERGY PARKS

The Ministry of Non-Conventional Energy Sources (MNES) under Special Area Demonstration Programme has provided financial support for setting up of renewable Energy Parks at 10 KVKs. Various solar devices sanctioned under this project including improved chulha, PV street light, PV domestic light, PV lanterns, water heating system, cookers, solar still, family size bio-gas plant, radio, colour TV, PV pump, wind pump, crop drier, biomass gastifier, educational kit and sprayers. The selected KVKs have already installed these devices in their premises and started imparting training and demonstrations to farmers, farm women and rural youths about the use of solar energy devices. Self- Help Groups (SHGs) members were given awareness about the renewable energy sources.

Solar Pv street light at KVK, Ranichauri

for 430 extension workers were organized on various production technologies of cotton. 35 field days, 4 kisan melas, 11 radio and TV coverages, 28 conventions and 2 exhibitions were also organized by the KVKs.

INTERFACE AT DISTRICT LEVEL

To strengthen research–extension linkages, KVKs organized 396 interface meetings involving the scientists and development officials at district level.

COLLABORATIVE PROGRAMME WITH CIMMYT

INSTITUTION-VILLAGE LINKAGE PROGRAMME (IVLP)

The Technology Assessment and Refinement through Institution-Village Linkage Programme (IVLP) was taken up under NATP. Out of 70 IVLP centres, 24 are located in Rainfed Zone, 19 in Irrigated Zone, 13 in Coastal Zone, 12 in Hills and Mountain Zone and 2 in Arid zone; covering 62,255 farm families in 253 villages. There were 3,558 technological interventions including 1,873 on crops, 646 on livestock, 762 on horticulture, 52 on forestry, 82 fisheries, 38 on gender implications and 105 on other related areas.

Refinement of intercropping technology of sunflower and pigeonpea under Institution-Village Linkage Programme at Solapur (Maharashtra)

Kisan gosthie at Institution-Village Linkage Programme Centre, Kanyakumari (Tamilnadu)

The trials on the use of zero-till-seed-cum-fertilizer drill were conducted by various KVKs, to make the farmers aware of the advantage of timely sowing and control of *Phalaris minor*. These trials were conducted in collaboration with the Regional Facilitator, Rice-wheat Consortium, International Maize and Wheat Improvement Centre (CIMMYT), New Delhi. Based on the results of 548 demonstrations covering 328.5 ha, an increase in wheat yield varied from 9.15 to 10.79% over the conventional tillage in Haryana, and from 0.99 to 9.78% in Punjab. Besides, a saving in the cost of land preparation was observed compared with conventional method. The density of *Phalaris minor* was lower in Haryana (20.50–29.32%) and Punjab (44.30%).

QUINQUENNIAL REVIEW TEAM (QRT)

Eight Quinquennial Review Teams for eight zones were constituted to review the achievements of the KVKs under State Agricultural Universities, Non-Government Organizations and other educational institutions.

Women in Agriculture

The woman is the backbone of agriculture but worldwide her hard work has mostly been unpaid. She does the most tedious and back-breaking tasks in agriculture fields, animal farms and homes. The research efforts at the ICAR institutes have tried to relieve her of the drudgery by providing time and labour saving tools. Trainings are also being conducted to train her in cottage industries, which she can start from her backyard. In extension activities the woman is now the centre of point and activities are being planned keeping her in view. Her enlightenment will change the face of rural India. Several programmes started at the National Research Centre for Women in Agriculture and under five components of AICRP on Home Science are right steps in this direction.

- The NRCWA has now ongoing 14 research projects to develop women-specific technologies. The NRCWA organized 30 training programme for 887 farm women 5 courses for 63 in-service extension personnel, besides one farmers' fair.

NATIONAL RESEARCH CENTRE FOR WOMEN IN AGRICULTURE

The NRC on Women in Agriculture (NRCWA) has been functioning at Bhubaneshwar, Orissa to develop methodologies for identification of gender implications in farming systems approach and to develop women specific technologies under different production systems. The salient achievements are given below.

There are 14 ongoing research projects, viz. Gender study on agriculture and household economy of tribal of Orissa; Development and testing of extension methods for farmwomen in eastern India; Studies on technological need for empowering women in rural aquaculture; Occupational health hazards of farmwomen in coastal Orissa; Standardization of women specific field practices in rice in Orissa; Identification and evaluation of interactive learning modules for dissemination of homestead technologies; Improvement in storage practices of seeds and grains of important crops with women perspective; Identification and improvement of farming systems suited to farmwomen in eastern India; Improvement in backyard poultry farming for farmwomen of different categories; Improving livelihood, poverty alleviation and income generation in coastal eco-system; Empowerment of women in agriculture; Collection, documentation and validation of ITK (storing of pulse grains by using dry chillies); Studies on women in agriculture in India with special emphasis on crop production technologies; and Reducing drudgery of women in agricultural operations through use of improved equipment.

In the project on 'Studies on technological need for empowering women in rural aquaculture', different aquacultural technologies were transferred to the selected women through demonstration and training related to carp culture, nursery raising including pond management and feed management, freshwater prawn culture along with carp polyculture in the backyard ponds, and ornamental fish breeding and production at village level. Success of these programmes have proved the potential of backyard fish culture and ornamental fish [guppy (*Poicilie reticulata*) and platy (*Xiphophorus maculates*)] production as a good source of income for the rural women, that has attracted others to join it.

In the project on 'Occupational health hazards among farmwomen of coastal agroecosystem', the common health hazards reported by the women involved in the activities like seed-bed preparation, transplanting, and harvesting of paddy are waist pain, backache, injury, and cold and cough. Similarly the common health

Trained women netting fish from the backyard pond

Women participating in farm women fair

INTRODUCTION OF DRUDGERY REDUCING IMPLEMENTS

NATIONAL RESEARCH CENTRE FOR WOMEN IN AGRICULTURE

Mandate

- Transfer of Technology for farm women
- Household economy of tribal woman
- Development of homestead enterprises
- Farming systems suitable for farm women
- Health hazards and drudgery reduction
- Standardization of cultivation practices
- Capacity building options in super cyclone affected areas
- Capacity building of extension functionaries and specialists
- Highlighting gender issues and gender sensitization

Achievements

Work availability to gender in a year

	Maximum number of days engaged	
	Men	Women
Agriculture sector		
(a) *Kharif* season (Rice)	52	78
(b) Other crops (Turmeric, vegetables etc.)	20	30
Non-agriculture	48	30
Total	120	138

Trainer's training programmes

Training	Duration	No. of participants
Main centre		
Care and management of new born calves —Women's domain	20–22 November 2001	6
Entrepreneurship development among farm women	26 November to 1 December 2001	15
Techniques of improving extension services for farm women	12–15 February 2002	7
Commercial manufacture of indigenous milk products and their marketing potential	29–31 July 2002	5
Sub-centre		
Women friendly agricultural technologies	22–24 January 2002	30

The selected enterprises

Technology/ Enterprise	No. of groups covered	Parameters for allotment of enterprise
Aquaculture	12	• Availability of ponds (both backyard and community ponds) • Good marketing facility • Easy access to research institute • Favourable attitude towards aquaculture
Mushroom cultivation including spawn production and vermi-composing	7	• Availability of paddy straw for mushroom cultivation • Recycling of mushroom waste through vermi-composting • Availability of congenial space • Low cost and simple technology • Leisure time activity • Good marketing facility
Manufacturing of value added dairy products	2	• Availability of surplus milk at home • Background knowledge for preparation of indigenous dairy products • Easy transportation to urban centres • Motivation of farm women for higher monetary returns
Floriculture and vegetable growing	5	• Availability of well-drained, upland, loamy soil in the vicinity • Availability of irrigation • Good market demand • Beneficiaries can give more time
Preparation of *masala* powder and *papad* making	4	• Preference for in-house income generating activities • Efficiency of women in grinding and other related works
Coir work	3	• Lower caste women folk having knowledge on rope making and weaving • Easy availability of raw material (coir) • Encounter seasonal unemployment
Nursery raising	1	• Availability of good land with assured irrigation • Vegetable growing areas have great demand for seedling • Quick return
Poultry	1	• Background of poultry rearing • Poultry shed exists • Good marketing facility • Perceived as a good income generating activity

Enterprises were selected with group consensus and above parameters came into force.

EMPOWERMENT OF WOMEN IN DIFFERENT ENTERPRISES

Training on tomato-seed extraction for a Self-Help Group

Heart-rate measurement of a farm woman operating a seed-treatment drum at sub-centre of NRCWA (*right*); Harvesting of mushroom by trained women of a Self-Help Group (*extreme* right)

hazards reported by the women involved in various post-harvest operations like transporting, threshing, crop drying, shelling, parboiling, and storage are headache, injury, eye irritation, skin infection, and pain. Women involved in various livestock activities like feeding of animals, cleaning of shed, collection of fodder, milking, and chaff cutting, reported pain in waist and hand more frequently.

In the Mission Mode Project on 'Empowerment of women in agriculture', 540 farmwomen were grouped into 18 experimental Self-Help Groups (SHGs). For each SHG, 2 link workers were selected for leading a group of 15 farm women. These link workers were trained on organizing training on different entrepreneurial activities like pisciculture, mushroom production, nursery raising and vegetable production, floriculture, processing of milk/milk products, agro-processing, coir work, and vermi composting. During the year, training was imparted to six groups, besides developing training materials like folders, video cassettes/multi media CD on the use of technologies for reduction of drudgery in transplanting, sowing, weeding and parboiling.

The NRCWA organized 30 training programmes for the benefit of 887 farmwomen. In addition, 5 trainings for trainers were organized for 63 in-service extension personnel. The NRC also organized one farmwomen fair with 300 rural women, where the women-specific technologies were demonstrated. In addition, the scientists of the centre participated in 3 radio and TV talks, published 6 popular articles and delivered 3 popular lectures.

At sub-centre of NRCWA, under the project on 'Reducing drudgery of women in agricultural operations through use of improved equipment', experiments were conducted for reducing the drudgery of women by using groundnut decorticator, tubular-maize sheller and seed-treatment drum.

Value added products using natural dyes have been developed

HOME SCIENCE

Development of human capital of rural women by bringing about changes in their capabilities and capacities is essential for keeping a balance between micro and macro farm production and consumption systems. For this, the five components of Home Science are exploring the temporal dimensions of realities of rural life in different agro-ecological conditions to accord rational and comprehensive and technical inputs towards an integrated improvement in quality of life of rural families. The multiple thrust of the project thereby, helps to recognize and acknowledge the

priorities of rural families for which each component is making intensive efforts to develop and disseminate need-based women-friendly technologies for its use within an ecosystem.

Nutritional Security for human health in agrarian ecosystem

Iodine deficiency results from geological rather than social and economic conditions. The problem is aggravated by environmental factors such as accelerated deforestation and soil erosion. Unlike other micronutrients it does not occur in specific food, rather it is present in soil and is imbibed through food grown on that soil.

Hence, analysis of food samples from different agro climatic zones available in urban markets and also farmers grown samples provide an estimate of iodine content based on which long term sustainable strategies could be planned to ensure that iodine reaches the entire population and is ingested on a regular basis. Awareness among population could be created to consume foods containing higher iodine so that no more cretins will be born, no more babies will suffer from retarded mental and physical development attributed to iodine deficiency.

Estimation of iodine in food samples was done based on the methodology of G. Anmont and J.C. Tressol (1986). The Study highlighted

- Large variation in iodine content was found in samples from each food group.
- Significant difference with respect to iodine content in food samples from different selected zones were found.
- Compared with plant foods iodine content was found to be higher in milk.
- Amaranth grain an unconventional and underutilized crop had an exceptionally higher iodine content.
- Unconventional green leafy vegetables from hilly region contained higher iodine content.
- RDA of iodine requirement could be met when the intake of population is adequate in terms of major foods such as cereals and pulses. However, inclusion of milk and green leafy vegetables in the daily dietary will also help in meeting the requirement of iodine.

Value addition to agro and animal based fibres and indigenous dyes

Keeping in view of the increased demand for eco-friendly products in textiles world wide, the All India Coordinated Research Project has rightly aimed at developing the eco-friendly natural dyes and processes on natural fibres. Around 36 new sources of natural dyes were identified and their dyeing procedures were standardized for silk/wool and cotton and around 5,184 shades were developed by all the nine AICRP centers. Mordanting with different combinations of mordants developed new natural shades on cotton and silk/wool. Six mordant combinations were selected namely, alum + chrome, alum + copper sulphate, alum + ferrous sulphate, chrome + copper sulphate, chrome + ferrous sulphate and copper sulphate + ferrous sulphate. Three mordant proportions, viz., 1 : 1, 1 : 3 and 3 : 1 and three mordanting methods were selected. Each AICRP–CT center has developed new shades on cotton and silk/wool with 6 mordant combinations using 4 natural dyes optimized earlier. Thus an additional 3,888 shades on silk/wool and cotton were developed using 36 natural dye sources during the current year. The dyed samples were assessed for colour fastness to all serviceable conditions such as washing, sunlight, crocking and perspiration. The results revealed that combining mordants have improved some of the shades.

Combining two natural dye sources by union dyeing produced several new shades. A total of 972 shades were produced by union dyeing. Among these 324 best shades were selected for which colour fastnesss tests were carried out. The combination of dyes produced a wide variety of shades to fill the spectrum of colours for the weavers and dyers in natural dyeing.

The technologies developed by each center were introduced to the artisans and

COMPREHENSIVE CHILD CARE THROUGH FARM CRECHE

The project on Comprehensive Child Care through farm creche—an intervention for optimum developmental outcomes of infants was concluded from birth to 18 months and 497 from experimental group drawn from nine AICRP (CD) centres with an interval of six months between two testing. The result indicated a improvement in psychomotor and mental development indices of infants from birth to 36 months.

Another component on Empowerment of Rural Girl Child for quality life and prevalence Etiology of exceptionalities in Rural Areas was also initiated during this period.

The prevalence of exceptionalities/ disability among children is being studied through snowball sampling. The causes of exceptionalities are being studied by interviewing the family members of the exceptional child. On the basis of situational analysis, intervention modules are being developed and intervention is being provided to rural adolescents in empowering them educationally, socially and economically and legally.

IMPROVED TECHNOLOGIES TESTED FOR DRUDGERY REDUCTION

Improved sickles for fodder cutting

MAU dibbler for dibbling

Wiper for mud plastering of house

Kilta for storing plucked tea leaves

Under AICRP on Home Science Ergonomic of farmwomen's drudgery in home, farm and allied activities was conducted.

On the basis of difficulty scores farm activities were assessed as very drudgery prone, but most of the dairy and household activities were assessed as moderately tiring by the farmwomen.

As regarding the health status of farm-women, it was observed from the findings that the maximum number of women had low weight, thin cylindrical body, average physical fitness status but good aerobic capacity. The women in excellent health status were found in very small number.

Results of the ergonomic cost of the selected activities showed that except cotton picking, dibbling and tea plucking activities physiological stress for performing selected farm activities was found very high and above the permissible limits of workload for women worker.

Similarly physiological workload for collecting and bringing fodder and milking animals under dairy activities and fetching water and mud plastering of house under household activities was found above the permissible workload.

Muscular stress for performing the selected farm, dairy and household activities were also found high due to the unnatural postures (bending and squatting) adopted by the farmwomen. Angle of bend of spinal column was found as high as 63° during harvesting, 58° during transplanting, and 32° during uprooting of seedlings, 17° for performing the weeding activities. Due to the poor postures adopted while performing the activities, women felt severe to very severe pain in the neck, shoulder joints, low back, knee, upper-thigh and feet and changed the posture frequently to get relief from the unbearable pain. Few of the improved technologies were tested in order to see the impact of these on the drudgery reduction of farm-women in selected activities to a significant level.

The use of improved tools also enhanced the work efficiency, reduced the time cost therefore reduced the total cardiac cost of work and physiological cost of work.

weavers who are the ultimate users of these technologies. Many value added products using natural dyes were developed by each center.

Data base on rural women and indigenous knowledge

For empowerment of rural women as subsistence-generating units, the Home Science Extension component developed database of 27,000 rural women of 41 agro-climatic zones on participation, decision making and time use pattern. The intensity and nature of participation is depending on crop and time allocation is primarily activity specific with highest time use during peak periods of agricultural operations. The decision making pattern is largely governed by joint decisions in various spheres of life. Data bank has been developed of 150 scientifically validated indigenous knowledge on maternal health. Nine technology kits consisting of multimedia resource materials have been developed for knowledge empowerment of extension functionaries.

Village adoption with a mission

One village adoption approach for integrated improvement in quality of life of rural families is being followed by each centre. In these adopted villages the self-help groups have been established for empowerment of women.

A.P. CESS FUND SCHEMES OF HOME SCIENCE

The adhoc scheme titled Study on supplementation of leaf powder concentrate on Vitamin A and iron status of children (1–3 year age) has been implemented by, Dr (Ms) K. Khanna, Director, Institute of Home Economics (IHE), New Delhi. The findings clearly indicated that Leaf Protein Concentrate (cauliflower leaf) based supplementary feeding was superior in improving the condition of the under nourished subjects. To improve hemoglobin levels significantly there is a need to supplement the receipes with ascorbic acid to increase the bio availability of the iron. This was needed in addition to other measures like (like controlling parasitic load) so as to improve iron status of children.

Development of diversified food formulations based on millets suitable for groups at risk particularly from Kumaon was implemented.by Dr (Ms) Sarita Srivastava, G. B. Pant University of Agriculture and Technology, Pantnagar. Food Products were developed and standardized for household level and for commercialization both, which were based on cereals. Audio Visual kits for demonstration as also recipe booklets were prepared. The project achievement highlights use of millets especially finger millet, barnyard millet and foxtail millet by popping and malting and further utilization in combination with other locally grown foodstuffs to produce nutritious, acceptable health foods for vulnerable groups. Adoption of this technology at household level and commercial level will benefit people from Kumaon hill by providing proper nutrition.

Gender Sensitization of Rural Women through the introduction of Agro based Vocations: A case study of Himachal Pradesh was implemented by Dr Y.S. Negi, Y.S. Parmar University of Horticulture and Forestry Nauni-Solan. The project highlights that women trained in the area of commercial cultivation of flower crops and vegetables in both managerial and marketing skills were found capable of establishing a strong agro based vocation unit of their own.

Dr (Ms) Saroj S. Jeet Singh and Dr (Ms) Neelam Pruthi, CCS Haryana Agricultural University Hisar led a **Study on designing the garments for physically and orthopaedically handicapped.** Through the project the problems of clothing of disabled were identified using interview and observation methods. Garments designed to ease the identified problems and camouflage the disability have been a contribution of this project. Special care has been taken to design for crutch users, limb amputees, Parkinson's/cerebral affected persons. To disseminate information a National level seminar was organized which involved organizations dealing with handicaps, industrialists and other takers of the technological know how in this effort.

Nutrition Education and Communication Support in Hill Areas of Uttar Pradesh. This project was implemented by Dr (Ms) A.R. Kumar G.B. Pant University of Agriculture and Technology, Pantnagar. The project highlighted that

Revolving *pihri* for milking of animals

Finger blades for tea plucking

Outfit designed for physically and orthopaedically handicapped

Project to highlight the nutritional status of adolescent girls of Haryana

Supplementary nutrition through iron-rich recipes

Sling and arm wrap for upper limb structure

nutritional education helped remove the major misconceptions about micronutrient deficiencies prevailing among the rural families, viz. Vitamin A deficiency and anemia. In this project the effectiveness increased due to utilization of the educational package Video films *Drishti*, *Rakt abhakhani anaemia Ki*, story books titled *rakt chethna lok chethna* and wall calender designed and the study confirmed that the exposure through single/combination media was significantly effective for the positive effect of nutrition education on targetted groups.

The Project on **Revival of Phulkari** has been implemented by Dr O.P. Singh at Punjab Agricultural University Ludhiana. Documentation of 51 traditional Phulkaris and 66 traditional Phulkari motifs was done photographically and graphically. New Phulkari motifs were developed graphically for use on different garments and household articles.A number of exhibitions on 'Phulkari embroidery' or 'Revival of Phulkaris' were organized for disseminating the traditional art to create awareness regarding our vanishing cultural heritage. Demonstrations and trainings were held in different villages of Punjab. The project highlights that the enhancement of knowledge of the skilled women would help initiate entrepreneurship, however, there is a requirement of financial and marketing support

THE MISSION MODE PROJECT OF NATP
EMPOWERMENT OF WOMEN IN AGRICULTURE

The empowerment of women being a visionary goal, this project envisages its mission as "Technological and economic empowerment of farm women to reduce their drudgeries and increase work efficiency in the context of agriculture and animal husbandry and skill development for entrepreneurship development.

The project works through Self Help Group and covers more than three thousand beneficiaries, drawn from seven states. Dr (Ms) Pushpa Gupta, Dean, College of Home Science, MPUA and T, Udaipur, is the Principal Investigator and Dr (Ms) Tej Verma, ADG (H.Sc.), ICAR, New Delhi is the mission leader of the project. Strong linkages have been built-up involving scientists and other multi-disciplinary areas covering agricultural and mechanical engineering, farm machinery and power, agro-processing and social science disciplines, NGOs and Industries alongwith home scientists placed at seven co-operating centres have successfully formulated the SHGs. The entrepreneurship development areas have been identified for execution. The Peer Review workshop of World Bank has also been held.

Scheme implemented on development of nectars from selected fruits and fruit blends (*above*) papaya powder (*below*) nectar and nectar blends with natural flavours

The Study on **Nutritional Status of Adolescent girls of Haryana with special reference to anemic and its eradication through iron supplementation** has been implemented by Dr Salil Sehgal, CCSHAU, Hisar. The project highlights the dietary survey result that the mean daily energy, protein, Vitamin A, iron, zinc intake of 13–15 years adolescent girls was less than 80% of recommended daily allowances. It was found that approximately 96% of the girls were anemic. Hemoglobin, PCV, serum iron of subjects in all the three supplementation groups significantly increased at the end of supplementation period as compared to initial and control groups. Increase in Haemoglobin level was maximum in the group fed with iron foliate tablets followed by the group fed on fortified salt and iron rich recipes.

The Scheme on **Development of Nectars from selected Fruits and Fruit Blends** was implemented by Dr K. Aruna at PG Research Centre, ANGRAU, Hyderabad. Fruit Pulp from Amal (Small), black grapes, Grapes (green), Guava, Mango (Baneshan), Mango (Rasalu), Mango (Raw), Papaya, Pineapple, Sapota and Water Melon prepared using Citric Acid as a preservative and storage life was evaluated. Later nectar blends were prepared. Fruit Powders were developed from papaya, pineapple, blackgrapes, watermelon and the shelf life was also standardized for commercialization.

3. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through the Vivekananda Pravatiya Krishi Anusandhan Sansthan (VPKAS), Almora, the ICAR Research Complex for Northern-Eastern Hills Region, Umaim, Meghalaya, and the Central Agricultural Research Institute (CARI), Port Blair, evolves technologies to meet the needs of tribal farmers in hilly areas.

These technologies are intended to improve the socio-economic status of the target group, and will help them to acquire special skills through vocational training in traditional and non-traditional crops, agroforestry, apiculture, sericulture, horticulture, animal husbandry, poultry and fisheries.

- One variety each of wheat (VL Gehun 804), pea (Vivek Matar 8) and barnyard millet (VL Madira 181) released.
- Vivek Sankul Makka 11 maize composite and VLT 9531 tomato variety identified for release in Uttaranchal.
- Shot-duration, blast-resistant strains (VL 95-6446 and VL 96-6747) of rice and exotic line (VHC 12) of capsicum identified for release in Uttaranchal hills.

VIVEKANANDA PARVATIYA KRISHI ANUSANDHAN SANSTHAN, ALMORA

Crop Improvement

Three varieties were released and notified.

Crop varieties released and notified

Variety	Adaptation region/ agro-ecology	Yield (tonnes/ha)	Duration/ other salient features
Wheat			
VL Gehun 804	Timely sown, irrigated and rainfed conditions of northern hill zone	4.13 (irrigated), 2.57 (rainfed)	178 days (rainfed), 164 days (irrigated)
Pea			
Vivek Matar 8	Uttaranchal, Himachal Pradesh and Jammu and Kashmir	11.5	138 days (mid-season)
Barnyard millet			
VL Madira 181	Bihar, Karnataka, Madhya Pradesh and Tamil Nadu	1.8–2.0	Early maturity (77 days); suitable for 200% cropping intensity and has non-shattering, non-lodging habits and easy threshability

VL Gehun 804 wheat having high degree of resistance to brown and yellow rusts and loose smut, gives yield 4.13 and 2.57 tonnes/ha under irrigated and rainfed conditions respectively

A promising garden pea variety Vivek Matar 8, having thick skin and free from fuit-cracking, contains higher total soluble solids (16.8%). It has better tolerance to cold and moisture stress and is moderately resistant to powdery mildew and white rot

Strains identified by the SVT of Uttaranchal for release in the state are:

Vivek Sankul Makka 11, an early-maturing (95–100 days) maize composite was tested as Pop 31 C_4HS bulk (Alm.). The grains are orange-yellow, flint and the plants are slightly shorter (200–205 cm) than Makka 16. It has shown tolerance to *Helminthosporium turcicum* leaf blight and yielded 4–4.5 tonnes/ha.

A tomato variety VLT 9531 was identified with an average yield potential of

VLT 9531 tomato gives 29.3 and 23.4% higher fruit yield than best checks Pusa Ruby and Rupali respectively (*left*); VHC 12, a promising genotype of capsicum, identified for release in Uttaranchal hills, outyielded best check California Wonder (*middle*); Vivek mandua/madira thresher developed at the VPKAS, Almora, for threshing and pearling grains of *mandua* and *madira* (*right*)

- Low-cost poly-tunnel technology developed for 1-month advance production of capsicum and tomato during winter.
- In a long-term fertility experiment under NP and NPK treatments, applied P resulted yield increase of 69.9% in soybean and 20% in residual wheat.
- Continuous FYM application with N alone or with NPK to soybean increased the productivity of soybean and wheat.
- Organically fertilized basmati rice plots showed less blast score and stem-borer incidence than chemically fertilized ones.

Resistant lines of rice and wheat

Disease	Resistant line
Rice	
Blast disease	VSR 8 and VL 4049
Brown spot	VSR 8, VSR 28 and VL 4015
Wheat	
Rusts	VL 796, VL 802 and VL 803
Loose smut	VL 826, VL 829 and VL 832
Karnal bunt and hill bunt	VL 798

22.27 tonnes/ha (fruit). The yield potential was higher than that of best checks Pusa Ruby and Rupali. Its fruits are round, medium large in size, deep red, thick skinned and free from fruit-cracking.

The following promising lines were identified for release in Uttaranchal hills. Two short-duration, blast-resistant strains of rice, viz VL 95-6446 (IET 16480) and VL 96-6747 (IET 16482), were recommended for on-farm trials in hills of Uttaranchal and Himachal Pradesh under rainfed upland conditions. Both the strains had genetically diverse parental lines in their parentage.

An exotic line VHC 12 was identified as one of the promising genotypes of capsicum, giving an average yield of 21.94 tonnes/ha compared with best check California Wonder (17.08 tonnes/ha).

Crop Production

Low-cost poly-tunnel (size 5 m × 1 m × 0.5 m) technology using 200 micron UV stabilized plastic film and locally available material, i.e. bamboo, was developed for raising seedlings of capsicum and tomato during winter month (January) under mid-hill conditions of N–W Himalayas. It enables advancement of production of these vegetables by one month and thereby helps fetch higher prices. The construction cost of tunnel was Rs 287.00 only.

A comparison of 27 years average yield data of soybean and wheat from a long-term fertility experiment under NP and NPK treatments, showed significant response to applied potassium, resulting in 69.9% increase in average yield of soybean and 20.0% increase in residual wheat crop. Continuous application of farmyard manure (FYM) in combination with N alone or NPK to soybean crop, also showed increasing trend in productivity of both the crops. This could be attributed to addition of 55.9 kg N, 15.4 kg P, 58.5 kg K, 117.7 g Zn, 3,329.0 g Fe, 560.3 g Mn, 22.7 g Cu, 40.6 g B and 170.5 g Mo/ha from FYM to soil every year.

The results of first year experiment showed advantage of organic farming over chemical fertilization. The rice crop responded well to applied organic manure and equivalent amount of NPK. With the application of 5, 10, 15 and 20 tonnes FYM/ha, the yield of VL Basmati 2 rice increased from 3,000 kg/ha to 3,805; 4,083; 4,416

and 4,722 kg/ha, respectively, based on 6 m^2 net plot yields. The corresponding yield of Basmati rice with chemical fertilizer (NPK) applied equivalent to 5, 10, 15 and 20 tonnes FYM/ha were 4,305; 4,694; 3,916 and 4,125 kg/ha respectively. Harvest index was higher under organic manured plots (37.6-40.9%) than inorganic fertilized plots (30.7–35.4%). Blast score (6.5) and incidence of stem-borer (9.33/plot) were higher under inorganic fertilized plots than blast score of 4 and stem-borer incidence score of 7.13 in organically fertilized plots. The compost applied in this experiment contained 0.73% N, 0.42% P and 0.63% K.

Vivek Mandua/Madira thresher was designed, fabricated and developed for threshing and pearling grains of finger millet (*mandua*) and barnyard millet (*madira*) based on the physical and rheological properties of *mandua/madira* grains.

Crop Protection

In all-India co-ordinated trials, lines of rice and wheat showed resistance to major diseases at most of locations.

ICAR RESEARCH COMPLEX FOR NEH REGION, UMIAM

Crop Improvement

An attempt made over the period of last 9 years culminated in the development and release of 4 rice varieties, viz. Bhalum 1 (RCPL 1-29) and Bhalum 2 (RCPL 1-27) for upland; and Shah Sarang 1 (RCPL 1-87-8) and Lum Pnah 1 (RCPL 1-87-4) for lowland. These varieties developed for both upland and lowland of mid-altitude conditions showed about 65–70% higher yield potential over the existing varieties.

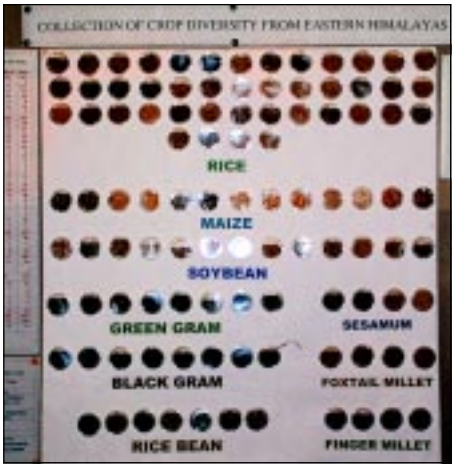
Rice varieties Bhalum 1 (RCPL 1-29) and Bhalum 2 (RCPL 1-27) developed for upland, gave 65–75% more yield than the existing cultivars

Use of Bio-fertilizer

A rich harvest of rice cv. RCPL 1-87-4 (3.95 tonnes/ha) could be obtained by curtailing 25% of the recommended dose of N : P : K (80 : 60 : 40 kg/ha) through application of azolla along with FYM @ 5 tonnes/ha.

Conservation of Plant Genetic Resources

The Institute had collected 1,645 crop germplasm, consisting of 492 rice, 271 maize, 92 other cereals, 343 legumes, 204 oilseeds, 60 fibre crops, 100 vegetables, 38 fruits and 45 spices and sent to the NBPGR for medium- and long-term storage in the National Seed Bank. In addition, an arboretum of 50 important tree species was established at the regional centre of the Institute at Basar, Arunachal Pradesh. Besides, 16 indigenous fruit species, 30 varieties of banana, 31 bamboo species and 26 citrus species were maintained at the regional stations.



The entire north-eastern region has been known as mega-diversity areas for plant genetic resources. A total of 1,645 crop germplasm was collected by the Institute, consisting of cereals, legumes, oilseeds, fibre crops, vegetables and spices

Vegetables

The capsicum grown under protected environments showed much bigger size than the one grown under open condition.

An advanced line of tomato was developed, having tolerance to both bacterial wilt and late blight diseases with high production potential. The other advanced lines developed are expected to be released next year. Similarly, out of 7 selection lines of brinjal 5 are in advanced stage of release, of which 2 lines having resistance to bacterial wilt are expected to be released next year.

Fruits

During the last two decades, the existing orchards are seriously affected by citrus decline. The Institute has developed not only citrus-rejuvenation package in the form of fertilizer schedule, micro-nutrient requirement and disease pest management

California Wonder capsicum developed bigger fruits when grown under protected condition than when grown under open condition

- Four rice varieties released (Bhalum 1 and Bhalum 2 for upland; Shah Sarang 1 and Lum Pnah 1 for lowland)
- Collected 1,645 crop germplasm, including cereals, legumes, fibre crops, vegetables, fruits, spices.
- A variety of turmeric Megha Turmeric 1 released.
- A high-yielding, advanced line of tomato developed having tolerance to bacterial wilt and late blight.
- A citrus-rejuvenation package developed and tissue-cultured, disease-free planting produced for farming community.
- Sun-drying, oven-drying and boiling could reduce HCN content in bamboo leaves for feeding livestock.
- Some farm implements developed at ICAR-RC-NEH accepted by farmers of Uttaranchal state.
- DNA-based rapid diagnosis techniques developed for salmonella and clostridial diseases.
- Software developed for protozoa parasitic diseases affecting domestic animals and birds.
- Watershed-based technologies could check soil loss from 46 to 5 tonnes/ha
- Farmers from NEH region trained for using modified implements and manufacturing implements.
- A technology perfected for soybean processing into products like soya milk, paneer and biscuits.

Turmeric is one of the widely grown species throughout the north-eastern region. Megha Turmeric 1 gave 196% higher yield than presently cultivated variety Lakadong

TURMERIC PERFORMANCE

A variety of turmeric Megha Turmeric 1 was released. It gave yield of 27 tonnes/ha which was around 196% higher than the presently cultivated Lakadong variety, with almost equal curcumin content. It has been accepted very well by the farming community and the State Department of Horticulture, particularly for its very high yield as well as its relative resistance to diseases and pests.

BAMBOO

Besides use of bamboo in the paper industry, its shoots are also taken as ethnic food. Bamboo leaves can serve as a good fodder resource particularly during the lean season. However, feeding of bamboo leaves to livestock is restricted due primarily to a higher level of HCN content. The research work conducted at the Institute could reduce the HCN content in bamboo up to 72.20% after sun-drying for 24 hr. Besides, boiling and oven-drying could also reduce the HCN content up to 100 and 82% respectively.

Higher HCN content in leaves of bamboo restricts its feeding to livestock. Sun-drying, boiling and oven-drying of bamboo greatly reduces the HCN content

but also successfully produced tissue-cultured, disease-free planting materials for the farming community.

Agricultural Mechanization

The Institute has designed and developed improvized tools and implements by blending the traditional and modern technologies. The tools like long handle weeder and motorized wireloop paddy thresher can save labour requirement by 60–80% over normal weeding and threshing. Some of the farm implements developed at the Institute have also been accepted by the farmers of the Uttaranchal state through the Institute like the VPKAS, Almora.

Rapid Diagnosis of Livestock and Poultry Diseases

The Institute has developed DNA-based diagnosis techniques, particularly for salmonella and clostridial diseases. Presence of enterotoxic gene of salmonella through PCR amplification was indicative of the presence of salmonella. Such diagnosis could be made within 3–6 hr.

Software for Protozoa Parasitic Disease Diagnosis

A software was developed, containing details about morphology, life-cycle, pathogenesis, diagnosis and treatment of different protozoan parasites affecting domestic animals and birds. It also covers different types of database for cestode, trematode, nematode etc. along with the facility to retrieve scientific names of different parasites.

The incremental capital-output ratio (ICOR) is lower in north-eastern states. In these states the additional investment will have larger impact on agricultural productivity. Now, special emphasis is being given north-eastern states because of their higher capital-use efficiency, and higher concentration of rural poor. The stress is on proportional rise in the investment and judicious use of the investment resources.

Scheme-wise/activity-wise allocation/expenditure for North-eastern Region, ending November 2002 (Rs in million)

State	Discipline (centre/location)	2002–2003 Allocation for NEH	2002–2003 Expenditure/ release on 30.11.2002
	Crop Sciences		
Meghalaya	Regional Station, NBPGR (Shillong)	5.000	0.857
Assam	Regional Station, CRRI (Gerua)	10.000	2.377
Assam	Regional Station, CRIJAF (Sorbhog)	5.000	0.700
AICRPs Regional Stations			
Assam	Rapeseed and Mustard (Shillongani)	0.300	0.327
Assam	Rapeseed and Mustard (Imphal)	0.200	
Manipur	Groundnut (Imphal)	0.300	0.045
Assam	Pulses:MULLARP (Shillongani)	0.210	0.900
Tripura	Pulses:MULLARP (Agartala)	0.145	
Manipur	Pulses: MULLARP (Imphal)	0.145	
Assam	Soybean (AAU, Jorhat)	0.240	
Manipur	Soybean (CAU, Imphal)	0.260	
Assam	Honeybee (AAU, Jorhat)	0.700	0.332
Assam	Biological Control (AAU, Jorhat)	1.000	0.322
Assam	Rodent Control (AAU, Jorhat)	1.200	0.930
Assam	Nematode (AAU, Jorhat)	1.000	0.460
Assam	Pesticide Residue (AAU, Jorhat)	1.100	0.520
Assam	Rice (Jorhat)	1.600	1.230
Manipur	Rice (Imphal)	0.200	
Assam	Rice (Karimganj)	0.100	
Meghalaya	Rice (Upper Shillong)	0.100	
Tripura	Rice (Agartala)	0.100	
Nagaland	Rice (Kohima)	0.100	
Manipur	Wheat (Imphal)	0.200	0.223
Assam	Wheat (Shillongani)	0.500	
Assam	Maize (Jorhat)	0.700	1.100
Sikkim	Maize (Gangtok)	0.400	
Assam	Forage Crops (AAU, Jorhat)	1.000	1.094
Assam	Sugarcane (AAU, Jorhat)	1.000	0.998
Assam	Jute (AAU, Jorhat)	1.000	1.250
Assam	National Seed Project (Crops) (AAU, Jorhat)	1.000	0.255
Assam	AICRP Chickpea (Shillongani)	0.200	0.170
Total		**35.000**	**14.090**

State	Discipline (centre/location)	2002–2003 Allocation for NEH	2002–2003 Expenditure/ release on 30.11.2002
	Horticulture		
Assam	AICRP Tuber Crops (Jorhat)	0.806	0.300
Assam	AICRP Vegetables (Jorhat)	2.000	1.154
Assam	AICRP Potato (Jorhat)	0.937	0.350
Assam	AICRP Floriculture (Kahikuchi)	0.705	0.602
Meghalaya	AICRP Mushroom (Barapani)	0.075	0.075
Assam	AICRP Tropical Fruits (Jorhat)	0.838	0.800
Assam	AICRP Tropical Fruits (Tinsukia)	0.935	0.830
Assam	AICRP Betelvine (Tinsukia)	1.465	0.545
Assam	AICRP Palms (Kahikuchi)	0.285	0.285
Meghalaya	Regional Station, CPRI (Shillong)		2.852
Sikkim	NRC Orchids (Sikkim)	17.000	1.360
Assam	Regional Station, CPCRI (Kahikuchi)	3.950	0.320
Total		**28.996**	**9.473**
	Natural Resource Management		
Meghalaya	ICAR Res. Complex for NEH Region (Barapani)	45.000	26.811
Assam	National Bureau of Soil Survey and Land-Use Planning (Jorhat)	0.488	0.265
Assam	AICRP Weed Control (AAU, Jorhat)	1.336	0.831
Assam	AICRP Water Management Res. (AAU, Jorhat)	1.997	0.900
Assam	AICRP Agrometerology (AAU, Jorhat)	1.102	0.397
Assam	AICRP Cropping Systems Research (AAU, Jorhat)	2.919	1.951
Assam	AICRP Agroforestry (AAU, Jorhat)	1.230	0.300
Total		**54.072**	**31.455**
	Agricultural Engineering		
Meghalaya	AICRP on FIM (Barapani, Shillong)	1.600	0.500
Assam	AICRP on FIM (AAU,Jorhat)	0.865	0.100
Assam	AICRP on RES (AAU,Jorhat)	0.935	0.236
Assam	AICRP on UAE (AAU,Jorhat)	1.500	0.608
Assam	AICRP on PHT*(AAU,Jorhat)	1.600	1.253

Table continued from prepage

State	Discipline (centre/location)	2002–2003 Allocation for NEH	2002–2003 Expenditure/ release on 30.11.2002
Assam	AICRP Jaggery and Khandsari (SRS, AAU, Jorhat)	0.900	0.292
Meghalaya	AICRP on APA (Barapani, Shillong)	0.600	0.550
Total		**8.000**	**3.539**
	Animal Sciences		
	AICRP on FMD	7.500	1.350
	AICRP on ADMAS		0.545
	Network on Gastro-intestinal		0.975
	Network on HS		0.300
	AICRP Micronutrients	5.000	0.750
	NRC Mithun	25.000	4.000
	NRC Yak	25.000	13.524
	NRC Pig and AICRP Pig	20.000	2.912
	Network on AGR	2.500	0.630
	AICRP Poultry Research	5.000	0.700
	AICRP Buffalo	5.000	0.825
Total		**95.000**	**26.511**
	Fisheries		
Assam	CICFRI (Guwahati)	15.000	0.438
Assam	CIFE (Kolkata)	0.500	0.261
Assam	NBFGR (Guwahati)	0.500	0.025
Assam	CFA	1.000	0.255
Arunachal Pradesh	CIFA		0.005
Nagaland	CIFA		0.014
Meghalaya	CIFA		0.046
Tripura	CIFA		0.022
Arunachal Pradesh, Manipur and Nagaland	NRC Cold Water Fisheries	0.500	0.038
NEH	CIFT	0.500	0.000
Total		**18.000**	**1.104**
	Agricultural Extension		
Meghalaya	ZC Unit III (Barapani)	4.544	4.544
Meghalaya	TTC (Barapani)	1.810	1.810
Arunachal Pradesh	KVKs (West Siang, Basar)	4.110	4.110
Assam	KVKs (Saonitpur, Napam)	4.660	
Assam	KVKs (Kakrajhar)	4.875	
Assam	KVKs (Golaghat)	4.410	
Assam	KVKs (Cachar)	4.530	
Manipur	KVKs (Imphal)	5.660	5.660
Manipur	KVKs (Hengbung, Senapati)**	0.350	0.350
Meghalaya	KVKs (West Garo)	4.000	4.000
Meghalaya	KVKs (Ri-Bhoi)**	1.500	1.500
Mizoram	KVKs (Lunglei)	4.310	4.310
Mizoram	KVKs (Kolasib)	5.010	5.010
Nagaland	KVKs (Dimapur, Medziphema)	2.810	2.810
Nagaland	KVKs (Phek)**	1.560	1.500
Sikkim	KVKs (East Sikkim)	4.335	4.335
Tripura	KVKs (West Tripura)	2.160	2.160
Tripura	KVKs (South Tripura)	3.110	3.110
Total		**63.774**	**45.209**
	Agricultural Education		
Assam	Development and Strengthening of SAUs including RAWE*** (AAU, Jorhat)		0.000
Assam	AICRP Home Science (AAU, Jorhat)	3.154	1.577
	NATP (Arunachal Pradesh, Assam, Meghalaya, Nagaland, Sikkim and Mizoram)	20.000	34.415
Assam	Central Agricultural University (Imphal)	230.000	120.000
Pipeline Projects		219.034	
Grand Total		**775.000**	**287.373**

Reported in the Expenditure review meeting held on 21.11.2002

*AICRP on PHT, no funds released to the centre as the funds are available with the centre from the savings of the Ninth Plan and the expenditure shown has been made from the savings of the Ninth Plan funds

**KVK established during the current financial year (2002–03)

***No funds released to AAU, Jorhat, on the ground that an unspent balance of Rs 24.46 million had accumulated with them as on 31.3.2002

Ornamental Fishes

The Institute could collect 200 germplasm out of the 270 ornamental fishes reported from the region. These fishes have further been grouped into classified ornamental fishes and non-classified ornamental fishes.

Transfer of Technology

- The development of watershed-based technologies could check the soil loss from 46 tonnes/ha to 5 tonnes/ha. Having achieved this, the Institute extended

SUCCESS STORY

HIGH-YIELDING RICE VARIETIES FOR MEGHALAYA

The State of Meghalaya has been experiencing a total foodgrain deficiency of 0.124 million tonnes and 82% of this deficiency could be met through the intervention of high-yielding rice varieties. The Institute, having earlier released 7 rice varieties for the region, has been successful in releasing 4 varieties for Meghalaya particularly for upland situation in the mid-hills. These varieties having higher production record than the presently grown cultivars, have occupied around 48% rice-growing areas in the mid-hill zones of the State.

the technology to the nearby villages through the development of watershed known as Shippra Watershed.

Besides developing 3 fishery ponds in the area, soil-conservation measures were also initiated by way of contour bunding, half-moon terracing etc. Upper ridges were put under horticultural crops while the lower ones were developed for agricultural purposes.

- Farmers from the NEH states have not only been trained on the use of modified farm implements but also were given skill-oriented training to manufacture the implements themselves.
- A technology was perfected for processing of soybean into products like soya milk, soya paneer and soya biscuit. The technology has been transferred to the people through the Departments of Agriculture of various states of the region.

CENTRAL AGRICULTURAL RESEARCH INSTITUTE, PORT BLAIR

Field Crops

Quing Livan 1, Nanjing 57161 and Milyang 55 proved to be the most promising rice varieties as second crop in rice–rice cropping sequence in Bay islands. A field gene bank, comprising 150 medicinal plantings indigenous to Bay islands, is being established at Garacharma farm of the CARI. Brinjal somaclones were developed and evaluated for agro-morphological parameters and for tolerance towards fruit-borer/shoot-borer and bacterial wilt. About 150 medicinal plants used by the local inhabitants were identified. Leaf and stem bark decoctions of *Mallotus peltatus* and *Alstonia macrophylla* possess substantial antimicrobial and anti-inflammatory activities. The bark paste of *Planchonia andamanica* could be used for treating fungal infection.

Natural Resource Management

Nitrogen dynamics associated with earthworm casts of *Dravida nepalensis* in soils of different land-management systems of South Andaman was studied. A low-cost earthern check dam was constructed on the nallah in Bloomsadale farm. Conjunctive use of mulch with irrigation increased the yield of okra by 65.8% over sole application of mulch and 34% over sole application of irrigation.

Animal Science

Growth rate of Quicken, sexually fertile intergeneric hybrid developed through

- Staggered planting at 1-month intervals recommended for round-the-year availability of tuberose flowers
- Brinjal somaclones developed.
- Herbal antimicrobial; anti-inflammatory and anti-histaminic formulation; mouth wash; and vaginal contraceptive developed and under processing for patent and marketing.
- Large-scale production of Quicken (fertile intergeneric hybrid) initiated in quail farming under deep litter system.

Bark paste of *Planchonia andamanica* can be used for treating the fungal infection

A low-cost check dam with rectangular weir constructed to measure run-off

Large-scale production of Quicken, a sexually fertile intergeneric hybrid, was initiated in quail farming under deep litter system

- An indigenous, heavy-weight goat germplasm Teressa found, showing triplets kidding and even quadruple kidding occasionally.
- For the first time in India, culturing of common clown *Amphiprion percula* standardized.
- Larval rearing of *M. rosenbergii* successfully done and juveniles could be produced.

artificial insemination using Nicobari fowl as male and quail as female, was found encouraging and its large-scale production was initiated in quail farming under deep litter system. An indigenous heavy-weight goat germplasm Teressa of these islands, found in Teressa, Bambooka, Car Nicobar and Katchal islands, resembles Kambling Kachang of Indonesia and shows triplet kidding and even quadruple kidding occasionally.

Culture of Marine Ornamental Fishes (*Amphiprion* species)

A study was carried out under laboratory conditions in Andaman and Nicobar Islands on symbiotic relationship (behavioural) of *Amphiprion percula, A. clarkii* and *A. sandarocinos. Entamaceia quadricoo, Macrodactyla dorensis, Stoichodactyla giganteum, S. haddoni, S. mertensii, Heteraetis aurora, H. cripsa, H. magnifica, H. malu* and *Crypteodentrum adhaesivum* were collected from the wild conditions, and fishes were introduced to each anemones to find out the suitable host. The fish

Marine ornamental fish *Amphiprion percula* fanning the eggs. Its culture has been standardized for the first time in India

spawned between 6.00 hr and 9.00 hr and between 12.00 hr and 17.00 hr. Each female spawned 200–500 capsule-shaped eggs and deposited on the sides of the tank. The eggs showed 2.00–3.00 mm length and 0.8–1.5 mm width. In each spawning 100% hatchability was obtained. For the first time in India, culturing of common clown *A. percula* was standardized.

Hatchery Seed Production of Marine Shell Fishes

In tiger prawn, 987 individual spawnings could be observed on an average of 1.2 times by each spawner in 15–30 days of treatment of each batch. A total of 120 million tiger prawn nauplii were harvested.

Growth and Survivial of Andaman Borne *P. monodon* nauplii to Stocking Seed Size

The survival was 80.6–86.2%, 69.7–80.1%, 52.4–77.7% and 49.7–74.3% during zoea, mysis, early post-larval and late post-larval stages, respectively, of the initial stocking.

TUBEROSE FROM ANDAMAN AND NICOBAR ISLANDS

Tuberose could be cultivated for both cut-flowers as well as loose flowers throughout the year in Andaman and Nicobar Islands. The bulbs were planted on raised beds of 30 cm × 30 cm apart, which were prepared after thorough breaking of clods and incorporating FYM @ 20 kg/m^2 in addition to 15 : 90 : 15 g/m^2 of N : P : K as basal dose. Staggered planting at monthly intervals in 100 m^2 plots each month has been recommended for round-the-year availability of tuberose flowers, and the farmers get a benefit : cost ratio of 2.40 : 1.

Staggered planting at 1-month intervals in 100 m^2 plots makes round-the-year availability of tuberose flowers in Andaman and Nicobar islands

Culture of milkfish *Chanos chanos*

The fattening of milkfish *Chanos chanos* was done in tide-fed brackish water ponds in Andamans for a period of 1 year and 4 months. The average weight at stocking and at harvest was 730 g and 1,207 g respectively. The net production at harvest was 1,030 kg/ha.

Breeding, Culture and Larval Rearing of Freshwater Giant Prawn *Macrobrachium rosenbergii*

A production of 450 kg prawn, 2,587 kg F_1 hybrid carp and 574 kg catla/ha was obtained in polyculture with stocking densities of 7,000 prawn and 11,000 carps/ha in Andaman.

A small unit was set up for breeding and larval rearing of freshwater prawn *M. rosenbergii*. Gravid prawns weighing 25–40 g with eggs of yellow to orange colour released zoea @ 200/g body weight. The larval rearing was successfully done and juveniles could be produced.

Partial harvest of prawn from polyculture systems with carps

Social Science

An application of pre-emergent herbicide Butachlor controlled the weed density by 3–6 times and significantly increased the net return at the farmer's field. The salt-tolerant BTS 24 rice recorded 30% more yield than the local variety C 14-8. Bacterial wilt-tolerant LE 3704 tomato gave 350% higher fruit yield and more net returns than BT 1, which was more susceptible to wilt.

Krishi Vigyan Kendra

The Krishi Vigyan Kendra has conducted 41 programmes on crop production, horticulture, livestock, home science, fishery and front-line demonstration. A total of 471 men and 477 women got trained in agriculture and allied activities.

- NARDI 110, a new high-yielding rice, performed better in on-farm testing and showed tolerance to stem-borer, gundhi bug attack and could withstand lodging. The yield was 4.75 tonnes/ha.
- In on-farm testing BWR line LE 3704 of tomato yielded 25.3 tonnes/ha with 43.82% increase in yield, followed by BT 1 (19.7 tonnes/ha) and local check (17.5 tonnes/ha).
- On-farm trial on watermelon showed that variety Sugar Baby gave an yield of 20.5 tonnes/ha with 57.69% increase in yield, followed by NS 1 (20.3 tonnes/ha). Kin-nu cucumber gave an yield of 9.7 tonnes/ha, showing 55% increase in yield. BTS 24 rice gave an yield of 3.0 tonnes/ha, compared with 2.01 tonnes/ha of local cultivar C 14-8.

HERBAL PREPARATIONS

Herbal preparations, viz. herbal antimicrobial; anti-inflammatory and anti-histaminic formulation (topical/oral); herbal mouthwash: herbal preparation for curing oral submucus fibrosis (OSF)—a pre-cancerous condition in oral cavity; herbal vaginal contraceptive, were developed and are under processing for patent and marketing.

4. National Agricultural Technology Project

- A number of recommendations of committees constituted by O & M Task Force for reforms in the ICAR implemented.
- PME cells established, 13 in SAUs and 12 in ICAR institutes for PME institutionalization in the NARS.
- The NCAP and PME Cells taken up impact assessment of the NATP.
- Websites *http://www.agrieconet.nic.in* and *http://iasri.delhi.in/ASN/* made operational for exchanging information and creating a primary-source dynamic database on Indian farming situation.
- DIPA brought electronic version of *Handbook of Horticulture, Vision 2020* and RPF Files, Digital Photolibrary.

The National Agricultural Technology Project (NATP), a World Bank-aided project, is being implemented by the ICAR and the Department of Agriculture and Co-operation (DAC) since November 1998. It has three major components, viz. Organization and Management (O&M) System, Research and Innovations in Technology Dissemination (ITD). The ICAR executes the O&M, Research and a part of ITD.

The progress made during the year under different components in the NATP is presented here.

ORGANIZATION AND MANAGEMENT SYSTEM

ICAR Reforms

The Organization and Management (O & M) Task Force, the apex body for supervising and guiding the reforms process, constituted several sub-committees and hired consultancies on various aspects of reforms. The key outcomes of recommendations of these are given below.

- Recommendations were made on 17 wide-ranging issues of administration, management, personnel policies and decentralization of powers, and 16 of those have been accepted.
- Of the recommendations made to make the technology delivery system of the ICAR purposeful and efficient, 12 have been implemented by the Extension Division.
- A scheme was finalized for incentives and rewards on three aspects: (i) non-cash-based incentives and rewards, for the administrative and finance functionaries of the ICAR, (ii) sports, recreation and general welfare support systems, and (iii) cash-based awards.
- Consultancy reports have been submitted by the National Institute of Financial Management on Financial Management Reforms of ICAR and Purchase Manual for ICAR.
- A Task Force for Mainstreaming Gender Issues into NATP activities have been set up under the chairmanship of Dr M. S. Swaminathan. The Work plan for gender mainstreaming has been formulated in the first meeting of the committee. The main thrust of the Work plan is the empowerment of rural women through trainings.
- The major recommendations that emerged from the Module II of the Retreat Programme for Top Executives of the ICAR are: the ICAR to have own rules and procedures; all matters of institutes to be delegated to SMDs; Governing Body to have full authority in all matters and all its decisions to be binding; and complete delegation of powers down the line and accountability thereafter.

Institutionalization of Research Priority Setting, Monitoring and Evaluation (PME), and Networking of Social Scientists

- Two publications, viz. *Guidelines for Monitoring and Concurrent Evaluation of Sub-projects under NATP* and *Mechanism of Monitoring and Evaluation under NATP,* were brought out by the IASRI and the NCAP respectively.

- In the process of institutionalization of PME in the National Agricultural Research System (NARS), 25 PME cells have been established (13 in SAUs and 12 in ICAR institutes).
- The NCAP has selected three sub-projects of Production System Research (PSR), four of Team of Excellence (TOE), three of Mission Mode (MM) and three of Competitive Grants Programme (CGP) and the overall O&M process for impact assessment. The PME cells have identified 23 PSR, four Technology Assessment and Refinement/Institution-Village Linkage Programme (TAR/IVLP), two MM, one CGP and one ATIC sub-projects for impact assessment.
- Nine sensitization-cum-trainings and workshops have been organized to sensitize the scientists regarding the PME philosophy and methods.

WEB-BASED NETWORKS

Two web-based networks, one among agricultural economists (*http://www.agrieconet.nic.in*) and another among agricultural statisticians (*http://iasri.delhi.nic.in/ASN/*) were made operational. They serve for exchanging information and creating a primary-source dynamic database of economic and social information on the Indian farming situations.

Human Resources Development for Agricultural Research and Education Management

- Three computer-assisted instructional modules have been developed. The instructional resource material in Gender has been developed on gender roles in agriculture, gender in time and labour use and, gender-specific knowledge and skills in agriculture.
- District-level databases of agricultural resources and production, covering 369 districts, were integrated into a database management system.
- The maps of the States of India and the Agro-ecological Sub-regions have also been digitized in Geomedia GIS. The maps of the States were linked to the all India state-level database, and thematic maps of agricultural production, trends, etc. were generated.

TRAINING MANUALS

Five training manuals, viz. Creating databases in MS Access, Querying Geographic Databases in ARCVIEW, GIS Project in Geomedia, GIS Project in IDRISI, GIS Application using MS Excel, with practical exercises were prepared.

Information System Development (ISD)

Library Information System (LIS)

- For developing a LIS that will make library information available electronically, to every scientist in the NARS, a project involving 18 Regional Libraries (4 DUs, 3 ICAR Research Institutes and 11 State Agricultural Universities) as the hub and 98 libraries as the satellite libraries have been launched. Scientific abstract databases have already been made available to all those libraries.
- In a training on Networking Agricultural Libraries conducted by a foreign consultant, 26 Libraries participated.

Directorate of Information and Publications of Agriculture (DIPA)

- In a pioneering effort the DIPA has brought out the electronic version of:
  - *Handbook of Horticulture* (e-book)
  - ICAR Research Projects Information System—a database on Research Projects Files (RPF)
  - Digital Photolibrary
  - *Vision 2020*
- Under the ICAR-CABI Work plan, the Director, Chief Production Officer and Technical Officer of the DIPA visited CABI for planning and acquiring technology for e-publishing and database development.
- The Agricultural Research Information Centre under the DIPA has developed the National Agricultural Research Database (NARD), as a continuing effort, under the ICAR-CABI Work plan, under NATP. Database on 82 All-India Co-ordinated Research Projects (AICRPs) was also developed.

RESEARCH

PRODUCTION SYSTEM RESEARCH (PSR) MODE

- Natural dye production technology developed from safflower petals, provides 60-70% additional income to farmers.
- A package of practices developed which maintains aflatoxin level in groundnut within limits needed by importers.
- Sorghum harvesting at physiological maturity, followed by drying and pearling reduced its grain discoloration and increased market value.
- Identified sweet sorghum genotypes for alcohol production and standardized the fermentation technology up to pilot level.

An intercropping of pigeonpea with finger millet in 2 : 8 ratio gives more gross returns than farmers' practice of finger millet + *akkadi*

Demonstration of harvesting at physiological maturity of sorghum crop to famers to avoid spoilage of grains

- Improved technology packages developed for *boro* rice cultivation.
- A quality protein maize hybrid CML 142 × CML 150 yielded 25% more than Shaktiman 1.
- A prototype for cotton stick and burr remover fabricated to reduce farmers' drudgery.

The wide-ranging results with potential of development into technologies were obtained under 264 sub-projects in five agro-ecosystems (AES).

Rainfed Agro-ecosystem

- Integrated pest management (IPM) comprising seed treatment with *Trichoderma viride* and soil application mixed with FYM was effective in controlling *Alternaria* leaf blight and white rust infesting mustard.
- A technology developed for natural dye production from safflower petals could provide the safflower farmers 60–70% additional income.
- A prototype safflower harvester has been developed, having harvesting and field efficiency of 98 and 87% respectively.
- A package of practices for cultivation and storage of groundnut developed could maintain aflatoxin level in groundnut within the limits demanded by the importers.
- Integrated Pest Management (IPM) technologies for pigeonpea and chickpea, could cut losses up to 15–20% and reduce the use of pesticides by 50%.
- In Rajasthan, Gujarat and Uttar Pradesh the dual-purpose CSV 15 sorghum proved the most promising for producing both grain and fodder.
- Paired row planting of pearl millet at 30/60 cm and opening of furrows 35 days after sowing along with the integrated nutrient management practices (50% recommended dose of fertilizer + FYM + biofertilizer) resulted in the highest gross (Rs 11,715/ha) and net (Rs 14,914/ha) returns and benefit : cost ratio of 1.73 over farmers' practice in Maharashtra, Karnataka and Tamil Nadu.
- Intercropping of pigeonpea with finger millet (2 : 8) gave higher gross returns of Rs 22,743/ha than farmers' practice of finger millet + *akkadi* (Rs 14,844/ha) in Karnataka.
- Supplementation with locally available feed ingredients like *subabul*, groundnut-cake, deoiled rice bran, cotton seed-cake and copra-cake can improve digestibility of pearl millet, sorghum and finger millet straws up to 20%.
- Harvesting of sorghum at physiological maturity, followed by drying and pearling significantly reduced grain discoloration and increased market value.
- Promising high biomass-producing genotypes of sweet sorghum could be identified for alcohol production. The fermentation technology has been standardized up to pilot level.

Irrigated Agro-ecosystem

- For *boro* rice cultivation improved technology packages including better seedling raising, protecting seedlings from cold injury, improved varieties and suitable date of sowing have been developed for different states.
- Improved lines of *basmati* rice having lodging resistance, high productivity and resistance to biotic stresses and grain quality were found at par with Taraori basmati.
- An evaporatively cooled room (3 m × 3 m × 3 m internal size) of about tonne capacity was developed for on-farm storage of fruits and vegetables.
- Supplementary pre-partum feeding, with urea molasses multi-nutrient block (UMMNB) and urea molasses mineral block (UMMB) improved both production and reproduction in buffaloes. Benefit : cost ratio of UMMB supplementary feeding was 4: 1.

- Sugarcane genotypes CoS 95255 and CoLk 8102 were found resistant to iron chlorosis.
- A quality protein maize hybrid (CML 142 × CML 150) yielded 25% more than check Shaktiman 1.
- A prototype of cotton stick and burr remover has been fabricated, which would help reduce drudgery of farmers and particularly of women.
- Intercropping of cotton, soybean, groundnut and blackgram proved remunerative in citrus pre-bearing orchards at different locations.

Coastal Agro-ecosystem

- The use of baculovirus for control of *Oryctes rhinoceros* has been popularized in the Andaman and Nicobar Islands, as the effect of virus is long lasting and eco-friendly and saves labour. The technology has been transferred to the State Department of Agriculture.
- A model was developed integrating coconut-based farming system with high yielding forage grasses as intercrops and dairy wash for production of biogas and compost.

An intercropping of maize in coconut for getting higher returns

- A high-density cropping-model demonstration plot with coconut, tissue cultured banana, pineapple and black pepper was established.
- Crops like banana, maize and chilli could be identified for intercropping with juvenile oil palm.
- A prototype has been fabricated for small-scale production of adhesives using sweet potato flour.
- A technology has been standardized for broodstock development and broodstock feed.
- A vaccine for the control of duck pasteurollosis has been developed.
- Cage system and deep litter system for rearing layer ducks has been standardized.
- Farmer-friendly PCR protocols for the diagnosis of white spot syndrome virus disease in shrimp have been developed.

Arid Agro-ecosystem

- Drought-tolerant and yellow mosaic virus-resistant varieties of cowpea, mungbean and clusterbean have been evolved.
- To supplement income and nutrition, backyard poultry have been introduced into 46 villages covering 750 farmers in Rajasthan.

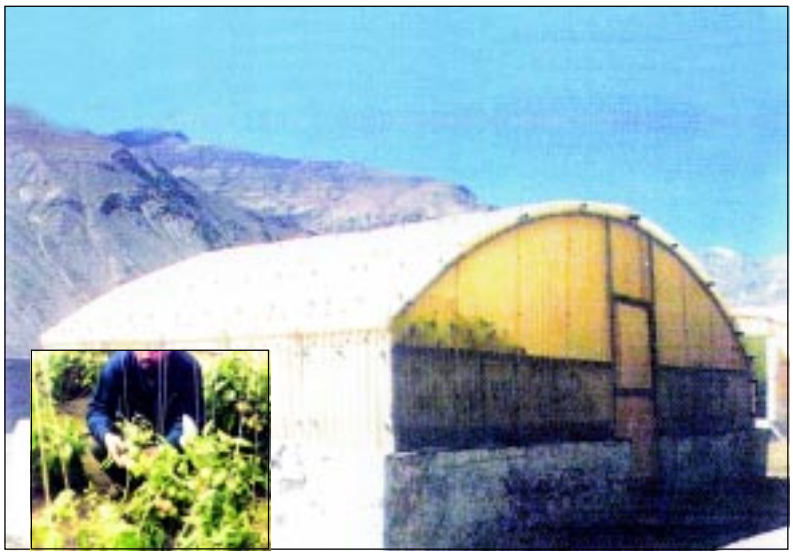
- Control of *O.rhinoceros* by baculovirus popularized in Andaman and Nicobar Islands and the technology transferred to State Department of Agriculture.
- Banana, maize and chilli identified for intercropping with juvenile oil palm.
- A prototype fabricated for small-scale production of adhesives using sweet potato flour.
- A technology standardized for broodstock development and feed.
- A vaccine developed for control of duck pasteurollosis.

Demonstration of high-density cropping model with banana, pineapple and black pepper

- Backyard poultry introduced into 46 villages to increase income and nutrition.
- Geenhouses, designed and installed, made vegetable growing possible in winter to cater to the need of people and army personnel stationed in cold desert regions.
- Camel-milk fermentation process standardized for producing *dahi* of quality matching to the IDFS.

Backyard poultry can increase income and generate employment in arid region

- To generate alternate employment and income, a technology for culturing brackish water shrimp and fishes in saline water, common in the arid region, has been introduced in four villages.
- In different cold desert regions, greenhouses designed and installed have made growing of vegetables possible in winter which can meet demands of the local people and army personnel stationed there.



Vegetable production in arch greenhouse at Lari (Leh)

- The standardized process of camel-milk fermentation could produce *dahi* with quality matching to the International Dairy Federation Standards. Goat milk paneer (soft, slightly salty with no goatee odour) was prepared by adding 0.1% citric acid in 77–88°C hot milk.
- Calf hair (40%) blended with viscose staple fibre was found suitable for bulk processing.

Hill and Mountain Agro-ecosystem

- In the Mussoori hills, the soil loss of 4,000 tonnes/ha in land slide-affected area of 7,200 m^2 became negligible when the area was treated with coir geo-textile and gabion structures.
- A rearing technology developed for Angora rabbit helped the local farmers to generate an additional annual income of Rs 1,500–2,000 with one pair of broiler rabbit.
- In the Khasi hills of Meghalaya, introduction of Indo-American hybrid tomato variety increased the production 2 times.
- About 200 genotypes of saffron have been collected from Kashmir and quality-planting material is being produced.

Collection of saffron. About 200 genotypes of saffron could be collected from Kashmir

MISSION MODE (MM) RESEARCH

About 800 Centres/Nodal points are in place for implementing 42 Mission Mode programmes. Salient achievements are as follows:

- Under Jai Vigyan National Science and Technology Mission on Conservation of Agro-biodiversity, besides collection, conservation and documentation of huge germplasm, a few trait-specific germplasm like scented types in rice, salinity-tolerant types in wheat, high sweet type in *matira*, powdery mildew-tolerant ber and bael were collected. Genetic characterization of livestock species/breeds including poultry has helped in conserving high-value breeds and other breeds, which are in danger of extinction. Eight new species of fishes have been reported for the first time.
- In different crops, 28 hybrids (rice 3, maize 9, sunflower 5, pearl millet 3, castor 2, cotton 5, sorghum 1) with improved quality, high yield and disease resistance have been developed and released. In vegetable crops 39 hybrids having multiple-disease resistance (tomato 22, brinjal 10 and chilli 7) have also been developed.
- Protected cultivation of vegetables and flowers has improved the yield by 10% and proved very effective to protect against insects, pests and mites.
- IPM modules for cotton, pigeonpea, chickpea, groundnut, cabbage, tomato, apple and mango were validated. Production of cabbage, tomato and chickpea using IPM and without pesticidal sprays is a success story.

- Eight new fish species reported for the first time.
- 28 hybrids of crops and 39 hybrids of vegetables developed.
- Produced cabbage, tomato and chickpea using IPM and without pesticidal sprays.
- A technology developed for packing ready-to-eat fish preparations.

MISSION MODE PROJECT ON NUTRITIONAL SECURITY

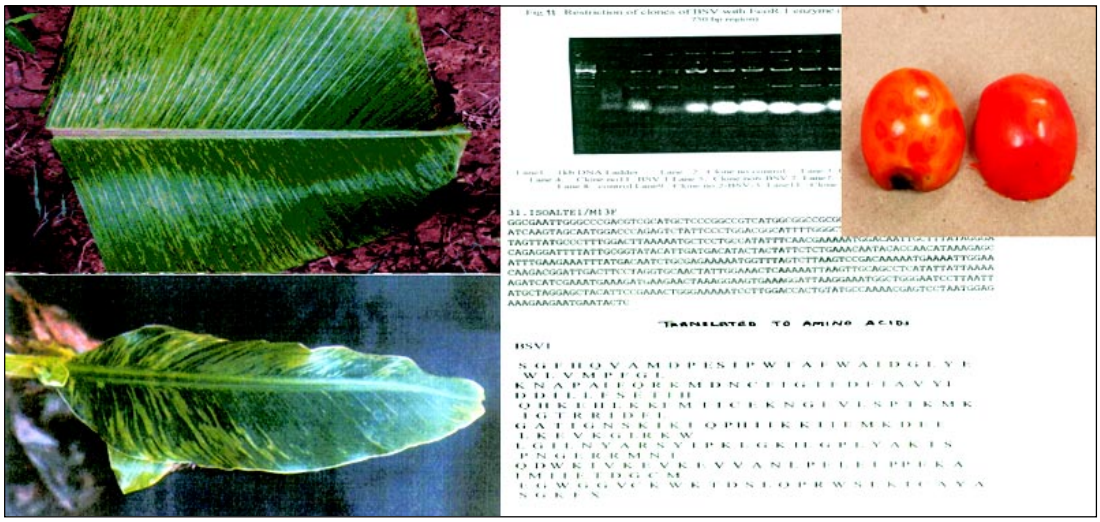
More than 6,000 farm families at 47 locations in 15 states in tribal, backward and hilly areas where benefits of Green Revolution did not reach, were brought under this mission mode project to improve their economic condition by supplying quality seed of improved varieties of life-support crops, planting material of fruit and vegetable crops and improved breeds of poultry, pig and fish and, production training. This is resulting in increase in income, living standards of people and also the employment opportunities and health.

- A novel process of producing neem oil micro-emulsion (an environment friendly pesticide) without employing a cosurfactant and alcohol has been developed, and filed for patent.
- Diagnostic kits for the peste des petits ruminants (PPR) virus disease of small ruminants have been developed. Linkages were also developed with industries for commercialization.
- A technology has been developed for packing ready-to-eat fish preparations in retortable pouches. The self-life of the packaged products is one year.

TEAM OF EXCELLENCE (TOE) MODE

- Info Crop, a user-friendly crop-modelling framework developed.
- Rust-resistant genes in wheat identified using molecular markers.
- A hot water treatment plant developed and fabricated for mango fruits, and mango stone weevil-free zones identified to meet export demand.
- An eco-friendly value-addition method developed for use of slaughter house by-products for protein recovery suitable for feeding pets and livestock.
- Immune-O-Check kit, developed for detection of failure of passive transfer in buffalo calves, would be instrumental in reducing neonatal calf mortality.

- A user-friendly crop-modelling framework, Info Crop, has been developed and is being evaluated for potato, soybean, cotton, maize, sorghum, mustard, groundnut and sugarcane. A methodology for forecasting wheat yields in India using models, remote sensing and spatial databases has been developed, which is being used by the Space Applications Centre for regular wheat forecasting.
- Methodology on sampling and measurement of CH_4 and N_2O flux from experimental fields has been developed and standardized.
- Application method of *Glucanoacetobacter* for sugarcane in pot-culture conditions and techniques for mass production of acid-tolerant cyanobactera in small tubs have been standardized.
- In wheat, culture of F_1 ears of WL 711 × C 306 cross produced viable seeds to overcome the hybrid necrosis barrier.
- In wheat, rust-resistant genes were identified using molecular markers.
- A quantum jump from 1.5 to 2.9 tonnes/ha in the production of hybrid seed of rice, leading to reduction of seed cost and better adoption of hybrid technology, has been achieved.
- Seed-enhancement technology in maize has been successfully adopted.
- Complete sequencing and cloning of the n-gene of *tospo* virus infecting tomato have been done.



Tospo virus n-gene sequenced and polyclonal antibodies developed-will lead to transgenics in tomato and banana for spotted virus

- Single chain polyclonal antibodies of N-protein have been generated through phage display technique.
- A hot water treatment plant for mango fruits has been designed and fabricated.
- Mango stone weevil-free zones have been identified to meet export requirements.

- A low pressure irrigation device has been designed and developed, which works at a pressure of 4.4 kg/cm^2.
- Tractor-operated till-plant machine has been developed and tested.
- A technology of sugar syrup feeding was developed for the management of *Apis mellifera* during the period of dearth of nectar.
- A cost-effective alternative nuclear material developed for culture of pearls, comparable to imported shell bead nuclei, will prove to be an important import substitute.
- Pearl mussel resources in different agro-ecological regions of the country have been mapped.
- Single serum dilution ELISA protocol for detection of Egg Drop Syndrome virus antibodies has been validated and would be an import substitute for the high-priced imported kit.
- Immune – O – Check kit for detection of failure of passive transfer in buffalo calves would be instrumental in reducing neonatal calf mortality. It can also be used on bovines.
- An eco-friendly value-addition method for use of slaughter house by-products for recovery of protein that is suitable for feeding pets and livestock, has been developed.
- A patent has been filed for oligonucleotide primer sequences for rapid identification of *Mycobacterium bovis* and *Mycobacterium tuberculosis* by a single-tube multiplex polymerase chain reaction.
- Under different sub-projects, 37 promising technologies were developed which will be taken to TAR-IVLP for assessment, refinement and adoption.

Human Resource Development

- Forty-eight trainings were conducted in which 857 scientists of the NARS participated. In the field of biotechnology, 26 trainings were organized in which 353 scientists were trained.
- In six sub-projects, CDs and manuals have been developed.
- Nine scientists have been honoured for their scientific achievements.
- Seven scientists were deputed to reputed laboratories abroad for enhancing their scientific skills/interaction with peer workers. One foreign consultant was invited to share his expertise on veterinary hybridoma and molecular virology with the scientists of Madras Veterinary College, Chennai, and group training was organized in which scientists from different ICAR institutes, SAUs and other organizations participated and got benefited. Each TOE group has been asked to conduct at least two training programmes per year in its field of excellence.

COMPETITIVE GRANTS PROGRAMME (CGP)

Till date, 443 projects have been sanctioned in three rounds, covering 10 thematic areas and 15% of the projects are in institutions outside the ICAR/SAU. This is the first time that such a large proportion of projects have been given to this Section. Major achievements of the first two rounds of projects are given here.

Agricultural Biotechnology

- To develop transgenic papaya resistant to papaya ring spot virus, the viral cDNA has been produced.
- Indian cassava mosaic virus (ICMV) genome has been cloned and characterized. Replicas (AC1), a gene of ICMV, was also cloned and sequenced completely.
- RAPD analysis of 36 pepper species and 24 major cultivars and released varieties of black pepper showed a wide diversity at DNA level. Mapping population has been developed for molecular tagging of gene for resistance against *Phytophthora*.

- Generated viral c DNA to develop transgenic papaya resistant to ring spot virus.
- Cloned and characterized Indian cassava mosaic virus.
- Identified microsatellite molecular marker (RM 258) to be linked with fertility-restorer genes for use in basmati rice breeding.

- In wheat, out of 450 sequence tagged microsatellite (STMS) primers used, 56, 77 and 77 primers identified were polymorphic for grain protein content (GPC), grain weight (GW) and pre-harvest sprouting (PHST) respectively. Analysis of five SAMPL primer combinations revealed 222, 178 and 168 polymorphic bands for GPC, GW and PHST, respectively, which will be useful for markers-aided selection for quality traits.
- Two antiviral glycoproteins (CCP-25 and CCP-27) isolated from *Celosia cristata*, exhibited more than 90% inhibition of local lesions on test host plants against tobacco mosaic virus and sunnhemp rosette virus.
- A microsattelite molecular marker (RM 258) has been identified to be linked with fertility-restorer genes for use in basmati restorer breeding and testing the genetic purity of hybrid seed lot of the first superfine grain aromatic rice hybrid Pusa RH 10.
- Putative transgenic groundnut plants with glycoprotein gene have been generated.

Integrated Pests and Disease Management

- Three isolates of arbuscular mycorrhizal fungi proved effective in reducing population of parasitic nematodes of vegetable crops.
- Effluents of cassava-based starch factory showed nematicidal property against root-knot nematode.

- Maximum seed germination was observed when seeds of sunflower were treated with *T. viride* formulation @ 4 g/1 kg seed, followed by *T. harzianum* and *P. flourescens*.
- Two sites of phytoplasma-free budwood banks of peaches in Himachal Pradesh have been developed at the University campuses, i.e. Solan and Hamirpur.
- Three isolates of arbuscular mycorrhizal fungi were found effective in reducing the population of plant parasitic nematodes of brinjal, tomato, chilli, coleus and amorphophallus.
- The effluent of cassava-based starch factory showed nematicidal property against root-knot nematode and high repellent action against Bihar hairy caterpillar.
- An entomopathogenic nematode (EPN) *Heterorhabditis indica* could be observed on the natural enemies of *Cylas formicarius* in sweet potato fields.
- To develop transgenic potato cultivars tolerant to potato tuber moth CRY IAB and fused (CRY IAB + CRY IB) genes under the control of constructive promoter Ca MV 35s have been developed.
- The entomopathogenic fungus *Metarrhizium anisopliae* was as effective as chemical pesticide on sugarcane root grub and as efficient as Bt and Ha-NPV on chickpea borer.

Horticulture

- Large-scale production protocols for *Chlorophytum borivilianum* and *Rauvolfia serpentina* standardized.

- The two-node repetitive micro-cutting technique has been devised for rapid multiplication of grapes.
- The arecanut hybrids Hirechalli Dwarf (HD) × Sumangala, Mohitnagar × HD and HD × Mohitnagar were found superior for dried kernel yield and desirable lowest height.
- Large-scale production protocols for *Chlorophytum borivilianum* and *Rauvolfia serpentina* have been tested and standardized.
- Storage of safed musli roots with sand in mud plastering minimized the weight loss by 49%, spoilage loss by 5.4% and enhanced the sprouting after storage by 60% and recovery of healthy roots by 45%.

Natural Resources Management

- Application of Dinitrosocifrol @ 8 kg/ha and Triacontanol @ 5 litres/ha through irrigation water improved sucrose content in sugarcane and that of Dithiocarbamate-based formulation @ 8–10 ppm on cane at pre-fibrizor stage minimized sucrose losses.

- Soil solarization with a transparent polyethylene sheet (125 m thick) for 8 and 10 weeks resulted in complete burning of the weeds including the underground portion of the weeds.
- Enhanced effectiveness of dried leaf powder of *Coleus amboinicus* on water hyacinth was observed with the introduction of the biocontrol agent *Neochetina bruchi*.

- Soil solarization with 125 mm thick transparent polythylene sheet for 8 and 10 weeks completely burnt weeds including their underground portions.
- *Neochetina bruchi* enhanced effectiveness of dried leaf powder of *Coleus* on water hyacinth.

Extension

- Expert system of extension, an intelligent computer program, has been developed and a website created— a first attempt in the field of extension to work on web-based expert system of extension in India.
- Forecasting models have been developed from the data collected on different aspects of jute.

Post-harvest and Value Addition

- Increased longevity of anthurium flowers was observed by covering with polyphone sleeves/covers and packing in cardboard cartons. Addition of ethylene absorbent, potassium permanganate in cartons, further extend the post-harvest longevity.
- Processing methods to preserve coconut inflorescence sap as honey, jam and toffee have been developed.
- Hard-shelled (*katha*) walnuts having low kernel yield were found suitable for oil-extraction purposes.
- A technology has been developed for the production of various types of fish cakes and fish sausages using meat of different fish species.
- Two instruments (consistometer and gelometer) have been designed and fabricated for the textural measurement of fish paste and paste products.
- A very simple picking force-measuring device for tomato has been fabricated. A tomato harvester has been designed that can harvest 2.5–3.0 times more than manual harvesting.
- A telescopic ladder attached to a trailer power tiller has been designed for the convenience of harvesting oil palm nuts from different heights.

- Processing methods developed to preserve coconut inflorescence sap as honey, jam and toffee.
- A technology developed for production of fish cakes and sausages.
- Designed a tomato harvester that harvests 2.5-3.0 times more than manual harvesting.
- Large diameter pit digger developed for planting of tree saplings.

Agricultural Engineering

- Large diameter pit digger has been developed for planting saplings of trees.
- A power-operated tiller-mounted basin lister for the coconut plantations and a 10-kg-capacity pneumatic pressure parboiler have been designed and fabricated.

Animal Sciences

- Protocol for isolation and purification of immunoprotective antigens (glutathione S-transferase, cysteine proteinase) has been standardized.
- The database on fecundity gene markers of sheep has been created by *in silico* search. The pedigreed genomic DNA repository of Garole and Black Bengal goat, up to F_1 generation, has been established.
- Nicobari fowl showed resistance to many diseases of poultry.

- Standardized protocol for isolation and purification of immunoprotective antigens.
- Established pedigreed genomic DNA repository of Garole and Black Bengal goats,up to F_1 germination.

TECHNOLOGY ASSESSMENT AND REFINEMENT (TAR) THROUGH INSTITUTION-VILLAGE LINKAGE PROGRAMME (IVLP)

The important technologies developed for adoption in a partnership mode with the farmers, are given here.

- Crossing *desi* goats with improved buck (Beetal) increased number of kids by 50%, generating additional benefit: cost ratio 5 : 1.
- Deep tillage at >45 cm depth increased groundnut pod yield 18% and decreased collar, stem and root rots 50, 45 and 80% respectively.

IVLP/TAR PROGRAMME

Through 70 IVLP/TAR programmes 1,450 interventions were assessed in 151 villages, covering 4,000 farmers' fields spread in all five agro-ecosystems. It has brought in not only visibility of the impact of new technologies but has also built in farmer-scientist- extension linkages. Since seeing is believing, the TAR/IVLP programmes are having cascading effect on adoption of new technology/ interventions, which have brought economic benefits to the adopted farmers. Large-scale adoption of new technologies by non-targeted farmers in adopted villages is realization of success of the new technology. The adoption of tribal, small and marginal farmers has enabled to meet one of our major developmental objectives of bringing benefits of science and technology to disadvantaged groups. The integrated approach in various programmes besides generating gainful employment opportunities has also brought higher economic benefits. The scientists have also benefited from interaction with farmers and the refinement in about 50 technologies as a result of this interaction. This is a success and the realization that farmers have also major contribution to make.

- Elephant foot yam intercropped with banana gave additional net returns of Rs 15,992.
- Introduction of catle, rohu, mrigala in 20 : 70 : 10 ratio increased net returns from Rs 18,000 to Rs 37,440 in freshwater aquaculture.

Rainfed Agro-ecosystem

- *Paira* cropping of linseed (T 397) in rice (IR 64) with moderate doses of nutrients (40 : 20 : 20 kg/ha) at Ranchi, coriander–rice and lathyrus–rice sequences at Raipur, and intercropping of rice and pigeonpea (4 : 1) at Cuttack enhanced the net income by Rs 4,500–5,000/ha compared to sole rice crop. Coverage of area under these systems in respective regions increased by 15% compared to the previous year.
- Crossing of *desi* goats with improved buck (Beetal) increased the number of kids by 50% and generated additional benefit : cost ratio of 5.0.
- Deep tillage at a depth > 45 cm increased the pod yield of groundnut by 18% over the farmer's practice and decreased the incidence of collar rot, stem rot and root rot by 50, 45 and 80% respectively.
- IPM in hybrid cotton, consisting of okra as trap crop, nuclear ployhedrosis virus (NPV), recommended insecticide based on economic threshold level and pheromone traps, resulted in 30% increase in yield.
- Use of mustard as trap crop and spraying neem-seed-kernel extract were effective in controlling diamond back moth in cauliflower, with a benefit: cost ratio of 3.74-4.0 compared with farmer's practice.
- Rearing of improved Italian bees at Koraput, fish and duck culture at Ranchi and mushroom culture at Raipur and improved methods of cultivation of fruits and vegetables provided employment opportunities for rural women during the off-season and increased the income by Rs 30/day/person.
- Contour cultivation in rainfed wheat at Bhopal, alternate furrow opening and sowing across the slope in cotton at Akola, formation of conservation furrows and application of 10 kg N/ha after the relief of drought spell in sorghum + pigeonpea (3 : 1), pigeonpea + mungbean (2: 1), castor and sunflower crops at Hyderabad were effective in conservation of rain-water and enhanced the productivity of crops by 15–30%.
- Improved farm implements (MB plough and Birsa ridge plough) increased the coverage (21%) and productivity gain (6–8%) compared to *desi* plough.

Irrigated Agro-ecosystem

- Wheat sown by zero-tillage machine gave higher net returns (Rs 20,600/ha) than conventional sowing (Rs 17,000/ha).
- Paddy transplanted through engine-operated transplanter proved very effective in maintaining proper plant population.
- Feeding of urea (4%)-enriched wheat straw increased the palatability of the straw (30–35%), milk production (average 0.8 kg/day in cows and 0.6 kg in buffaloes) and improved the body condition (0.5–1.0 point). This technique can save up to 1 kg/animal/day of concentrates.
- Treatment of dairy animals with Piperazine @ 20 mg/30 kg body weight for the control of endoparasites, increased the milk production considerably. The dairy animals treated with Butox @ 50 ml/animal repeated 3 times at 10-day intervals controlled the ticks, significantly improved the milk production and animal health.
- Honey yield by Italian bees was 40 kg/box, compared with 15 kg/box in local strains.
- The use of an indigenous technical knowledge of growing pointed gourd on scaffold with or without application of Mancozeb could protect the crop from fruit and vine rot disease caused by *Phytophthora* sp. for 270–300 days after planting. A 17.50–38.24% increase in yield compared to the farmer's practice of growing the crop on soil was obtained.

Coastal Agro-ecosystem

- Elephant foot yam when intercropped with banana, gave an additional net returns of Rs 15,992 without affecting the growth and yield of banana.

- The farmwomen were immensely benefited with the interventions like rearing Rhode Island Red (RIR) and Nandanam poultry birds in backyard, and preparation of pickle from locally available fish and prawn for value addition and income generation at Chennai.
- Another successful intervention was the assessment of freshwater aquaculture in the community ponds by introducing catla, rohu and mrigala in the ratio of 20 : 70 : 10 respectively. Net returns were increased from Rs 18, 000 to Rs 37,440.

Arid Agro-ecosystem

- In mustard, adoption of variety Bio 902 resulted in 43.38% increase in yield over the local. The addition of 1 tonne neem-cake/ha along with 20 kg S/ha further enhanced yield 29.7%.
- Seed treatment of pearl millet with Apron (Metalaxyl) + Mancozeb (Dithane M-45) decreased the downy mildew incidence by 26% and with *Trichoderma* by 18%.
- Licking of multi-nutrient block (MNB) by cattle and buffaloes resulted increased food uptake (16.7%), showing higher milk yield and body weight gain. The daily milk yield increased by 1.5–2.5 litres/animal/day.
- Dry matter and water intake of cattle and buffaloes increased by 20–25% when fed with urea-enriched fodder.
- Supplementing the feed of sheep and goat with mineral mixture @ 5–10 g/animal/day increased their grazing period by 20% and as a result increased milk yield by 19.2% and wool yield by 18%.

- Bio 902 mustard showed 43.38% increase in yield over local.
- Milk yield increased by 1.5–2.5 litres/animal/day on licking of multi-nutrient block by cattle and buffaloes.

Hill and Mountain Agro-ecosystem

- Application of Borax @ 2 kg + ammonium molybdate @ 120 g as soil application and foliar spray of boric acid @ 0.1% + ammonium molybdate @ 0.05% in cauliflower seed production plots doubled the farmer's income.
- Cowpea as a cover crop in exposed terrace ridges of rice field checked soil erosion considerably at Kalimpong.
- Integrated Plant Nutrient System (IPNS) in orange orchard increased the fruit yield by about 150% at Kalimpong.
- To reduce drudgery of women, manual paddy thresher was introduced which saved 200% time over manual threshing of paddy at Srinagar.
- Introduction of income-generating interventions like bee-keeping and button mushroom cultivation have made significant impact and more landless villagers are coming forward to take it up.

- Soil application of borax 2 kg + ammonium molybdate 120 g and foliar spray of boric acid 0.1% + ammonium molybdate 5% in cauliflower seed production plots doubled the farmer's income.
- IPNS in orange orchard increased 150% fruit yield.
- Interventions like bee-keeping and button mushroom cultivation made significant impact, and more landless villagers are coming forward to take it up.

INNOVATIONS IN TECHNOLOGY DISSEMINATION: ICAR COMPONENT

The Innovations in Technology Dissemination–ICAR Component, having four sub-projects, has made significant contribution in terms of empowerment of farmers and stakeholders, on-farm trials, preparation of extension literature both in printed and electronic form and distribution/sale of quality agro-inputs and planting materials.

- To empower the farmers, rural women, unemployed youths and other stakeholders, 1,367 innovative training programmes based on their needs were organized, benefiting 33,342 farmers.
- To enhance the extension delivery system, 287 training programmes were organized in which 6,753 extension personnel participated. A close collaboration and co-operation with government departments, NGOs, research institutes, rural groups etc. were ensured.

- Telephone help-lines installed in eight ATICs.
- Through ATICs farmers were greatly benefited by the supply of quality agro-inputs and planting materials.
- ATICs generated gross revenue of Rs 53 million.
- 33,342 farmers benefited from various trainings.

WORLD BANK REVIEW

The World Bank has reviewed the NATP during 30 September–11 October 2002. The progress of the project was found satisfactory. The Supervision Mission found that, a steady stream of usable technologies has begun to emanate from different modes of research" and it appreciated ". . . the substantial progress in project implementation and reporting. . . ." The ongoing thrust is now to document the success stories, proper monitoring and assessing the impact of the NATP.

- In total 741 front-line demonstrations in an area of 440 ha and 71 on-farm trials were conducted at farmers' fields.
- More than 0.2 million copies of information material have been supplied to farmers and other stakeholders.
- Success stories in diverse fields have been documented and widely disseminated throughout the districts.
- In eight Agricultural Technology Information Centres (ATICs) telephone help-lines were installed to solve location-specific problems of the farmers.
- Through ATICs farmers were greatly benefited in terms of supply of quality agro-inputs and planting materials. During the year, 260 tonnes of quality seeds, 0.45 million nursery plants and 1.35 million packets of biofertilizers and biopesticides were sold.
- About 9,600 soil samples were tested and 12,200 diseased plants were diagnosed. In veterinary clinics 39,638 animals were treated, benefiting 61, 438 farmers. The ATICs generated a gross revenue of Rs 53 million.

ZONAL AGRICULTURAL RESEARCH STATION

Number of trainings	2,181
Farmers trained	55,000
Training of extension workers	287
Number of extension workers trained	6,753

5. Organization and Management

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December, 1973. Subjects allotted to the DARE as per the Government of India (Allocation of Rules) are specified in Appendix I of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India in the DARE functions as the Director-General of the ICAR. The Financial Adviser of the DARE is the Financial Adviser of the ICAR. Generally single-file system is followed between DARE and ICAR.

The DARE has 14 Group A, 10 Group B, 14 Group C and 6 group D employees. The recruitment to the post in the Groups A, B, C is being made centrally, either through the Department of Personnel and Training or through the Department of Agriculture and Co-operation, depending on the level of the post. The DARE makes direct recruitment only to Group D posts. Such recruitments are being made in accordance with the orders of the Government of India regarding reservations for Scheduled Castes, Scheduled Tribes and Other Backward Classes. Presently, DARE has 7 Scheduled Caste employees.

A detailed break up of the posts and names of the important functionaries is given in Appendix II of DARE. The financial requirement (Grant No. 2) includes budget estimates (BE) and revised estimates (RE) of DARE and ICAR (Plan and Non-Plan) 2002-2003 respectively. The detailed break up of these financial figures is given in Appendix III of DARE.

Dr Mangala Rai, [DG (ICAR), second from right] is attending maiden Press Conference after becoming DG, ICAR

ICAR

The Indian Council of Agricultural Research is the apex organization at the national level for promoting science and technology programmes in the agricultural research and education.

The ICAR was set up on the 16 July 1929 as the Registered Society under the Societies Registration Act 1860, on the recommendations of the Royal Commission on Agriculture. It was reorganized twice, in 1965 and in 1973. The headquarters of the ICAR is located at the Krishi Bhavan, and its other buildings Krishi Anusandhan Bhavans I and II, New Delhi.

The Minister for Agriculture is the President of the ICAR, and the State Minister for Agriculture is the Vice-President. The principal executive officer of the ICAR is Director-General, who is also the Secretary to the Government of India in the Department of Agricultural Research and Education.

The General Body of the ICAR Society is the supreme authority of the ICAR, and the Minister for Agriculture, Governments representatives of India, heads it. The members for this are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of various state governments, representatives of Parliament, industry, education institutes, scientific organizations and farmers (Appendix 1).

The Governing Body (Appendix 2) is the chief executive and decision-making authority of the ICAR. It is headed by the Director-General. It consists of eminent agricultural scientists, educationists, legislators and representatives of the farmers. It is assisted by the Standing Finance Committee, Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and

- The Screening Committee was constituted for the first time for finalization of the Annual Recruitment Plan of the ICAR system.
- The ICAR has filled up 96 posts of the Gazetted Officers out of 154, and 936 posts of non-gazetted officials out of 746.
- The Mehta Committee Recommendations were sent to all Head, Subject Matter Divisions to process them for operationalization/implementation in the ICAR with the approval of the Competent Authority.
- The National Institute of Financial Management revised the report and ICAR officials would visit the NIFM for updating/making further corrections of the Report.

Media persons highly appreciated the meeting with new DG, ICAR-Dr Mangala Rai

Publications Committee. In the scientific matters, the Director-General is assisted by 8 Deputy Director-General, one each for (i) Crop Science, (ii) Horticulture, (iii) Natural Resource Management, (iv) Agricultural Engineering, (v) Animal Sciences, (vi) Fisheries, (vii) Agricultural Education, and (viii) Agricultural Extension. The DDGs are responsible for the Institutes, National Research Centres and Project Directorates in their respective fields. The members of Standing Finance Committee are DG (ICAR), Secretary (Agriculture), Scientists, Senior Officers, Farmers, and Members of Parliament (Appendix 3). The senior officers posted at the ICAR (headquarters) are listed in Appendix 4 of the ICAR.

The ICAR receives funds from the Government of India and from the proceeds of the Agricultural Produce Cess.

The ICAR develops technologies and disseminates knowledge to farming community not only for increasing yields of crops and maintaining natural resources but also for elevating community's economic status.

The Directorate of Information and Publications of Agriculture is working independently with the approval of the competent authority and brings out 1 title on every third day.

The Research set up of the ICAR includes 47 Central Institutes (Appendix 5), 5 National Bureaux (Appendix 6), 12 Project Directorates (Appendix 7), 33 National Research Centres (Appendix 8), and 82 All-India Co-ordinated Research Projects (Appendix 9). Besides ICAR finances research scheme; and 12 externally-aided projects are also in operation through the United States-India Fund.

The ICAR promotes research, education and extension education in 40 state agricultural universities, 5 deemed-to-be-Universities and 1 Central Agricultural University for the North-Eastern Hills Region by giving financial assistance in different forms (Appendix 10).

For effective communication of research findings among farmers, the ICAR maintains an effective network of Krishi Vigyan Kendras, and Trainers' Training Centres along with Zonal Co-ordinating Units.

The total sanctioned as well as existing strength of the employees of the ICAR system, including Scheduled Castes, Scheduled Tribes and Other Backward Classes, is given in Appendix 11.

Thus with an extensive network of research infrastructure, backed by the excellent teams of scientists and other employees, the ICAR is making rapid strides in agricultural research, and provides support to the national efforts towards achieving food security and self-sufficiency.

- The constitution of the VIII Task Force was recommended during Xth meeting of the Standing Policy and Planning Committee of the Governing Body under the Chairmanship of Dr M S Swaminathan.
- Seventy-seven officers were notified in the Gazettes of the Government of India.
- ICAR (Hq.) and its Institutes celebrated Hindi Chetna Mass since 14 September 2002.
- The Budget Estimates and Revised Estimates of DARE and ICAR (Plan and Non-Plan) was Rs 14,045.5 million for 2001–02.
- A new Chaudhary Devi Lal Outstanding AICRP award is being given away for the first time.

ADMINISTRATION

Recruitment rules

Recruitment Rules for the post of Director (OL), LDC, Record Keeper (Group C), Studio Attendant (Group D), and Franking Machine Operator (Group D) ICAR were framed.

Filling up of vacant posts

Many vacant posts like Senior Administrative Officers, Administrative Officers, Senior Finance and Accounts Officers, Finance and Accounts Officers, Section Officers, Assistants, UDCs, Personal Assistants, LDCs and Supporting Staff Grades etc. were filled up. For filling up the various posts under LDE quota for Assistants/ Section Officers competitive examinations were held by the Agricultural Scientists' Recruitment Board. As per the Government of India instructions, the Screening Committee was constituted for the first time for finalization of the Annual Recruitment Plan of the ICAR system.

Probation/Confirmation

Cases of Clearance of Production Period/Confirmation of Administrative Officers, Finance and Account Officers/Assistants/PAs/LDCs were taken up/during the year.

Gazetted posts sanctioned/filled/vacant in the ICAR as on 31.12.2002

Posts	Scale of pay	No. of posts sanctioned	Filled posts	Vacant posts	No. of SC	No. of ST	No. of OBC	Remarks
Director (P)	14,300–400–18,300	01	01	–	–	–	–	–
Director (F)	14,300–400–18,300	02	02	–	–	–	–	–
Director (OL)	12,000–375–16,500	01	–	01	–	–	–	–
Deputy Secretary	12,000–375–16,500	05	02	03	01	–	–	–
Deputy Director (P)	12,000–375–16,500	02	01	01	–	–	–	
Deputy Director (F)	12000–375–16,500	02	02*	–	–	–	–	*excludes one post of DD (F) at NATP as the same has been temporarily shifted from IVRI, Izatnagar
Deputy Director (OL)	12,000–375–16,500	01	–	01	–	–	–	–
Controller of Examination	12,000–375–16,500	01	01	–	–	–	–	–
Under-Secretary	10,000–325–15,200	14	14	–	03	01	–	–
SA to Chairman, ASRB	10,000–325–15,200	01	01	–	–	–	–	–
Senior Finance and Accounts Officer	10,000–325–15,200	01	01*	–	–	–	–	*excludes one post of SF & AO at NATP as the same has been temporarily shifted from CPRI, Shimla
Legal Adviser	10,000–325–15,200	01	01	–	–	–	–	–
Finance and Accounts Officer	8,000–275–13,500	06	06	–	01	–	01	–
Assistant Legal Adviser	6,500–200–10,500	02	02	–	–	–	–	–
Assistant Director (OL)	6,500–200–10,500	02	02	–	–	–	–	–
Junior Analyst	6,500–200–10,500 + Spl. Allowances	02	02	–	–	–	–	–
Desk Officer	6,500–200–10,500	06	06	–	01	–	–	–
Protocol Officer	6,500–200–10,500	01	01*	01	–	–	–	–

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Posts	Scale of pay	No. of posts sanctioned	Filled posts	Vacant posts	No. of SC	No. of ST	No. of OBC	Remarks
Assistant Finance and Accounts Officer	6,500–200–10,500	06	05	01	–	–	–	*includes one AF & AO who is presently on deputation with Deputy Speaker (Lok Sabha) on Co-terminus basis
Section Officer	6,500–200–10,500	81 –2*=79	75	04	10	06	02	*2 posts kept in abeyance for creation of posts under NATP
Private Secretary	6,500–200–10,500	30	29*	01	04	–	–	*excludes one post as its incumbent is presently on deputation with NCA, Indore

*Including *ad hoc* appointment.

Non-Gazetted Posts (Groups C and D) sanctioned/filled/vacant in ICAR as on 31.12.2002

Posts	Scale of pay	No. of posts sanctioned	Filled posts	Vacant posts	No. of SC	No. of ST	No. of OBC	Remarks
Assistant	5,500–175–9,000	175	156*	19	32	07	05	27 UDCs working as Assistants on *ad hoc* basis against these 34 posts
Personal Assistant working	5,500–175–9,000	56	53*	03	07	01	03	5 Steno. Grade III as PA on *ad hoc* basis
Senior Research Assistant	5,500–175–9000	01	01	–	01	–	–	–
Junior Law Officer	5,500–175–9,000	02	–	02	–	–	–	–
Junior Accounts Officer	5,500–175–9,000	04	02	02	–	–	–	–
Data Collector and Assessor	4,500–125–7,000	02	02	–	–	–	–	–
Steno Grade III	4,000–100–6,000	54	41	13	05	01	–	–
UDC	4,000–100–6,000	188	158	30	32	10	–	–
Sports Assistant	5500–175–9,000	01	–	–	–	–	–	Kept in abeyance
Confidential Assistant (Awards)	5,500–175–9,000	01	–	–	–	–	–	Kept in abeyance
Programme Officer	5,500–175–9,000	01	–	–	–	–	–	Kept in abeyance
Senior Sales Assistant	5,000–150–8,000	04	03	–	–	–	–	Kept in abeyance
Junior Sales Assistant	4,500–125–7,000	02	02	–	–	–	–	Kept in abeyance
Confidential Assistant (AM)	5,500–175–9,000	01	–	01	–	–	–	–
Language PA with AM	5,500–175–9,000	01	–	01	–	–	–	–

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Posts	Scale of pay	No. of posts sanctioned	Filled posts	Vacant posts	No. of SC	No. of ST	No. of OBC	Remarks
LDC	3,050–75–3,950–80–4,590	164	134	30	28	04	09	–
Peon	2,550–55–2,660–60–3,200	118	87	31	29	04	08	–
Farash	2,550–55–2,660–60–3,200	14	12	02	06	02	–	–
Chowkidar	2,550–55–2,660–60–3,200	02	02	–	–	01	–	–
Mali	2,550–55–2,660–60–3,200	06	06	–	–	–	–	–
Packer	2,550–55–2,660–60–3,200	12	08	04	01	–	03	–
Studio Attendant	2,550–55–2660–60–3,200	01	01	–	–	–	–	–
Store Attendant	2,550–55–2,660–60–3,200	01	01	–	–	–	–	–
Safaiwala	2,550–55–2,660–60–3,200	16	15	01	15	–	–	–
Daftry	2,610–60–2,910–65–3,300–70–4,000	45	45	–	10	02	01	–
Jamadar	2,610–60–2,910–65–3,300–70–4,000	08	08	–	04	–	–	–
Head Packer	2,610–60–2910–65–3,300–70–4,000	01	01	–	–	–	–	–
Junior Gestner Operator	2,610–60–2,910–65–3,300–70–4,000	02	02	–	02	–	–	–
Franking Machine Operator	2,610–60–2,910–65–3,300–70–4,000	01	–	01	–	–	–	–
Record Keeper	2,750–70–3,800–75–4,400	01	01	–	01	–	–	–
Library Attendant	2,750–70–3,800–75–4,400	03	02	01	–	–	01	–
File Attendant	2,750–70–3,800–75–4,400	01	–	01	–	–	–	–
Despatch Rider	3,050–75–3,950–80–4,590	01	01	–	01	–	–	–
Senior Gestetner operator	3,050–75–3,950–80–4,590	02	02	–	–	02	–	–

*Including *ad hoc* appointment

POLICY AND PERSPECTIVE PLANNING

ICAR has taken a number of initiative for O & M reforms to improve the working environment and for making research need-based, effective, efficient and relevant. Under the National Agricultural Technology Project (NATP), Organization and Management (O & M) reforms constitute an important component. The important activities organized under O & M component of NATP are given here.

Operationalization of the recommendations of the O* and *M Task Force Sub-committee on Administrative Matters: The recommendations of the Sub-Committee on Administrative Matters of the O & M Task Force, popularly known as Mehta Committee, were sent to all the Heads of the concerned Subject Matter Divisions of the Council with the request to them for feed back for operationalization/ implementation in the ICAR with the approval of the competent authority. The report is thus under examination.

Operationalization of the recommendations of O and M Task Force Sub-Committee on Agricultural Extension of ICAR: The Extension Division has accepted all the recommendations of the sub-committee for its implementation by the Krishi Vigyan Kendras but for the recommendation which states the Trainers' Training Centres (TTCs) have lost their relevance and be abolished and their work should be entrusted to the ICAR/State Agricultural Universities. The Extension Division has communicated the acceptance of the recommendations to all the Zonal Co-ordinators for implementation and transmission to all the Krishi Vigyan Kendras for improving their effectiveness.

Report of the Review of the ICAR Institutes: The recommendations of the Consultants are multidisciplinary in nature and relate to various Heads of the Subject Matter Divisions of the Council. The key recommendations and action points arising out of the report of the consultants have been sorted out and put up for the approval of the competent authority. The report is thus under examination.

Report on the Finance and Audit, Budget and Procurement System Reforms: National Institute of Financial Management (NIFM) had revised the report after a follow up of the meeting held on 29 April, 2001. The revised report was again discussed in a meeting held on 25 October, 2002 under the Chairmanship of Additional Secretary, DARE and Financial Adviser DARE wherein an officer of NIFM also participated. During the course of deliberations it was emerged that the revision in the report was however, only marginal and fell quite short of expectations. It was pointed out that the revision did not re-structure the report as desired, so as to make it specific to activities relating to items of expenditure. After considerable deliberations, it was agreed that the NIFM would further revise the report to incorporate the Sub-Sections/Sections as suggested in the meeting. It was also agreed that once the NIFM had brought out the Report as indicated above, the ICAR officials would visit the NIFM for updating/making further correction of the Report.

Training: Keeping in view the importance of the Human Resource Development, various training programmes were conducted in various training institutions of repute for 18 officials from Scientific, Technical, Administrative and Finance categories during the reported period. The ICAR also organized a Module-II Retreat programme for Senior Executives of the Council at the Indian Institute of Management (IIM), Ahmedabad from 6 to 8 September, 2002.

Standing Policy and Planning Committee

The ICAR organized Xth meeting of the Standing Policy and Planning Committee (SPPC) of the Governing Body on 30th September, 2002 under the Chairmanship of Dr M S Swaminathan. This Committee recommended the constitution of the Eight Task Forces viz. a task force each on the Farming System Diversification and Value Addition, developing action plans for accelerating agricultural progress in areas with considerable untapped production potential, enhancing factor productivity with special reference to irrigation water, mobilizing frontier technologies for the

technological upgrading of farm families during the production and post-production phases of farming, IARI in the 21st century, home and International trade, climate change, and agriculture and commercialization of technologies.

RESERVATION OF POSTS FOR SCHEDULED CASTES, SCHEDULED TRIBES AND OBCs

Direct recruitment on the All-India basis	SCs	STs	OBCs
(a) By open competition (i.e. through the UPSC or by means of open competitive test held by any other authority)	15%	7.5%	27%
(b) Other than at (a) above	16.66%	7.5%	25.84%

These reservations were made applicable to the ICAR (Hq) and its Research Institutes/Centres. The position regarding the percentage of Scheduled Castes/ Scheduled Tribes and Other Backward Classes in the ICAR (headquarters) and its Research Institutes/National Research Centres/Project Directorates during 2002–2003 is as given here.

Category	(%) SCs	(%) STs	(%) OBCs
Scientific Posts	8.52	1.03	10.21
Technical Posts	23.63	6.82	9.89
Administrative Posts	22.07	6.01	7.86
Supporting Staff (excluding *Safaiwala*)	28.74	7.49	6.54
Supporting Staff (*Safaiwala*)	93.70	3.25	3.56
Auxiliary Posts	32.00	6.00	20.75

PROGRESSIVE USE OF HINDI

DARE

Department of Agricultural Research and Education has an Official Languages Section for the compliance and implementation of the Official Language Policy of the Government of India. It consists of one post each of Assistant Director (Official Language), Junior Hindi translator, Hindi steno and Hindi typist. Besides the Hindi Translation of the Budget, Annual Report of the Department etc. The functioning of this section also includes to hold Hindi workshops, meetings, reports, organizing Hindi week to encourage the employees for doing their official work in Hindi.

Dr Panjab Singh is giving away flower bouquet to our guest on Hindi award ceremony

ICAR

There are 250 offices under ICAR and out of these 72 are main Institutes while remaining 178 are regional stations of the Institutes/Project Directorates/National Research Centres/Bureaux etc. Out of these offices total 77 offices of the Council were notified as Hindi offices in the Gazette of the Government of India under rule 10 (4) of the Official Language Rule 1976.

Joint Official Language Implementation Committee of the DARE and the ICAR working under the Chairmanship of the Additional Secretary, DARE/Secretary, ICAR met regularly. Similarly, Official Language Implementation Committees constituted at 86 ICAR Institutes/Centers etc. held their meetings regularly. Remaining institutes

Mr Ramesh Kumar, UDC, DIPA, secured second position in Hindi typing test

etc. were instructed to constitute such committees immediately.

Proceedings of the Official Language Implementation Committee meetings held by the Institutes etc. as well as the quarterly progress reports regarding use of Official Language Hindi received from various institutes at the ICAR (headquarter) were reviewed, and remedial steps were suggested to overcome the shortcomings found in the proceedings and the reports.

Rosters were maintained for imparting training in Hindi, Hindi typing and Hindi Stenography and officials were accordingly deputed for training and 12 stenographers and 9 typists were nominated for Hindi Stenography and Typing during the reported year.

ICAR (headquarter) and its institutes celebrated "Hindi Chetna Mass" since 14 September, 2002. Prizes were given away on 12 November 2002. The messages of Hon'ble Minister of Agriculture, and Secretary, ICAR were issued in which they appealed to do maximum official work in Hindi.

During 2002 Hindi Workshops (3) were organized for officers/staff members.

During 2001–2002 cash awards were given to 10 officials at the ICAR (headquarters) for doing their maximum official work in Hindi.

Under the 'Rajarshri Tandon Rajbhasha Purskar' scheme launched in 1998–99, Indian Agricultural Research Institute, Pusa, New Delhi received first prize; National Dairy Research Institute, Karnal received second prize under the category of Large Institutes. Under Category of Small Institutes, Central Institute for Sub-tropical Horticulture, Lucknow got first prize and the National Research Centre for Soybean, Indore received second prize. Under Category of 'C' region Central Institute for Fisheries Technology, Cochin received first prize and National Academy of Agricultural Research, Hyderabad received second prize.

In accordance with the recommendations made by Department of Official Language and Parliamentary Committee on Official Language, to assess the progress of use of Hindi at the Council (headquarter) as well as its institutes, during 2002 fifteen offices were inspected and suggestions were given to improve the shortcomings.

The *RAJBHASH ALOK* (5th issue) was published which gives a brief description of progress made in Hindi work at the Council and its institutes. Other institutes also brought out Hindi publicatios.

Most of the computers at the ICAR (headquarter) are bilingual and some of them work cent per cent in Hindi only.

The Council and its institutes are organizing regular training programmes for farmers in Hindi and in other regional languages and remarkable progress was observed in Krishi Vigyan Kendras of Hindi speaking region and in the other regional languages in their day to day official work.

During 2002 Town Official Language Implementation Committee, Hyderabad awarded Rolling Shielf to National Academy of Agricultural Research Management, Hyderabad for the best performance in Implementation of the Official Language Policy of the Union among the Central Government Offices and for original writing in Hindi on technical subjects, while Central Research Institute for Dryland Agriculture, Hyderabad was awarded with Research Laboratory Rolling Shielf for being the best research laboratory of the town using Hindi in their day to day official work during the reported year. Similarly Central Agricultural Research Institute, Port Blair was awarded with 'Chal Bajayanti Shields' for doing maximum work in Hindi during 2001–02.

Besides all the material regarding Parliament, Annual Report, Xth Five-Year Plan, Report, Review of demands for grants, General Body, Standing Finance Committee, Parliamentary Standing Committee on Agriculture, Annual General Meeting of ICAR society and many other meetings were prepared bilingual. The Hon'ble Agriculture Minister and other higher officials delivered their speeches in Hindi. The draft of speeches of Hon'ble Union Agriculture Minister and other higher officials of ICAR were prepared originally in Hindi also.

FINANCE AND AUDIT

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan and Non-Plan) for 2001–2002 are Rs 14,045.5 million and Rs 1,325 million respectively and BE for 2002–2003 (Plan and Non-Plan) is Rs 14,980.5 million. The detailed break-up of these financial figures are given here.

The details of Department of Agricultural Research and Education (DARE) are given in respect of BE and RE for 2001–2002 and BE for 2002–2003. This excludes the payment to the ICAR.

Budget Estimates and Revised Estimates of DARE and ICAR

(Rupees in million)

Item		Budget Estimates 2001-2002		Revised Estimates 2001-2002		Budget Estimates 2002-2003	
		Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451'							
090	Secretariat	–	10.00	–	10.00	–	10.50
Major Head '2415'							
80	General						
798	International Co-operation						
010032	India's membership contribution to Commonwealth Agricultural Bureau International	–	1.00	–	1.00	–	1.00
020032	India's membership contribution to Consultative Group on International Agricultural Research	–	33.80	–	33.80	–	34.30
030032	Other Programmes	6.00	–	6.00	–	5.00	–
040032	India's contribution to Asia Pacific Association of Agricultural Institutions	–	1.00	–	0.50	–	0.50
050032	India's contribution to NACA	–	0.95	–	0.95	–	1.00
060032	India's contribution to CGPRT	–	0.50	–	0.50	–	0.50
070032	India's contribution to Seed, and Seed Testing Association	–	0.10	–	0.15	–	0.15
080032	ISHS, Belgium	–	0.15	–	1.00	–	0.50
010031	CAU, Imphal	–	–	–	–	2.30	–

ICAR AWARDS CEREMONY 2002

The ICAR, over the years, has instituted a number of awards recognizing that an appropriate incentive and reward system in an organization makes the performance of its employees proficient, productive and satisfying. There could be no greater satisfaction to a scientist, extension worker, farmer and development official than to witness him or her sincere efforts being recognized at national level. A new award, Chaudhary Devi Lal Outstanding All-India Co-ordinated Research Project award, which was instituted last year, is being given for the first time to the two All-India Co-ordinated Research Projects as joint award for their meritorious contributions.

This year, the awardees included 27 scientists and their 46 associates from the ICAR Institutes, 18 scientists/teachers and their 13 associates from State Agricultural Universities. Out of the total 112 awardees, approximately 15% were women

Dr M P Yadav, Director (IVRI, Izatnagar), is receiving Sardar Patel Outstanding ICAR Institution award 2001

scientists. Nine awards were given away to the Scientists of the Defence Research Development Organization, Field Research Laboratory, Leh, Ladakh; Mumbai Veterinary College, Mumbai; and Shri Venketeshwar University, Triputhy. There were all outside the National Agricultural Research System comprising ICAR Institutions and State Agricultural Universities. A book written by a farmer on *Indigenous Traditional Knowledge* and farming practices was also been rewarded. One agricultural university, one National Institute and one National Research Centre/ Project Directorate received Best Institution Awards for their excellent contribution to agricultural research and education.

There are 18 'Jawaharlal Nehru Awards' for doctoral thesis including one Joint Award. The research work done by the young scientists has broken several new grounds in the field of Crop Science, Animal Sciences, Fisheries, Natural Resource Management, and Post-harvest Technology and Agricultural Engineering. Distinguished contribution of the awardees has been in isolation of RIL and APR gene for achieving durable resistance in wheat, heat tolerance in wheat, establishing protoplast regeneration system from *indica*, *japonica*, wild abortive cytoplasmic male sterile and maintainer line of rice, and RT-PCR and nucleic acid hybridization assays for detection of blue-tongue virus in sheep, identification of casual agent of sterility mosaic disease of pigeon pea, insect tolerance to Bt toxins/straints, sustainability of rice-wheat cropping system and groundwater management for sunflower cultivation after rice. The other candidates made significant contributions in breeding bananas for resistance to nematodes and Sigatoka leaf sport *in vitro* screening of genotypes against *Fusarium* yellow disease resulting in insensitive clones to the disease; research on modeling of salinization and nitrogen losses under sub-surface drainage system; development of process for long-life and instant mix of the milk product *kheer*; diagnosis and management of selenium toxicity in animals; various aspects of the IBD disease; development of thermal processing for buffalo meat products to be preserved in retort pouches; pathology of aflatoxin toxicity in Indian major carp; impact of tannery effluent pollution on agriculture and socio-economic conditions of the farming community, and study of iron deficiency in children and its management through nutrition education in Sirsi Taluk of Karnataka.

'Punjabrao Deshmukh Women Agricultural Scientist Awards' were given for the development and patenting of a novel, superfast and powerful hyper-spectral data analyzing method and a software for natural resource monitoring from satellite or aircraft platform. Another candidate made improvement of the nutritive value of poor quality roughages evolving suitable treatment with alkali, ammonia and impregnation with urea.

'The Vasantrao Naik Award for Research Applications in Agriculture for 2001' was given away for the development of a comprehensive technology for water harvesting and rainwater management for providing full irrigation to transplanted rice-based two crop rotation system. Adoption of technology offers potential to transform the agriculture from subsistence to occupational level in the drought prone areas of Orissa.

'Fakhruddin Ali Ahmed Award' was given away for the efforts made on standardization, patent and subsequent transfer of technology for commercial production of herbal beverage from fruits of seabuckthron wildly grown in Leh, Ladakh, and mud carb culture in brackishwater of Andaman and Nicobar Islands.

'The ICAR Team Awards' were given away for wheat improvement, pearl millet improvement and production technology; silvipastrol system; developing techniques for value addition and environment safety in rice milling industries; conservation and characterization of coconut germplasm; fish products technology; livestock feed management; and determination of technical needs of the farmers in wet-temperate high hills and sub-temperate sub-humid mid-hills of the Himachal Pradesh based on farming system approach.

Eight teachers were honoured for their significant teaching contribution in Plant Breeding and Genetics, Crop Physiology, Horticulture, Natural Resource Management, Fisheries, Avian Diseases and Home Science.

NG Ranga Farmer Award for Diversified Agriculture 2001 is being given away by MoA, Shri Ajit Singh

In the area of technology assessment, refinement and transfer, the role of Krishi Vigyan Kendras were widely recognized. This year, out of the two awards, one each goes to the ICAR Institute and State Agricultural University for their distinguished contributions under Institute-Village Linkage Programme for holistic development of farming community, and integrated pest management in cotton.

'The Jagjivan Ram Kisan Puruskar' was given away to a farmer from village Kailar, District Solan, Himachal Pradesh for his outstanding contribution in innovative farming practices. 'The N.G. Ranga Farmer Award' was conferred for Diversified Agriculture to a farmer from Tripura for developing a technique of using groundwater for aquaculture, establishment of a feed mill, developing the farming system in diversified agriculture and transfer of management practices.

'The Rajendra Prasad Puruskar' was given away to 8 technical books in Hindi on Integrated Pest Management, Beekeeping, Soil Conservation and Water Management, Hydrology, Poultry Management, Livestock Diseases in Humans, Indian fisheries, and Indigenous Traditional Knowledge and Practices.

The Chaudhary Charan Singh Award for Excellence in Agricultural journalism has gone to a Stalwart who has a distinction of serving the cause of Indian Agriculture for more than 29 years through the laudable analytical contribution.

Hon'ble Union Agriculture Minsiter, Shri Ajit Singh, gave away the prizes to the Awardees (Appendix 12).

TECHNICAL CO-ORDINATION

Financial support to scientific societies

With the approval, the Standing Committee financial assistance was provided to 48 scientific societies for publication of journals, to 26 societies and academic universities for holding National Seminars/Symposia/Conferences and to 8 societies for holding International Seminars/Symposia/Conferences.

Assistance and monitoring *DARE/ICAR Annual Report 2002–2003* and Highlights of Achievements of *A.P. Cess Fund Supported Schemes*

Manuscripts pertaining to *DARE/ICAR Annual Report 2002–2003* and significant achievements of *A.P. Cess Fund Supported Schemes* were co-ordinated between the corresponding Heads, Subject Matter Divisions and the Directorate of Information and Publications of Agriculture.

Monthly summary

Compiled monthly summary on major research achievements, exports, import and other related matters of all the Institutes/Project Directorates was submitted to Cabinet, Government of India, and other related departments.

Support to DSIR

Evaluated, processed and provided comments on various proposals submitted by the private and public funded organizations related to agriculture for recognition of their Research and Development Units to the Department of Scientific and Industrial Research (DSIR), Government of India.

Best Annual Report Awards

Applications for the 'Best Annual Report Awards' for 2000–2001 to the ICAR Institutes have been processed.

ICAR International Training Programme

Material for ICAR's International Training Programmes 2003 document was

collected from all the ICAR Institutes and State Agricultural Universities, compiled, collated and co-ordination is being done with the Directorate of Information and Publications of Agriculture for its publication**.**

Technical Backstopping

Provided technical input like co-ordination and preparation of Memoranda of Understandings and Work Plans, preparation of technical briefs, attending to related querries and monitoring deputation reports.

Parliament questions, VIP references and material for papers/talks/replies and preparation of technical notes: Collected and compiled information for reply of parliament questions and VIP references, and prepared papers/talk/replies and technical notes on various issues which concerned more than one Head, Subject Matter Division of the ICAR.

6. Partnership and Linkages

The 'Partnership and Linkages' is an important wing of the DARE/ICAR in which DARE and ICAR have International collaborations through Memoranda of Understandings/Work Plans, Projects, Training Courses, exchange visits etc.

During the 2002–03 the major breakthrough includes organizing a meeting of Plan Policy Dialogue on 'Forward Thinking Policies for Groundwater Management—Energy Water Resources and Economic Approaches' between the Indian Council of Agricultural Research (ICAR), India, and International Water Management Institute, Colombo.

Further DARE/ICAR have organized a meeting of the Counsellors-in-charge of Agriculture in the Embassies/High Commissions/Honorary Consulates General/Honorary Consulates in Delhi on 3 October 2002 to inform them about the training facilities available within the National Agricultural Research System.

DARE has sent 82 scientists abroad to attend conferences/meetings/seminars/workshops and has got signed 2 Projects in 2002; and has concluded workshops (4), meetings (4), and Training Courses (2) organized by CGIAR centres in India.

H E (Dr) Ephrain Kabaija, Minister of Agriculture, Animal Resources and Forestry, Government of Rwanda Republic with H E Shri Ajit Singh (MoA)

International Co-operation

The International Co-operation in the ICAR/DARE has been operating through the MoUs/Work Plans signed with various countries/International organizations with ICAR/DARE as the Nodal Department and through participation of ICAR/DARE in the MoUs/Work Plans signed by the Department of Agriculture and Co-operation as Nodal Department. In addition, Ministry of Science and Technology has developed Programmes of co-operation with various countries and International organizations in which ICAR/DARE is the participating agency in agricultural research. The Joint Commissions/Working Groups constituted by the Ministry of External Affairs and the Ministry of Commerce have the component of agriculture/agricultural research in which DARE participates directly or through the Department of Agriculture and Co-operation.

MoUs/Work Plans

- ICAR/DARE agreed on Minutes of the meeting of the Committee on 'Agriculture and Rural Development' under the 12th Session of the Indo-Iran Joint Commission that was signed on 20 May 2002.
- An agreement between Department of Agricultural Research and Education, Government of the Republic of India and Ministry of Agriculture, Water and Rural Development of the Republic of Namibia was signed on 29 April 2002 to extend the validity of existing Work Plan up to 31 December 2003.
- A Protocol was signed on 11th July, 2002 during the 14th session of Indo-Bulgarian Joint Commission held in Sofia, Bulgaria from 11 to 13 July,

- At Jhansi in provenances trial, provenance Bhopal was found outstanding for growth parameters.
- DARE has sent 82 scientists to attend conferences/seminars/workshops/meetings in different countries of the world.
- MoUs/Workshops were signed with Iran, Namibia and Bulgaria.
- Five foreign aided research projects were signed during 2002–2003 with the United Kingdom, Australia, Indonesia, Thailand and China.

- Foreign delegations (more than 8) came to India during the reported period.
- Indian delegations (more than 65) visited to foreign countries.
- DARE/ICAR have conducted 4 workshops, 4 meetings, 2 training courses organized by the CGIAR centers in India.
- The short-term and long-term courses were arranged for foreign nationals of Nepal, Bhutan, ITEC Programmes, FAO etc.

2002 for extension of the Work Plan between ICAR and Bulgarian National Centre for Agrarian Sciences, Bulgaria up to 31 December 2004.

Research Projects

- Collaborative Implementation of the research project, "Strategies and Options for Sustaining Fisheries and Aquaculture Production to benefit poor household in Asia" was signed between ICAR and IC&ARM, Malasiya on 1st March 2002.
- Collaborative Implementation of the research project "Developing Sustainable Coconut based income generating Technologies in poor rural communities in India" was signed between ICAR and IPGRI on 8 August 2002.

International linkages

A number of foreign aided research projects were received in this Department during 2002–03 and the following projects were approved.

- DARE conveyed no objection for participation of Indian Agricultural Research Institute, New Delhi in the Ministry of Environment and Forests. Project viz. "Impacts of Climate Change on Agriculture" with the UKwas signed for 3 years and is commencing from January 2002. The aim of the project is to assess effect of inter-and intra-seasonal climatic variability on yield of major crops.
- ICAR-Natural Resource International (NRI), the UK signed on a collaborative project viz. 'Integrated Management of Fruit Flies (Diptera: Tephritidae)'. The project is for 3 years and is commencing from 1 January 2002. The aim of the project is to develop integrated pest management methods to reduce the problems of fruit flies Diptera: Tephritidae for small farmers in the country.
- ICAR-Australian Centre for International Agricultural Research (ACIAR) project viz. 'Permanent beds for irrigated Rice-Wheat and alternative cropping systems in North-West India and South-East Australia' was signed for 5 years and is to be implemented by the Punjab Agricultural University, Ludhiana. The objectives of the project are to increase the sustainability, yield, resource use efficiency and profitability of Rice-Wheat systems of the Indo-Gangatic Plain (IGP) and of the cropping systems in the rice growing areas of Australia, through improves soil, water and nutrient management using permanent beds.
- International Foundation for Science (IFS) Project, Stockholm, Sweden viz. 'Development of rhizome disinfection technology for management of bacterial wilt of ginger' was approved on 5 September 2002 for 3 years. The objective of the project is to develop a simple disinfection technology for rhizome *Rhizobium solanacearum* using renewable solar energy. The project is to be implemented by the Indian Institute of Spices Research, Calicut.
- The Project viz. 'Development of locally-adapted, multiple disease-resistant, high-yielding chilli (*Capsicum annuum* L.) cultivars for targeted countries in Asia' was approved on 16 September 2002 w.e.f. 1 March 2002 for 3 years. The project is to be implemented in 4 collaborating countries viz. India, Indonesia, Thailand and China. The project was prepared in consultation with South Asian Vegetable Research Network and Asian Vegetable Network partners and is being funded by them.

Dr Panjab Singh signed on a work plan between ICAR, India and IRRI, Manila, Phillipines

PROTOCOL ACTIVITIES

Foreign delegations to India

- The Indonesian experts were trained in the field of 'Pathology and Wheat Breeding' at Directorate of Wheat Research, Karnal for 1 month w.e.f. 1 March 2002.
- H E Mr Dato Choo Slew Kioh, High Commissioner of Malaysia led 9-member-delegation and visited Indian Agricultural Research Institute, New Delhi on 2 May 2002.
- H E Mr C J Mesang (Member of Parliament, Indonesia), Dr Haryono and Mr. Suwarna from Secretariat Agency for Agricultural Research and Development, Indonesia visited India from 5 to 8 May 2002.
- H E Mr Bungaran Saragih, Minister of Agriculture and Forestry, Indonesia, visited Indian Agricultural Research Institute, New Delhi; Directorate of Wheat Research, and National Dairy Research Institute, Karnal from 13 to 14 May 2002.
- Dr Stein W Bie, Director-General, International Service for National Agricultural Research (ISNAR), Netherlands, and Dr Willem Janssen (Director, ISNAR) visited to India from 26 to 29 May 2002.
- Dr Patrick Durand (Director of External Affairs, CIRAD), Dr Roberto Bacilleri (Secretary General, External Department., INRA), and Dr S Kaushik (Director, Hydrobiology Lab, INRA) from France visited India from 17 to 25 July, 2002 and held discussions for promoting joint collaboration among the ICAR, CIRAD and INRA.
- H E Professor Mostata Moeen, Hon'ble Minister of Science, Research and Technology, Islamic Republic of Iran and accompanied senior level delegation visited Indian Agricultural Research Institute, New Delhi on 23 October 2002.

Dr Panjab Singh (Ex-DG, ICAR) is attending an Ethopian delegation on 10 July 2002. Dr Mangala Rai (*extreme right*), present DG, ICAR, (since 9 January 2003) is also looking into the matter

- H E Dr Ephraim Kabaija, (Minister of Agriculture, Animal Resources and Forestry, Rwanda) led 15-member delegation and visited Indian Agricultural Research Institute, New Delhi on 30 October 2002.
- A two-member delegation from France namely Dr Patrick Durand, Director of External Affairs, CIRAD and Dr Robert Bacilleri, Secretary General, External Department, INRA visited India from 21 to 22 November 2002 to discuss formulation of MoU/ Work Plan between ICAR, INRAQ URAD.
- Two experts namely Mr. Matomola Brendan, Bagari Research Station and Ms. Otti Lie Shivolo, Masharo Research Station from Namibia visited IIHR, Bangalore for training in the field of indigenous fruits, vegetables etc. for 16 days from 22 November to 7 December 2002.
- Training of 5 Sri Lankan Scientists namely Ms. W. Illangantilake, Ms. N. Hettiarachchi, Ms. I. Mudannayake, Ms. I.I.I.Pieris and Ms. Sumetra Herath in Library Sciences from 7 to 6th June, 2002 at Indian Agricultural Research Institute, New Delhi under ICAR-CARP Work Plan for 2000-2001 (extended up to 31.12.2002)

Indian delegations to foreign countries

- Dr V M Reddy (Principal Scientist, National Research Centre for Oilpalm, Pedavegi, Andhra Pradesh) visited Malaysia from 3 to 4 June 2002 to study the Programme of Oilplam Plantation.
- Dr Panjab Singh, (Secretary, DARE, and Director-General, ICAR) visited Ohio State University, USA from 19 to 22 July 2002 to study future collaborative programmes and formulation of Work Plan between the ICAR and OSU, USA in the agricultural research.
- Dr B M C Reddy [Project Coordinator (Tropical Fruits)] and Dr V V Sulladmath, (Scientist, Indian Institute of Horticultural Research, Bangalore)] visited Sri Lankan Council for Agricultural Research Policy (CARP), Sri Lanka in the field of 'Nursery Production and Management of Rambutan Mangosteen and Durain' from 5 to 17 August 2002.
- Dr S H Jalikop (Senior Scientist, Indian Institute of Horticutural Research, Bangalore) visited Sri Lankan Council for Agricultural Research Policy (CARP), Sri Lanka during 5 to 17 August 2002 in the field of 'Joint exploration of germplasms for mangosteen and jackfruit'.
- Dr D K Tandon (Senior Scientist, Central Institute for Subtropical Horticulture, Lucknow) and Dr R B Tewari (Scientist, Indian Institute of Horticultural Research, Bangalore) visited Sri Lanka Council for Agricultural Research Policy (CARP), Sri Lanka in the field of 'Post-harvest Management of Tropical Fruits' from 5 to 18 August 2002.

- Dr G Kalloo, DDG (Hort.), and Dr R C Maheshwari, ADG (TC), ICAR visited Sri Lanka Council for Agricultural Research Policy (CARP), Sri Lanka to review the Work Plan for 2000–2001 and for finalization of the Work Plan for 2003–2004 between the ICAR and CARP from 19 to 23 August 2002.
- Dr O P Joshi (Principal Scientist, National Research Centre on Soybean, Indore) visited Indonesia to study the 'Production Technology of Soybean' under Work Plan 2001–2002 for 10 days w.e.f. 21 August 2002.
- Dr Mangala Rai, DDG (Crop Science), ICAR (hqrs), New Delhi visited South Africa as member of the delegation led by Agriculture Minister during 16 to 20 October 2002.
- Dr D K Paul, [Principal Scientist (IWM), ICAR (hqrs) visited Sri Lankan Council for Agricultural Research Policy (CARP), Sri Lanka from 21 to 26 October, 2002 for 'On-Farm Irrigation Management in Mahaweli Area' under the Work Plan between the ICAR and CARP, Sri Lanka.
- Dr S Ghosh, Sr. Scientist, IVRI, Izatnagar, visited Cuba for training in the field of 'newer generation vaccine and diagnosis including tick control at the CENSA bio-control Institute, Cuba under the Work Plan for 6 days w.e.f. 24 to 29th November 2002.
- Dr M R Dinesh, Sr. Scientist, IIHR, Bangalore visited CARP, Sri Lanka from 16 to 28 December 2002 for Joint exploration of germplasm for mango.
- Dr S N Shukla, ADG (FFC), was deputed to Hanoi, Vietnam for participation in the 4th International Symposium on 'Hybrid Rice' under the United Nations Development Project on 'Development of Hybrid Rice Technology for large-scale adoption in India' for 4 days w.e.f. 14 May, 2002.
- Dr B S Dhankar, ADG (Vegetable Crops), was deputed to Bangkok, Thailand for participation in the Planning Workshop under the German Government funded Project viz., 'Development of locally-adapted, multiple disease-resistant, high-yielding chilli cultivars for targeted countries in Asia' for 7 days w.e.f. 9 May 2002.
- Dr C D Mayee (Director, Central Institute for Cotton Research, Nagpur) was deputed to the United Kingdom for attending the project coordinating committee meeting under ICAR-NRI, the UK collaborative project on Sustainable control of the cotton bollworm '*Helicoverpa armigera* in small-scale cotton production systems' for 3 days w.e.f. 10 June, 2002.
- Dr N K Tyagi (Director, Central Soil Salinity Research Institute, Karnal) was deputed to Beijing (China) for participation in the concluding workshop under Indo-European Commission (EC) Project, 'Policies for Water savings in Yellow River Basin; A DSS applied to Ningxia and Shandong' for 5 days w.e.f. 24 June 2002.
- Dr H P Singh (Director, Central Research Institute of Dryland Agriculture, Hyderabad) was deputed to the United Kingdom for attending the meeting for preparation of DFID-CRIDA project 'Better livelihoods through improved natural resources management in SAT India' on 27 June 2002.
- Dr Partap Narain (Director, Central Arid Zone Research Institute, Jodhpur) was deputed to Damascus, Syria for participation in the 5th Session Focal Point Meeting for 5 days w.e.f. 8 July 2002.
- Dr A K Shikka (Director, ICAR Research Complex for Eastern Region, Patna) was deputed to the United Kingdom under DFID projects 'Integrated Management of Land and Water Resources for enhancing productivity in Bihar and Eastern UP' and 'Livelihoods improved through improved crop and soil management' for 9 days w.e.f. 5 September 2002.
- Dr J S Samra, DDG (NRM), was deputed to Australia for attending Annual Meeting of ACIAR-ICAR Projects on 'Physiological and genetic approaches for the development of waterlogging tolerance in wheat on sodic/alkaline and natural soils in India and Australia' for 2 days w.e.f. 9 September 2002.
- Dr S Edison (Director, Central Tuber Crops Research Institute, Thiruvananthapuram) was deputed to Bellagio, Italy for participation in the Global Cassava Plan Strategic Meeting under USAID Programme for 5 days, w.e.f. 1 October, 2002.
- Dr N B Singh, ADG (OP), was deputed to Rothamsted, the United Kingdom for interaction meeting with scientists of the United Kingdom and monitoring and reviewing the progress of Indo-UK Project on Oilseeds Crops for 11 days w.e.f. 20 September 2002.
- Dr M K Praharaj (Sr. Scientist, Project Directorate of Poultry, Hyderabad) visited at INRA, France for 1 year w.e.f. December 2001 for availing Post-doctoral Fellowship.
- Dr R Madhusudhana (Scientist, NRCS, Hyderabad) visited at Institute of Grassland and Environmental Research, Aberystwyth, UK for 1 year w.e.f. 26 June 2002 for availing BOYSCAST Fellowship.
- Dr A Sarangi (Scientist, Indian Agricultural Research Institute, New Delhi) visited at Mc Gill University, Canada for 2 years w.e.f. 03 January 2002 for availing Post-doctoral Fellowship.
- Dr Dheer Singh (Scientist, National Research Centre on Camel, Bikaner) visited at University of South Carnila, USA for 1 year w.e.f. January, 2002 for availing BOYSCAST Fellowship.
- Sh. Gorakh Mal, (Scientist, National Research Centre on Camel, Bikaner) visited at the University of Sheffied, the UK for 3 years w.e.f. January, 2002 for availing higher studies leading to award of Ph.D.
- Dr Suresh Gurduru (Scientist, Indian Grassland and Fodder Research Institute, Jhansi) visited at Wageningen, the Netherlands w.e.f. 14 January to 25 July 2002 for availing 2002 Anglophone ICRA Fellowship.
- Dr V N Waghmare (Scientist, Central Institute of

Cotton Research, Nagpur) visited at the University of Georgia, USA for 1 year w.e.f. 27 March 2002 for availing BOYSCAT Fellowship award.

- Dr P H Zaidi (Scientist, Directorate of Maize Research, IARI, New Delhi) visited at CIMMYT, Mexico for 1 year w.e.f. 20 February 2002 for availing BOYSCAST Fellowship.
- Dr Ashok Santra (Scientist, Central Sheep and Wool Research Institute, Avikanagar) visited Australia for 1 year w.e.f. 2 September 2002 for availing BOYSCAT Fellowship.
- Sh. P G Patil (Incharge, Ginning Training Centre, CIRCOT, Mumbai) visited at M/S LUMMUS Corporation, Savannah, USA for 1 week to attend spot Technical Training w.e.f. 28 January 2002.
- Dr R K Sharma (Scientist, Indian Agricultural Research Institute, New Delhi) visited to Germany for 3 months w.e.f. 1 February 2002 to attend training under INSA's International Scientific Collaboration and Exchange of Scientists Programme.
- Dr K S Shivashankara (Scientist, Indian Institute of Horticultural Research, Bangalore) visited at National Food Research Institute, Tsukuba, Japan, for availing Post-doctoral Fellowship for1 year and 14 days w.e.f. 1 April 2002.
- Dr S Chakraborthy (Scientist, Indian Institute of Vegetable Research, Varanasi) visited University of Missouri, St. Louis, USA for 12 months w.e.f. 7 May 2002 for availing BOYSCAST Fellowship award.
- Dr (Mrs) Sunita Grover (Scientist, National Dairy Research Institute, Karnal) visited at National Food Research Institute, Japan for availing UNU Post-doctoral Fellowship for 1 year w.e.f. 1st week of April 2002.
- Dr C D Singh (Scientist, Central Institute of Agricultural, Bhopal) visited for 2 years w.e.f. 1st week of April 2002 for persuing Ph.D. Degree under Japanese Government Scholarship, 2002.
- Sh. Sanjeev Kumar Srivastava (Scientist, National Bureau of Fish Genetic Resources, Lucknow) visited Canberra, Australia for 3 years w.e.f. 31 March 2002 for persuing Ph.D. Study.
- Sh. H K Barman, (Scientist, Central Institute of Fisheries Aquaculture, Bhubaneshwar) visited the Kasgoshima University, Japan for persuing higher studies in Biotechnology for 2 years w.e.f. 1 April 2002.
- Dr Himanshu Pathak (Sr. Scientist, Indian Agricultural Research Institute, New Delhi) visited at IWNI, Sri Lanka to attend an interview for the post of Sr. Soil Scientist for 2 days w.e.f. 4 April 2002.
- Dr N Kanna Babu (Scientist, National Research Centre for Sorghum, Hyderabad) and Dr Sanjay Gupta (Scientist, Indian Institute of Pulses Research, Kanpur), visited at IAC, Wageningen, The Netherlands w.e.f. 29 April 2002 for 10 weeks to attend an I.C. on 'Seed Production and Seed Technology'.
- Sh. Ravi Chandran (Scientist, CPRS, Muthorai, Tamil Nadu) visited at IAC, Wageningen, The Netherlands for 10 weeks w.e.f. 22 April 2002 to attend an I.C. on Potato, Production Storage and Seed Technology.
- Dr A Mohan Rao (Assistant Professor, University of Agricultural Sciences, Bangalore) visited IAC, Wageningen, The Netherlands for 10 weeks w.e.f. 20 April 2002 to attend an I.C on 'Applied Plant Breeding'.
- Dr (Mrs) M Sujatha (Sr. Scientist, Directorate of Oilseeds Research, Hyderabad) visted at IAC, Wageningen, The Netherlands for 12 days w.e.f. 13–24 May 2002 to attend course on 'Plant Biotechnology'.
- Dr Prikhshyat Singh (Principal Scientist, Indian Agricultural Research Institute, New Delhi) visted Germany for 6 months w.e.f. 26 July 2002 under INSA's Bilateral Exchange of Scientists Programme.
- Sh S P Singh (Technical Assistant, NRCIPM, New Delhi) visited the Netherlands w.e.f. 13 May to 28 June 2002 to attend training course on Integrated Pest Management.
- Dr (Mrs) Nisha Patel (Senior Scientist, Central Arid Zone Research Institute, Jodhpur) visited Israel for 4 weeks w.e.f. 21 May to 18 June 2002 to attend training course on 'Research and Development of New Concepts in Integrated Biological Pest Management'.
- Dr J S Bentur (Principal Scientist, Directorate of Rice Research, Hyderabad) visited at International Rice Research Institute, Manila to attend an interview for the post of Entomologist for 6 days w.e.f. 20 May 2002.
- Dr Jagdev Sharma (Scientist, National Research Centre on Garlic, Pune) visited Israel to attend International course on 'Pressurized Irrigation Systems' for 3 weeks w.e.f. 28 May 2002.
- Dr S P Trehan [Principal Scientist, CPRS, Jalandhar (Punjab)] visited Germany for under INSA's Bilateral Exchange of Science Programme.
- Dr C K Beura (Scientist, Central Avian Research Institute, Izatnagar) visited Israel to attend training course on 'Poultry Management, Nutrition Physiological and Veterinary aspects' for 4 weeks w.e.f. 25 June 2002.
- Dr O P Yadav (Sr. Scientist, Central Arid Zone Research Institute, Jodhpur) visited UK for 3 months w.e.f. 5 August 2002 under INSA's Programme to attend training course on 'Molecular mapping marker assisted selection and analysis drought tolerance in pearlmillet'.
- Dr (Mrs) B Meenakumar (HOD TT, Central Institute of Fisheries Technology, Kochi) visited Canada for 3 months w.e.f. 15 July 2002 for availing Post-doctoral fellowship at the University of Davis, USA.
- Dr (Mrs) Anita Grover (Senior Scientist, Indian Agricultural Research Institute, New Delhi) visited USA for 2 years w.e.f. 1 August 2002 for availing post-doctoral fellowship at the University of Davis, USA.
- Dr S S Giri (Scientist, Central Institute for Fish

Aquaculture, Bhubaneshwar) visited Germany for undergoing specialized research at Institute for Tierrnahring, University of Boon, Germany under INSA's Bilateral Exchange Programme for 3 months w.e.f. August 2002.

- Dr Samadhan J Jadhao (Scientist, HSADL, Bhopal) visited USA for availing Post-doctoral Fellowship at Washington, USA for 1 year w.e.f.12 August 2002.
- Dr B Venkateswarlu (Principal Scientist, Central Research Institute of Dryland Agriculture, Hyderabad) visited China to attend an International course on 'Biological Fertilizer Technology' at Hebei, China for 1 months w.e.f. 28 August 2002.
- Dr S K Chakrabarty (Senior Scientist, Indian Agricultural Research Institute, New Delhi) visited Japan to attend a training course on 'Protection of Plant Breeder's Right' in Japan for 8 and half week w.e.f.19 August 2002.
- Dr R S Chandel (Assistant Scientist, Dr YSPUH&F, Solan) and Dr S K Lavania (Assistant Professor, GBPUAT, Pantnagar, Uttaranchal) visited Germany to attend training course on 'Improvement of the Training Quality in Colleges of Agriculture and Forestry' in Germany for 5 week w.e.f. 7 October 2002.
- Dr S K Chakrabarty (Scientist, Central Potato Research Institute, Shimla) visited USA for availing Biotechnology Overseas Association award at the State University of New Jersey, USA for 6 months w.e.f. 30 November 2002.
- Dr Jagdish Singh (Senior Scientist, Indian Institute of Vegetable Research, Varanasi) visited to Israel to attend training on 'Biotechnology in Agriculture Plant Microorganisms' for 19 days w.e.f. 29 October 2002.
- Dr B P Mishra (Senior Scientist, National Bureau of Animal Genetic Resources, Karnal) visited USA for availing Biotechnology Overseas Association (long-term) award in USA for 12 months w.e.f. 2 November 2002.
- Dr K V Ravishankar (Senior Scientist, Indian Institute of Horticultural Research, Bangalore) visited USA for availing Biotechnology Overseas Association (long-term) award in USA for12 months w.e.f. 6 December 2002.
- Dr U K Behera (Scientist, Indian Agricultural Research Institute, New Delhi) visited UK to attend training in the areas of 'Farming Systems Research' at the Royal Society of London, UK for 3 months w.e.f. 15 October 2002.
- Sh. Murtaza Husan (Scientist, Indian Agricultural Research Institute, New Delhi) visited Israel to attend a training course on 'Research and Development in Irrigation and Fertigation in Controlled Environment' for 40 days w.e.f. 5 November 2002.
- Dr Mam Chand Singh (Scientist, Indian Agricultural Research Institute, New Delhi) visited Israel to attend training on 'Sustainable horticultural crops production underclimatic constraints' from 8 October to 25 November 2002.
- Dr K P Jithendran (Senior Scientist, Central Institute of Fish Aquaculture, Bhubaneshwar, Orissa) visited Philippines to attend in the field of 'Diagnostic for virol Diseases in Shrimps and Marine Fisheries' at SEAFDEC for 15 days w.e.f. 6 November 2002.
- Shri A Chakravarty, Director, DIPA of ICAR visited at CAB International, UK, from 9-13 December 2002 to attend a detailed programme of planning meetings for Electronic Publishing.
- Shri V K Bharti, Chief Production Officer, DIPA of ICAR visited at CAB International, UK, from 9-13 December 2002 to attend a Professional training in Advance Production Techniques for Electronic Publishing.
- Dr S M Vidyasekhar, Technical Officer, DIPA of ICAR visited at CAB International, UK, from 9-13 December 2002 to attend a Professional training in database developement for Electronic Publishing.

7. Agricultural Scientists' Recruitment Board

The analytical information on the major initiatives and accomplishments of the Agricultural Scientists' Recruitment Board (ASRB) from 1 April 2001 to 31 March 2002 is given here.

RECRUITMENT BY EXAMINATION

Examination held during 2001–2002

The Board held examination for Agricultural Research Service (ARS)/National Eligibility Test (NET)/Senior Research Fellow (SRF) in October 2001.

Candidate	General	SC	ST	OBCs	Total
Applied	11,593	2,367	498	4,338	18,796
Appeared	7,365	1,463	316	2,783	11,927

The ARS Examination 2001 in respect of Special Recruitment Drive for the North-eastern Hills Region and Andaman and Nicobar Islands was held in December 2001.

The Limited Departmental Examination for Stenographers (Grade II) at the ICAR headquarters was notified on 25 July 2001 for 8 posts. The examination was held on 3 October 2001 and skill test on 4 February 2002.

The Limited Departmental Examination for Section Officers/Assistants at the ICAR headquarters was notified on 21 February 2002 for 10 posts (Section Officers 1 and Assistants 9).

Limited Department Examination for Stenographers (Grade II)

Candidates applied for the examination	41
Candidates appeared in the examination	35
Candidates called for skill test	30

RECRUITMENT BY INTERVIEW

Quantum of Work

The Board received requisitions for 190 posts during the year and requisitions for 155 posts were carried-over from the previous year. Against a total number of 345 posts, action to advertise could not be taken for 40 posts as the same were received at the end of the year. The Board issued 5 advertisements for 305 posts during the year. Besides the 305 advertised posts during the year, earlier year advertised posts (176) were also taken for action during the year. Accordingly 481 posts were taken up during the year for recruitment. Requisitions for 6 posts were withdrawn by the ICAR. Hence out of 475 posts, in 60 cases, no candidate was found eligible after interview, in 11 cases no candidate appeared for the interview, in 104 cases no candidate was found eligible to be called for interview as screened by the expert committees, and for 1 post no candidate had applied. The recommendations were communicated to the Council for 299 posts.

Interview and Selection

For the 474 posts (excluding six posts for which no application received), for which recruitment process was completed, 3,944 applications were received. Of the 2,423 candidates called for interview, 1,367 appeared.

USE OF HINDI

- Adequate arrangements were made to promote progressive use of Hindi in the office of the Board. To ensure compliance of Official Language Policy of the Central Government/ICAR and to fulfil the target fixed in the annual official language programme, a Hindi Translator is exclusively attending to the related work.
- About 65% of Officers and 80.2% staff working in the Board have acquired working knowledge of Hindi.
- Representative of the Board participates in the quarterly meeting of the Official Language Implementation Committee of the ICAR headquarters where the progress made in the use of Hindi in the official work of the Board is reviewed.
- Examination rules, notice, syllabi, instructions to candidates, admission certificate, test booklets, answer sheets, application forms, attendance sheets and attendance lists, etc. were printed both in English and Hindi simultaneously.
- All the advertisements issued by the Board were prepared and published both in Hindi and English in the leading newspapers of the country including *Rozgar Samachar*.
- Hindi version of this annual report of the Board is also being published.

Category-wise break-up of 305 posts is as follows:

(i)	Deputy Director-General and Directors of National Institutes	4
(ii)	Assistant Directors-General, Directors of Institutes, Project Directors and Joint Directors of National Institutes	58
(iii)	Project Co-ordinators and Zonal Co-ordinators/Joint Directors of Institutes	12
(iv)	Heads of Divisions/Regional Stations	62
(v)	Principal Scientists	15
(vi)	Senior Scientists	154
	Total	**305**

Category-wise break-up of 481 posts for which recruitment action taken/ recommended for re-advertisement

Scientific		
(i)	Deputy Director-General and Directors of National Institutes	4
(ii)	Assistant Directors-General, Directors of Institutes, Project Directors and Joint Directors of National Institutes	35
(iii)	Project Co-ordinators and Zonal Co-ordinators/Joint Directors of Institutes	12
(iv)	Heads of Divisions/Regional Stations	75
(v)	Principal Scientists	49
(vi)	Senior Scientists	200
Technical		2
Posts recommended for re-advertisement		104
	Total	**481**

Reforms

With a view to sharp focus during interview and to gauge the candidates in their areas of strength, the concept of asking Work Plan for next 5 years has been further strengthened and revised, and the candidate is asked to submit:

(a) A brief note (not more than one page) reviewing the work done by the candidate during the last 10 years, highlighting the achievements and accomplishments during the period including technology developed, project completed, contributions to physical and infrastructure development, interdisciplinary programme formulation and participation in research activities, mobilization of external funding for projects etc.

(b) A Work Plan (not more than three pages) on how the candidate proposes to organize the activities of the post for which he/she is an applicant. The information provided may include new research projects/thrust areas of work that he or she proposes to introduce, physical and infrastructure facilities proposed to be developed, linkages with other research units and development departments proposed, as well as the expected outcomes from these changes. The plan should be practical and realistic in nature and should be achievable within in 5 years and feasible within the available resources of the institute. In preparing these plans, the past and present achievements, as well as technology development may be critically reviewed and the critical gaps identified. The annual report, department as well as project reports, may be consulted for developing this plan.

To bring total objectivity and transparency in the selection process, a score card system has been developed by appointing a committee of experts and sent for approval of the competent authority.

ASSESSMENT, REVIEW OF ASSESSMENT AND INDUCTION INTO THE ARS

Three proposals for assessment under ARS Rules were considered during the year relating to Scientists Grade S-1 and S-2. Two cases of induction relating to Research Management Positions were considered during the year and recommendations were sent to the ICAR. No proposal for review of assessment result was received during the year.

Scientists Placement Scheme

One case was referred to the Board during the period and the Board has recommended the same.

Assessment cases under carrier advancement scheme of ICAR during 2001–2002

Assessment cases received in the ASRB	1,768
Senior Scientists found eligible to be assessed for Principal Scientists	1,688
Number of absentees	63
Scientists recommended for promotion to Principal Scientists	1,518 (93.4%)
Scientists not recommended for promotion	107 (6.6%)

8. Publications and Information

Shri Ajit Singh, Union Agriculture Minister, releasing four CDs developed by DIPA on electronic publishing. Shri Hukumdeo Narayan Yadav, MoS, Dr Panjab Singh, DG, ICAR and Ms Shashi Misra, Secretary ICAR are also seen standing by his side while Shri Chakravarty, Director, DIPA explaining a point to the minister

ICAR publications brought out by the Directorate of Information and Publications of Agriculture both in English and Hindi

The Indian Council of Agricultural Research, through a network of institutes and State Agricultural Universities, spread all over the country, conducts and coordinates research, education and training activities on agriculture, animal husbandry and fisheries. Dissemination of the results of research, conducted at these institutes, to the end-users is the prime task of the Council.

Keeping this in view, the ICAR, through the Directorate of Publications and Information brings out a number of periodicals i.e., magazines, newsletters, bulletins, brochures, and reports, matching with international standards, both in English and Hindi for the benefit of progressive farmers, scientists, extension workers, students and the general public.

Now, the DIPA has made inroads into e-publishing in a big way and has recently released four CDs.

PUBLICATIONS

English Editorial Unit

During 2002-2003, the Indian Council of Agricultural Research brought out 50 publications in English including *Handbook of Animal Husbandry*, *Textbook of Plant Nematology, Fish Processing, Field Crop Production and Vegetables, Tubercrops and Spices*. Besides DARE/ICAR Annual Report 2001-2002, a number of miscellaneous and ad hoc publications like *Drought Management Strategies, Inventory of Indigenous Technical Knowledge in Agriculture I, ICAR Handbook of Disciplinary Matters* etc. were also brought out clearing the backlog.

In addition to books, the DIPA also brings out four periodicals regularly. *The Indian Journal of Animal Sciences, The Indian Journal of Agricultural Sciences, Indian Farming and Indian Horticulture* and three quarterly newsletters, viz. *ICAR News, ICAR Reporter* and *ARIS News.*

The two monthly scientific journals—*The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, which are indexed and abstracted internationally continued to maintain the standard both in quality and content. *Indian Farming*, a popular monthly magazine, brought out two special issues, one on the occasion of World Food Day (16 October) and another for International Agronomy Congress (26-30 November 2002), *Indian Horticulture*, a semi-technical quarterly, brought out a special issue on Floriculture (Jan-Mar 2002). *ICAR News*, a quarterly newsletter disseminates research information pertaining to innovations made and new technologies developed both at the institutes and the headquarters. It also covers profiles of the institutes to get a first hand information about their activities. It has a wide readership and is circulated both in India and abroad. *ICAR Reporter*, a in-house quarterly newsletter covers all important activities of the Council such as meetings, seminars, conferences and workshops and publishes reports. It also covers reforms, personnel, international linkages etc at the ICAR headquarters and the institutes. The Council brought out *ARIC News*, a quarterly magazine on information and communication technology regularly.

Hindi Editorial Unit

During the year under report, Hindi Editorial Unit brought out 11 publications including books, bulletins and reports, besides its regular periodicals, viz. *Kheti*

(monthly), *Phal-Phool* (quarterly), *Krishi Chayanika* (quarterly) and *ICAR Reporter* (quarterly).

Kheti and *Phal-Phool* are popular magazines, which mainly cater to the needs of farmers and students. *Kheti* publishes articles relating to agriculture and allied vocations such as fisheries, animal husbandry, and beekeeping etc., while *Phal-Phool* publishes articles pertaining to fruits, vegetables, spices and medicinal plants. *Kheti* brought out five special/accent issues on Environment (June), ICAR Foundation Day (July), World Food Day (October) and International Agronomy Congress (November) and Fisheries (February). New columns were started in *Kheti* for the benefit of farmers. *Phal-Phool* published its 100th issue (Jan-March) as a special number on 'Fruit King', mango.

Krishi Chayanika, an informative agriculture digest reports latest achievements/researches carried out in the field of agriculture and allied sciences. It presented the synopsis of latest research findings carried out in India and abroad in its columns.

In addition to DARE/ICAR Annual Report (2002-2003), the Hindi Editorial Unit brought out some important books, such as *Bharat Mein Dugdh Utpadan*, *Phalon Ke Rog Sutra, Bher Evam Bakri Nasl Sudhar, Papita* and *Madhu Makhi Palan.* The book *Phalon ke Rog Sutra*, presents useful information in poetry form whereas *Madhu Makhi Palan*, a pocket book, provides information in user-friendly format. Some books which were in great demand were also reprinted.

Dr Panjab Singh, DG, ICAR and Secretary, DARE meeting Dr Steniw Y Bie of ISNAR, Netherlands. Ms Shashi Misra, Secretary, ICAR was also present in the meeting

Production Unit

The Production Unit, being responsible for technical management of all the administrative aspects of printing and publishing books and journals, including time-bound publications for the headquarters of the Council, continued to play an important role in the functioning of the DIPA. All the monthly journals (3 in English and 1 in Hindi) were printed well in time maintaining the desired print quality. Council's prestigious quarterly newsletters 'ICAR News', 'ICAR Reporter' and 'ARIS News' were printed well in time using the best paper, and the state-of-art print technology to achieve the desired print quality, keeping in view their national and international readership. Besides, 50 publications in English and 4 in Hindi were printed maintaining the high class print standards.

Special care is taken for the printing of annual publications of the Council required for AGM of ICAR Society such as DARE/ICAR Annual Report in English and Hindi, Agenda Notes, Speeches of Agriculture Minister and DG, ICAR, ICAR Budget Book, etc. The time-bound publications/certificates/citations/invitation cards meant for ICAR Awards Ceremony were also produced nicely within a short-time during the reported period.

The selected important publications brought out in English were 'Handbook of Animal Husbandry', 'Textbook of Plant Nematology', 'Fish Processing Technology', 'Field Crop Production' and 'Vegetables, Tubercrops and Species'. Some other miscellaneous publications brought out in English were Drought Management Strategies, Inventory of Indigenous Technical Knowledge in Agriculture-I, ICAR Handbook of Disciplinary Matters, International Training Programme. Some Hindi publications, 'Phalon ke Rog Sutra', 'Bhed avem Bakri Nasl Sudhar', 'Papita', 'Madhu Makhi Palan', Poster for Hindi Week, etc., were printed. Assistance was provided to NATP in production of various publications brought out by them during the year. Education Division was also assisted in the production of various curricula. For Hindi Section of the Council, various certificates and citations were designed and produced in Hindi. Production Unit is consistently providing support in the production of electronic publications for DIPA. Chief of the Production Unit was sent to CABI, UK for training on Advanced Production Techniques in Electronic Publishing which will further refine the production processes.

Art and Photo Unit

The get-up and design play an important role in enhancing the beauty and attractiveness of any publication and thereby increases its sale value. Keeping this

in view, the Art Unit has been striving hard to improve the quality of designs and illustrations of publications and publicity material including books, newsletters, reports etc. brought out by the DIPA by adopting newer techniques in conformity with the development in printing industry.

During the year under report, the art unit adopted Digital Designing process for all its publications. The art unit has been successful in digitizing with database all the photographs on web page of ICAR. The unit is also making on-line delivery of photographic materials to international organizations like FAO as per their requirement.

In addition to the regular job, the art unit was responsible for making designs aesthetically keeping in view the relevance of the subject for some important special numbers of magazines brought out on the occasion of national and international conferences, which received much appreciation from one and all.

The Photography Unit provides photographs, colour transparencies for various publications of the ICAR. It covered other activities of the ICAR including visits of dignitaries from other countries and press conferences of the Union Minister of Agriculture and the State Minister of Agriculture and the Director-General, ICAR. The photo library has provided visual support to the publications brought out by the DIPA and during the year 1,500 photographs were added to the library.

Business Unit

Business Unit looks after the advertisement, distribution and marketing of ICAR publications, both priced and unpriced. This unit generates revenue for ICAR by marketing the publications through its large network among farmers, agricultural scientists, research scholars and students. This unit also distributes the important publications like ICAR/DARE Annual Report, ICAR News, ICAR Reporter, ICAR Budget Book and Telephone Directory etc. to Parliament and other dignitaries regularly.

During the period under report, it earned a total revenue of Rs 40 lakh approximately from sales and advertisements. Out of this amount, Rs 32 lakh have been received from sale of publications, Rs 6.15 lakh from books published under Revolving Fund and Rs 1.75 lakh from advertisements. It is noteworthy that out of Rs 25 lakh received from ICAR Revolving Fund for publication of books, an amount of Rs 11 lakh has already been refunded to ICAR headquarters.

To augment the sales of ICAR publications, vigorous efforts were made by participating in Kisan Melas and organizing Book Exhibitions at a number of places throughout the country. During the year, the Business Unit participated in seven agricultural fairs/exhibitions including India International Trade Fair, New Delhi and Agri-Index, Coimbatore. It has also made tie-up with ICAR institutes and agricultural universities for sale of ICAR publications through Agricultural Technology Information Centre (ATIC).

Steps have also been taken to renovate and modernize the Business Section. The publications sale counter, which is functioning at the ground floor of KAB-I, has been renovated and the entire billing system has been computerized.

Agricultural Research Information Centre (ARIC)

Agricultural Research Information Centre (ARIC) is the central source of research information of the Council. It collected and processed information on AP Cess Fund Schemes, Research Projects of ICAR Institutes (RPFs), Indian agricultural periodicals, AICRPs, retired ICAR scientists, crop varieties released by ICAR and National Agricultural Research Database (NARD). ARIC, as the National input centre for AGRIS database of FAO, submitted AGRIS Inputs. SDI and document delivery services were provided to about 200 scientists, research scholars and students. ARIC brought out the biennial publication Directory of Conferences, Seminars, Symposia, Workshops in Agriculture and Allied Sciences and the ICAR Telephone Directory (2002 and 2003).

Major achievements during 2002-2003 are:

National Agricultural Research Database (NARD)

The Indian National Agricultural Research Database (NARD) was conceptualized and developed by ARIC as a part of the ICAR-CABI workplan under NATP programme. ARIC will be the coordinating centre of all activities relating to development of the database and all ICAR institutes and SAUs will act as data acquiring centres. The database covers the bibliographical details of all Indian research information published in India or outside in the fields of agriculture and allied sciences. Staff of different libraries will be required for acquisition and management of documents, preparing bibliographic input worksheets. One thousand six hundred input records were procured and added to the database. A database of 800 agricultural periodicals received by the ICAR institutes was developed for allotment to the sub-centres for indexing of information into the database. As an outcome of the database, two quarterly abstracting journals, viz. Indian Agricultural Sciences Abstracts and Indian Animal Sciences Abstracts were started.

As an HRD activity under the database, trainings were organized for the staff of data acquisition centres and persons from professional/scientific societies in indexing, document acquisition and management, input worksheet preparation, use of NARD indexing tools etc. NARD tools include Training Manual, AGROVOC Thesaurus, Subject Categorization Scheme. First tool was prepared at ARIC and the remaining two were reproduced locally with due permission from the FAO.

ICAR Research Projects Information—Research Project Files Database (RPF)

Database on ongoing Research Projects of ICAR institutes was developed which contains information on 2000 Research Projects covering 62 ICAR institutes and it was released in electronic format on CD. The database contains information on the title, objectives, location, P.I., co-workers, technical programme, major achievements, abstract and keywords on each project. The information is easily searchable through internet explorer. The CD was released by the Union Agriculture Minister in the Award Ceremony of the Council.

Handbook of Horticulture (e-book)

ARIC brought out the electronic book (e-book) based on the 'Handbook of Horticulture'. An easy navigation through all the sections and chapters of the e-book has been made possible by incorporating a user-friendly software. This is the first-e-book of its kind in ICAR system which paves the way for the electronic publishing of its publications by the ICAR. Low cost technology, with no compromise on quality, has been adopted for bringing out this e-book. The e-book was released by the Union Agriculture Minister in the Award Ceremony of the Council on 16 July 2002.

Database of Photographic Material of ICAR

ARIC was associated in creating a database on all the photographic material available with Photo Unit and its digitalization. A user-friendly software was developed for easy searching and selecting of the photographs. The database CD was released in the Award Ceremony of the Council. It will be useful to the scientists, editors and others involved in publishing work and it will be a permanent repository of photo library.

ICAR Vision 2020 Document

ARIC was associated with the conversion of ICAR Vision 2020 policy document into an electronic format that makes navigation through all the chapters an easy task for the user. This is the first CD on policy document developed in the ICAR system.

All-India Coordinated Research Projects Database (AICRP)

ARIC developed database on 82 AICRPs, covering information on title, code number, PC name centres, objectives, date of start, date of completion, budget, manpower, research achievements, AGROVOC keywords, technologies developed, QRT recommendations, publications, abstract of each project. A CD, with search facilities, will be released soon on this database which will be useful for monitoring the AICRPs at the Council's headquarters and act as a national information source.

International Cooperation

The information published in Indian journals on agricultural and allied sciences was documented, processed and supplied to FAO for inclusion in the global database i.e. AGRIS. One thousand six hundred published articles were documented and sent for this purpose.

Checking Duplication of Research Efforts

With a view to avoid wasteful duplication of research efforts, ARIC scrutinized about six hundred ad hoc research scheme proposals, received from different Divisions of ICAR and Project Coordinators. These proposals were compared with the research schemes already sanctioned for financial support from the Council's AP Cess Fund. The comparison was made on the basis of project title, its objectives and assigned keywords to each of the proposals.

Web Page of DIPA

Web page of DIPA was modified and upgraded with free text search facilities for books, journals, adhoc schemes and ICAR Telephone Directory. Information about 150 English and Hindi books was updated. Also the information about title, author and abstract of articles of all ICAR English journals published from 2000 onwards, was incorporated in the web page. All the issues of ICAR News and ICAR Reporter from 2000 onwards were also included.

DIPA Library Activities

DIPA Library was equipped with a collection of about 3,017 books, 1,100 annual reports of ICAR institutes and SAUs, 5,500 issues of different periodicals and newsletters. The Library procured about 1,100 books, 65 annual reports and 360 journals during the reporting period. It provided services to the scientists, students and DIPA staff.

ICAR Library

The ICAR Library added 1,800 publications to its collection during the year. About 14,000 readers visited the library and consulted 20,000 publications for reference and information searches. Against specific request, information support was extended for consulting the database of the centre for Agriculture and Bio-sciences International (formerly the Commonwealth Agricultural Bureaux International). The document-delivery service was extended to individuals and libraries against specific requests for supply of Indian documents from AGRIS database.

The Hindi Library at the headquarters purchased 261 books and subscribed to multiple copies of Hindi magazines. It issued 5,000 books to its 750 members.

Since July 1994, the ICAR Library has been arranging payment of newspaper bills to the ICAR officers who are eligible for getting newspapers at their residence.

Publicity and Public Relations Unit

The Publicity and Public Relations Unit plays a pivotal role in dissemination of information pertaining to agriculture and allied subjects, policy decisions and

achievements of the research set-up of the ICAR, i.e. Central Institutes, National Bureaux, Project Directorates, National Research Centres and All-India Co-ordinated Research Projects, etc. to the print and electronic media. For effective communication of research findings among the farmers and public, the PR Unit maintains an effective liaison with the media persons. It is responsible for publicizing the achievements of ICAR in the country and abroad. It also organizes press conferences/briefings addressed by the Union Agriculture Minister, Minister of State for Agriculture, DG, ICAR, DDG's and Directors of various research institutes and projects.

The PR Unit broadly performs the following functions:

Liaison with print and electronic media*:* The unit issued material of immediate value to various newspapers, agricultural and current affairs magazines and electronic media from time to time to give a wide publicity to the events. Such material received adequate coverage in the media at national and international level. This unit also runs a feedback service for senior officials of the ICAR. The unit keeps eyes on the print media and provides relevant newspaper clippings to the DG, ICAR and other senior officers of the Council on daily basis.

Publicity through print and electronic media: This includes issuing of press

ICAR PARTICIPATED IN THE FOLLOWING EXHIBITIONS

Exhibition	Venue	Period
Agri-Intex 2001	Coimbatore	1-7 August, 2002
National Science and Culture Expo-2002	Kolkata	04-11 September 2002
Agro Tech India Gramin Shilpa Mela 2002	Kolkata	29 September to 10 November 2002
International Global Meet on Climatic Change	Asoka Hotel, New Delhi	27 October to 1 November 2002
India International Trade Fair 2002	Pragati Maidan, New Delhi	14-27 November 2002
International Harihar Kshetra Mela	New Delhi	18 November to 12 December 2002
International Conference on Agronomy, Food and Environment	New Delhi	26-30 November 2002
Kisan Mela-cum-Awareness Campaign	CIRG, Makhdoom, Uttar Pradesh	4 January 2001
Kisan Fair	Pune, Maharashtra	11-14 December 2002
Rural Market Exhibition and Farmers Workshop	Saharanpur, Uttar Pradesh	15-16 February 2003
Rural Market Exhibition and Farmers Workshop	Baghpat, Uttar Pradesh	19-20 February 2003
Rural Market Exhibition and Farmers Workshop	Meerut, Uttar Pradesh	21-22 February 2003
Rural Market Exhibition and Farmers Workshop	Agra, Uttar Pradesh	5-6 March 2003
Krishi Expo 2002	Pragati Maidan, New Delhi	8-16 March 2003

*ICAR institutes also participated in various Kisan Mela-cum-Awareness Campaigns during the period.

Dr Panjab Singh, DG, ICAR addressing a Press Conference on the occasion of International Agronomy Congress in New Delhi

Shri Hukumdeo Narayan Yadav, Minister of State for Agriculture, inaugurating the International AgronomyCongress exhibition held from 26-30 November 2002 in New Delhi

releases and articles, organizing press conferences and conducting press tours to various ICAR projects and institutes to disseminate information relating to their activities and achievements. This unit also undertakes development of video films on the activities and achievements of ICAR as a whole and on important issues pertaining to agriculture of immediate concern to farmers. These films are distributed to various ICAR institutes, KVKs, Extension Directorates of SAUs for dissemination of information to farmers.

Visits of media persons: PR Unit arranged visits of media persons to various ICAR institutes to highlight the achievements and to make success stories. Various international and national level press conferences and visits of media persons were organized during the period.

Participation in exhibitions at regional, national and international level: Organizing exhibitions is another focal point of publicity activities of the PR Unit. The Unit organized exhibitions and displayed important items relating to agricultural development in an interesting manner to spread awareness of new ideas, varieties, technologies, etc. and also advised the institutes on exhibition-related issues. Nearly 20 ICAR institutes took part in the 14-day IITF 2002 exhibition at New Delhi (November 14-27, 2002). Also, ICAR organized impressive exhibitions of the ICAR institutes on the occasion of 2nd International Agronomy Congress during November 26-30, 2002 and Kisan Samman Saptah during December 21-23, 2002.

Reception and Monitoring of Public Grievances: The CP&PRO functions as Staff Grievances Officer under the direct supervision of Secretary, ICAR. Necessary instructions are issued from time to time to all the concerned officials for speedy disposal of the grievances. To cater to the in-house grievances of the employees, the ICAR has an Internal Grievances Committee.

NICNET-based Public Information and Facilitation Centre: In pursuance of Government's commitment to bring greater transparency through better access to information, a NICNET-based Public Information and Facilitation Centre has been established jointly by the three departments of the Ministry of Agriculture—DARE/ICAR, Department of Ministry of Agriculture and Cooperation and Department of Animal Husbandry and Dairying at Krishi Bhavan (Room No. 19 A). The centre provides information of state and central government agencies, economists, consultants, scientists, farmers and general public. CP&PRO is the nodal officer coordinating with the centre.

National Agricultural Science Museum: This is a new and prestigious activity of the PR Unit. A National Agricultural Science Museum is being established at the Chaudhary Devi Lal Agricultural Science Centre in IARI, Pusa Campus. The work of first phase is almost completed. The work is being carried out by the National Council of Science Museums, Kolkata in consultation with PR Unit. After completion of the second phase, this will be opened to farmers, general public, scientists and various delegations all over the country.

Appendices

(A) DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

APPENDIX I

The Government of India (Allocation of Business) Rules
The Second Schedule
(Rule 3)

(A) Distribution of Subjects in the Department (*Vibhag*), Ministry of Agriculture (*Krishi Mantralaya*)

(B) Department of Agricultural Research and Education (*Krishi Anusandhan aur Shiksha Vibhag*)

PART I

The following subjects which fall within List I of the Seventh Schedule to the Constitution of India.

1. International co-operation in the field of agricultural research and education including relations with foreign and international agricultural research and educational institutions and organizations, including participation in international conferences, associations and other bodies dealing with agricultural research and education and follow-up of decisions at such international conferences, etc.
2. Fundamental, applied and operational research and higher education including co-ordination of such research and higher education in agriculture including agroforestry, animal husbandry, dairying and fisheries, including agricultural statistics, economics and marketing.
3. Co-ordination and determination of standards in institutions for higher education or research and scientific and technical institutions insofar as it relates to food and agriculture including animal husbandry, dairying and fisheries.
4. Cesses for financing to the Indian Council of Agricultural Research, and the Commodity Research programmes other than those relating to tea, coffee and rubber.
5. Sugarcane research.

PART II

For Union Territories the subjects mentioned in Part I above so far as they exist in regard to these territories and in addition the following subject which falls within List II of the Seventh Schedule of the Constitution of India.

6. Agricultural education and research.

PART III

General and consequential:

7. All matters relating to foreign aid received from foreign countries and International Organizations in sofar as agricultural research and education and allied subjects are concerned, including all matters relating to assistance afforded by India to foreign countries in the field of agricultural research and education and allied subjects.
8. Plant introduction and exploration.
9. All-India Soil and Land-Use Survey relating to research, training, correlation, classification, soil mapping and interpretation.
10. Financial assistance to state governments and agricultural universities in respect of agricultural research and educational schemes and programmes.
11. National Demonstrations.
12. Indian Council of Agricultural Research and its constituent research institutes, stations, laboratories and centres.
13. Offences against laws with respect to any of the subjects allotted to this department.
14. Enquiries and statistics for the purpose of any of the subjects allotted to this department.
15. Fees in respect of any of the subjects allotted to this Department except fees taken in a court.

APPENDIX II

Total Number of Posts and Names of Important Functionaries

Group	Designation	Scale of pay (in rupees)	Santioned strength
A	Secretary	26,000 (Fixed)	1
A	Additional Secretary (DARE)/Secretary, ICAR	18,400 – 24,400	1
A	Financial Adviser and Additional Secretary	18,400 – 22,400	1
A	Director	14,300 – 18,300	1
A	Senior Principal Private Secretary	12,000 – 16,500	1
A	Under Secretary	10,000 – 15,200	8
A	Principal Private Secretary	10,000 – 15,200	1
B	Private Secretary	6,500 – 10,500	1
B	Assistant Director (Official Language)	6,500 – 10,500	1
B	Assistant	5,500 – 9,000	4
B	Personal Assistant	5,500 – 9,000	4
C	Junior Hindi Translator	5,000 – 8,000	1
C	UDC-cum-Cashier	4,000 – 6,000	1
C	UDC	4,000 – 6,000	2
C	Steno Grade 'D'	4,000 – 6,000	5
C	UDC-Hindi Typist	4,000 – 6,000	1
C	Staff Car Driver	4,000 – 6,000	1
C	LDC	3,050 – 4,590	3
D	Daftry	2,550 – 3,540	1
D	Peon	2,440 – 3,200	5
	Total		44

Names of the Important Functionaries

S.No.	Name	Designation
1.	Dr Mangala Rai	Secretary, DARE/DG, ICAR
1.a	Dr Panjab Singh	Secretary, DARE/DG, ICAR up to 31.12.02
2.	Ms Shashi Misra	Additional Secretary, DARE/Secretary, ICAR
3.	Mr Gautam Basu	Additional Secretary/Financial Adviser, DARE
4.	Dr K N Kumar	Director, DARE
5.	Mr R S Bhandari	Senior Principal Private Secretary
6.	Mr G Chandra Sekhar	Under-Secretary
7.	Mr Vijay Kumar	Under-Secretary
8.	Ms Vandana Sharma	Under-Secretary
9.	Mr B J Bhattacharya	Under-Secretary
10.	Mr M C Chand	Under-Secretary
11.	Mr S C Mishra	Under-Secretary
12.	Mr Madan Lal	Under-Secretary
13.	Mr D K Chhatwal	Under-Secretary
14.	Ms Geeta Nair	PPS

APPENDIX III

Activity Programme Classification

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2001–2002 are Rs 1,404.55 crores and Rs 1,325 crores respectively and BE for 2002–2003 (Plan and Non-Plan) is Rs 1,498.05 crores. The detailed break-up of these financial figures are given below in Tables 1 and 2.

Department of Agricultural Research and Education (DARE): The details in respect of BE and RE for 2001–2002 and BE for 2002–2003 are given in Table 1. This excludes the payment to the ICAR.

Table 1 Budget estimates and revised estimates of DARE and ICAR

(Rupees in lakhs)

Item	Budget Estimates 2001–2002		Revised Estimates 2001–2002		Budget Estimates 2002–2003	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451'						
090 Secretariat						
Major Head '2415'	–	100	–	100	–	105
80 -General International Co-operation						
(010032) -India's membership contribution to Commonwealth Agricultural Bureau	–	10	–	10	–	10
(020002) -India's membership contribution to Consultative Group on International Agricultural Research	–	338	–	338	–	343
(030032) -Other Programmes	60	–	60	–	50	–
(040032) -India's contribution to Asia Pacific Association of Agricultural Institutions	–	10	–	5	–	5
(050032) -India's contribution to NACA	–	9.5	–	9.5	–	10
(060032) -India's contribution to CGPRT	–	5	–	5	–	5
(070032) -India's contribution to Seed Seed Testing Association	–	1.0	–	1.5	–	1.5
(080032) -ISHS Belgium	–	1.5	–	1.0	–	0.50
(01031) -Imphal	–	–	–	–	23.0	–

Table 2 Details of Financial Outlay

Demand No. 2. Department of Agricultural Research and Education

(Rupees in crores)

	Major Head	2001–2002 Budget			2001–2002 Revised			2002–2003 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
A.Budget Allocation, net of recoveries										
Revenue		684.00	705.05	1,389.05	684.00	712.09	1,396.09	775.00	723.80	1,498.80
Capital		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		684.00	705.05	1,389.05	684.00	712.09	1,396.09	775.00	723.80	1,498.80
1. Secretariat - Economic Service Agricultural Research and Education Payments to ICAR	3451	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.05	1.05
2. Crop Husbandry										
2.1 Payments of net proceeds of cess under Agricultural Produce Cess Act, 1940	2415	0.00	40.00	40.00	0.00	40.00	40.00	0.00	40.00	40.00
2.2 Other Programmes of Crop Husbandry	2415	513.00	542.99	1,055.99	526.17	549.66	1,075.83	0.00	0.00	0.00
2.2.01 Crop Sciences	2415	0.00	0.00	0.00	0.00	0.00	0.00	125.50	163.50	289.00
2.2.02 Horticulture	2415	0.00	0.00	0.00	0.00	0.00	0.00	58.30	64.10	122.40
2.2.03 Agricultural extension	2415	0.00	0.00	0.00	0.00	0.00	0.00	94.30	0.00	94.30
2.2.04 Agricultural Education	2415	0.00	0.00	0.00	0.00	0.00	0.00	72.00	4.00	76.00
2.2.05 Economics, Statistics and Mgmt.	2415	0.00	0.00	0.00	0.00	0.00	0.00	3.00	12.15	15.15
2.2.06 Agricultural Engg.	2415	0.00	0.00	0.00	0.00	0.00	0.00	21.20	21.00	42.20
2.2.07 ICAR Hq Admn. including ASRB and DIPA	2415	0.00	0.00	0.00	0.00	0.00	0.00	19.50	185.25	204.75
2.2.08 National Agril. Technology Project	2415	0.00	0.00	0.00	0.00	0.00	0.00	151.50	0.00	151.50
2.2.11 Indo-French Proj. on Seabass Breedings and culture	2415	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50
Total Other Programme of Crop Husbandry		513.00	542.99	1,055.99	526.17	549.66	1,075.83	545.80	450.00	995.80
Total Crop Husbandry		513.00	582.99	1,095.99	526.17	589.66	1,115.83	545.80	490.00	1,035.80
3. Soil and water conservation										
3.1 Soil and Water Conservation Institutes	2415	3.58	6.70	10.28	3.00	6.80	9.80	3.25	10.50	13.75
3.2 Other NRM Instts. including Agroforestry Research	2415	0.00	0.00	0.00	0.00	0.00	0.00	57.25	57.50	114.75
Total- Soil &Water Conservation		3.58	6.70	10.28	3.00	6.80	9.80	60.50	68.00	128.50
4. Animal Husbandry	2415	49.60	45.44	95.04	48.10	45.53	93.63	65.50	108.50	174.00
5. Dairy Development	2415	7.00	22.24	29.24	5.75	22.24	27.99	0.00	0.00	0.00
6. Fisheries	2415	30.00	30.36	60.36	27.00	30.59	57.59	25.20	52.50	77.70
7. Forestry	2415	11.82	12.57	24.39	4.98	12.57	17.55	0.00	0.00	0.00
8. Lump-sum provision for Projects/ Schemes for the benefit of North-Eastern Region and Sikkim	2552	68.40	0.00	68.40	68.40	0.00	68.40	54.50	0.00	54.50
Total		68.40	0.00	68.40	68.40	0.00	68.40	54.50	0.00	54.50
Total-Payments to ICAR		683.40	700.30	1,383.70	683.40	707.39	1,390.79	751.50	719.00	1,470.50
9. Contribution to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institutes	2415	0.60	3.75	4.35	0.60	3.70	4.30	0.50	3.75	4.25
10. Assistance to Central Agricultural University, Imphal	2415	0.00	0.00	0.00	0.00	0.00	0.00	23.00	0.00	23.00
Total-Agricultural Research and Education		684.00	704.05	1,388.05	684.00	711.09	1,395.09	775.00	722.75	1,497.75
Grand Total		684.00	705.05	1,389.05	684.00	712.09	1,396.09	775.00	723.80	1,498.80

	Major Head	2001–2002 Budget			2001–2002 Revised			2002–2003 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
	Head of Div.	Budget support	IEBR	Total	Budget support	IEBR	Total	Budget support	IEBR	Total
B. Plan Outlay										
1. Agricultural Research Education	12415	684.00	0.00	684.00	684.00	0.00	684.00	775.00	0.00	775.00
C. Major Head-wise Total										
Total	Total	684.00	705.05	1,389.05	684.00	712.09	1,396.09	775.00	723.80	1,498.80
	2415	615.60	704.05	1,319.65	615.60	711.09	1,326.69	720.50	722.75	1,443.25
	3451	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.05	1.05
	2552	68.40	0.00	68.40	68.40	0.00	68.40	54.50	0.00	54.50

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

The Society shall have the following *Ex-Officio* Members:

(i) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet, President of the Society*

1. Mr Ajit Singh
   Minister of Agriculture
   Government of India, Krishi Bhavan
   New Delhi 110 001

(ii) *Minister of State in the Union Ministry of Agriculture, dealing with the ICAR, Vice-President*

2. Minister of State for AHD&DARE
   Government of India, Krishi Bhavan
   New Delhi 110 001

(iii) *Union Ministers holding charge of Finance, Planning, Science and Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/ Department concerned)*

3. Mr Jaswant Singh
   Minister of Finance, Government of India
   New Delhi 110 001
4. Ms Vasundhra Raje
   Minister of State for Planning
   Yojana Bhawan, Government of India
   New Delhi 110 001

5,6 Dr Murli Manohar Joshi
   Minister of Science & Technology, and
   Human Resource Development
   Government of India, Shastri Bhawan
   New Delhi 110 001

7. Mr Murasoli Maran
   Minister of Commerce,Government of India
   Udyog Bhawan, New Delhi 110 001

(iv) *Other Ministers in the Union Ministry of Agriculture*

8. Mr Hukumdeo Narayan Yadav
   Minister of State for Agriculture
   Government of India, Krishi Bhavan,
   New Delhi 110 001

(v) *Ministers in the States/Incharge of Agriculture/Animal Husbandry/Fisheries*

Andhra Pradesh

9. Mr V S Rao
   Minister for Agriculture
   Government of Andhra Pradesh
   Hyderabad (Andhra Pradesh) 500 022
10. Mr N Krishnappa
    Minister of Animal Husbandry
    Government of Andhra Pradesh
    Hyderabad
    (Andhra Pradesh) 500 022
11. Mr N Narsimha Rao
    Minister of Fisheries
    Government of Andhra Pradesh
    Hyderabad 500 022
12. Mr P Narayana Swamy
    Minister for Horticulture
    Government of Andhra Pradesh
    Hyderabad 500 022

Arunachal Pradesh

13. Mr Tako Dabi
    Minister for Agriculture
    Government of Arunachal Pradesh
    Itanagar (Arunachal Pradesh) 791 111
14. Mr Kahfa Bangia
    Minister for Animal Husbandry and Dairy Development
    Government of Arunachal Pradesh
    Itanagar (Arunachal Pradesh) 791 111
15. Mr Mukut Mithi
    Chief Minister holding the charge of Fisheries
    Government of Arunachal Pradesh
    Itanagar 791 111
16. Mr Japu Deru
    Minister for Horticulture
    Government of Arunachal Pradesh
    Itanagar 791 111

Assam

17. Dr A K Dey
    Minister for Agriculture, Government of Assam
    Janta Bhavan, Guwahati (Assam) 781 006
18. Mr G C Langthasha
    Minister for Veterinary and Animal Husbandry
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006
19. Mr. Bharat Chandra Narah
    Minister for Fisheries, WPT&C and Parliamentary Affairs
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006

Bihar

20. Mr Gulam Sarwar
    Minister for Agriculture
    Government of Bihar,
    Patna (Bihar) 800 015
21. Mr Rama Ashray Sahni
    Minister for Animal Husbandry and Fisheries
    Government of Bihar,
    Patna (Bihar) 800 015

Chhatisgarh

22. Dr Prem Sahi Singh
    Minister for Agriculture, Animal Husbandry & Fisheries
    Government of Chhatisgarh
    Raipur (Chhatisgarh)
23. Mr Manoj Singh Mandavi
    Minister for Horticulture
    Government of Chhatisgarh
    Raipur (Chhatisgarh)

Delhi

24. Minister for Agriculture
    Development and Food
    National Capital Territory of Delhi, Delhi

Goa

25. Mr Dayanand Raya Mandrekar
    Minister for Agriculture
    Government of Goa, Panaji (Goa) 403 001
26. Mr Manohar Parrikar
    Chief Minister holding charge of Animal Husbandry, Fisheries and Horticulture
    Government of Goa, Panaji (Goa) 403 001

Gujarat

27. Mr Parshotambhai Rupala
    Minister for Agriculture and Horticulture
    Government of Gujarat
    Gandhinagar, (Gujarat) 382 010
28. Mr Devanandbhai Solanki
    Minister of State for Animal Husbandry
    Government of Gujarat,
    Gandhinagar, (Gujarat) 382 010
29. Mr Purushottambhai Solanki
    Minister for Fisheries,
    Government of Gujarat
    Gandhinagar (Gujarat) 382 010

Haryana

30. Mr Jaswinder Singh Sandhu
    Minister for Agriculture & Horticulture
    Government of Haryana, Chandigarh
    (Haryana) 160 001
31. Mr Mohammed Ilyas
    Minister for Animal Husbandry and Fisheries
    Government of Haryana, Chandigarh
    (Haryana) 160 001

Himachal Pradesh

32. Mr Vidya Sagar Chaudhary
    Minister for Agriculture
    Government of Himachal Pradesh
    Shimla (Himachal Pradesh) 171 002
33. Mr Ram Lal Markande
    Minister of State for Animal Husbandry
    Government of Himachal Pradesh
    Shimla 171 002
34. Mr Narindra Bargata
    Minister for Horticulture
    Government of Himachal Pradesh
    Shimla 171 002
35. Mr Kishori Lal Vaidya
    Minister for Fisheries
    Government of Himachal Pradesh
    Shimla 171 001

Jammu and Kashmir

36. Minister for Agriculture, Animal Husbandry and Horticulture
    Government of Jammu and Kashmir
    Srinagar (Jammu and Kashmir) 190 001
37. Minister of Fisheries
    Government of Jammu & Kashmir
    Srinagar (Jammu & Kashmir) 190 005

Jharkhand

38. Mr Deo Dayal
    Minister for Agriculture
    Government of Jharkhand
    Ranchi (Jharkhand)
39. Mr Devidhan Besra
    Minister for Animal Husbandry and Fisheries
    Government of Jharkhand
    Ranchi (Jharkhand)

Karnataka

40. Mr V S Koujalgi
    Minister for Agriculture,
    Government of Karnataka
    Bangalore
    (Karnataka) 560 001
41. Mr M Mahadeva
    Minister for Animal Husbandry
    Government of Karnataka, Bangalore
    (Karnataka) 560 001
42. Mr M Shivanna
    Minister for Horticulture
    Government of Karnataka
    Bangalore
    (Karnataka) 560 001
43. Mr Vasant V Saliana
    Minister of Fisheries
    Government of Karnataka
    Bangalore 560 001

Kerala

44. Ms K R Gouri Amma
    Minister for Agriculture & Coir including Animal Husbandry and Horticulture
    Government of Kerala
    Thriuvananthapuram (Kerala) 695 001
45. Prof K V Thomas
    Minister of Fisheries
    Government of Kerala
    Thiruvananthapuram (Kerala) 695 001

Madhya Pradesh

46. Mr Mahendra Singh
    Minister for Agriculture
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 423 006
47. Hira Lal Silawat
    Minister for Fisheries
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 423 006
48. Mr K P Singh
    Minister for Animal Husbandry
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 423 006

Maharashtra

49. Mr Rohit Das Patil
    Minister for Agriculture and Parliamentary Affairs
    Government of Maharashtra
    Mumbai (Maharashtra) 400 032
50. Mr Anand Rao Deoka
    Minister for Fisheries and Dairy Development
    Government of Maharashtra
    Mumbai 499 932
51. Mr Dasbrath Bhande
    Minister for Animal Husbandry and Mining
    Government of Maharashtra
    Mumbai (Maharashtra) 400 032
52. Mr Ajit Pawar
    Minister for Horticulture and Irrigation
    Government of Maharashtra
    Mumbai (Maharashtra) 400 032

Manipur

53. Mr Ibobi Singh
    Chief Minister holding charge of Agriculture
    Government of Manipur
    Imphal (Manipur) 795 001
54. Mr Y Mani Singh
    Minister for Animal Husbandry
    Government of Manipur
    Imphal (Manipur) 795 001
55. Mr W Keishing
    Minister for Fisheries
    Government of Manipur
    Imphal (Manipur) 795 001
56. Mr R K Thekho
    Minister for Horticulture
    Government of Manipur
    Imphal (Manipur) 795 001

Meghalaya

57. Mr J D Rymbai
    Minister for Agriculture
    Government of Meghalaya
    Meghalaya Secretariat
    Shillong (Meghalaya) 793 001
58. Dr R A Lyngdoh
    Minister for Animal Husbandry, Veterinary and Soil Conservation
    Government of Meghalaya, Meghalaya Secretariat (C)
    Shillong (Meghalaya) 793 001
59. Mr M R Marak
    Minister of Fisheries,Government of Meghalaya
    Meghalaya Secretariat, Shillong 793 001
60. Mr B K Sangma
    Minister for Horticulture
    Meghalaya Secretariat (e)
    Shillong (Meghalaya) 793 001

Mizoram

61. Mr Aichhinga
    Minister for Agriculture
    Government of Mizoram
    Aizwal (Mizoram) 796 021
62. Mr J Lalrinchhana
    Minister for Animal Husbandry
    Government of Mizoram
    Aizwal (Mizoram) 796 001
63. Mr H Vanlalauva
    Minister for Fisheries
    Government of Mizoram
    Aizwal (Mizoram) 796 001
64. Mr Zoram Thanga
    Minister for Horticulture
    Government of Mizoram
    Aizwal (Mizoram) 796 001

Nagaland

65. Mr A Nyamnyei Konyak
    Minister for Agriculture
    Government of Nagaland
    Kohima (Nagaland) 797 001
66. Mr T Sentichuba
    Minister for Animal Husbandry
    Government of Nagaland
    Kohima (Nagaland) 797 001
67. Mr Kakheto
    Minister for Fisheries, Government of Nagaland
    Kohima (Nagaland) 797 002
68. Mr K Yamakam
    Minister for Horticulture
    Government of Nagaland
    Kohima (Nagaland) 797 001

Orissa

69. Mr Amar Prasad Satpathy
    Minister of Agriculture, Government of Orissa
    Bhubaneshwar (Orissa) 751 001
70. Mr. B B Harichandan
    Minister for Animal Resources Development and Fisheries
    Government of Orissa
    Bhubaneshwar (Orissa) 751 001

Pondicherry

71. Mr A Namassivayam
    Minister for Agriculture, Horticulture, Animal Husbandry and Fisheries
    Government of Pondicherry
    Pondicherry 605 001

Punjab

72. Mr. Jagmohan Singh Kang
    Minister of Animal Husbandry, Fisheries and Dairy Development
    Government of Punjab
    Chandigarh (Punjab) 160 001
73. Ms Rajinder Kaur Bhattal
    Minister for Agriculture
    Government of Punjab
    Chandigarh (Punjab) 160 001

Rajasthan

74. Mr Gurjar Govind Singh
    Minister of State for Agriculture and Ground Water
    Government of Rajasthan
    Jaipur (Rajasthan) 302 005
75. Mr Hari Singh Kumar Kumher
    Minister for Livestock and Dairy Development
    Government of Rajasthan
    Jaipur (Rajasthan) 302 005
76. Mr Kishan Motwani
    Minister for Fisheries
    Government of Rajasthan
    Jaipur (Rajasthan) 302 005

Sikkim

77. Mr G M Gurung
    Minister for Agriculture, Horticulture, Irrigation and Flood Control
    Government of Sikkim
    Secretariat, Gangtok (Sikkim) 737 101
78. Mr P S Tamang
    Minister for Animal Husbandry
    Government of Sikkim
    Secretariat, Gangtok (Sikkim) 737 001

Tamil Nadu

79. Mr R Jeevanathan
    Minister for Agriculture
    Government of Tamil Nadu
    Chennai, (Tamil Nadu) 600 009
80. Mr M Radhakrishnan
    Minister for Fisheries
    Government of Tamil Nadu
    Chennai (Tamil Nadu) 600 009

Tripura

81. Mr Aghore Deb Barma
    Minister for Agriculture and Horticulture
    Civil Secretariat, Government of Tripura
    Agartala (Tripura) 799 001
82. Mr Narayan Rupini
    Minister for Animal Resources and Development
    Government of Tripura
    Agartala (Tripura) 799 001
83. Mr Sukumar Barman
    Minister for Fisheries and Transport
    Government of Tripura,
    Agartala (Tripura) 799 001

Uttaranchal

84. Mr Mahinder Singh Mahra
    Minister for Agriculture
    Government of Uttranchal
    Dehradun (Uttranchal)
85. Mr Govind Singh Kunjwal
    Minister for Horticulture
    Government of Uttranchal
    Dehradun (Uttranchal)
86. Mantri Prasad Naithani
    Minister for Co-operative, Fisheries, Milk, Animal Husbandry
    Government of Uttaranchal
    Dehradun (Uttaranchal)

Uttar Pradesh

87. Mr Hukam Singh
    Minister for Agriculture
    Government of Uttar Pradesh
    Lucknow (Uttar Pradesh) 226 001
88. Mr Lalji Tandon
    Minister for Animal Husbandry and Fisheries
    Government of Uttar Pradesh
    Lucknow (Uttar Pradesh) 226 001
89. Mr Dhanraj Yadav
    Minister for Horticulture
    Government of Uttar Pradesh
    Lucknow (Uttar Pradesh) 226 001

West Bengal

90. Mr Kamal Guha
    Minister for Agriculture,Government of West Bengal Writers' Building
    Calcutta (West Bengal) 700 001
91. Mr Anisur Rahman
    Minister for Animal Resources Development
    Government of West Bengal
    Calcutta, (West Bengal) 700 001

92. Mr Kironmoy Nanda
Minister for Fisheries & Aquatic Resources and Fishing Harbours
Government of West Bengal
Calcutta (West Bengal) 700 001

93. Mr Sailen Sarkar
Minister for Horticulture & Food Processing Industries
Government of West Bengal
Writers Building
Calcutta (West Bengal) 700 001

(vi) *Member of Planning Commission, Incharge of Agriculture*

94. Mr Som Pal
Member (Agriculture), Planning Commission
Yojana Bhavan,
New Delhi

(vii) *Six members of Parliament (Four elected by Lok Sabha and two elected by Rajya Sabha)*

95. Mr Oscar Fernandes 3.5.2003
Member of Parliament (RS)
Doris Rest Haven, Ambalpadi
Post Brahmagiri
Udupi, Karnataka and
C-1/12, Humayun Road
New Delhi 110 001

96. Mr S S Ahluwalia 3.5.2003
Member of Parliament (RS)
Boring Canal Road
Ward No. 4
P S Shri Krishna Puri
P.O.-G.P.O., Patna
Patna (Bihar), and
10, Gurudwara Rakab Ganj Road
New Delhi 110 001

97. Mr Jagannath Mallik 15.12.2002
Member of Parliament (Lok Sabha)
At Mohanti Patna
P.O. Jajpur,
Jajpur (Orissa) and
32, Mahadev Road,
New Delhi

98. Mr Shivaji Mane 15.12.2002
Member of Parliament (Lok Sabha)
At. Khemegaon, P.O. Shiwala
Tal. Kalmanuri
Distt. Hingoli (Maharashtra), and
68 North Avenue, New Delhi 110 001

99. Mr Uttamrao Patil 15.12.2002
Member of Parliament (Lok Sabha)
11 Mahabali Layout Wadgon
Yavatmal (Maharashtra), and
No.3, Mahadev Road
New Delhi

100. Vacant

(viii) *Director-General, ICAR*

101. Dr Panjab Singh
Director-General, ICAR
Krishi Bhavan, New Delhi 110 001

(ix) *All Secretaries in the Ministry of Agriculture*

102. Mr J N L Srivastava
Secretary (Agriculture and Co-operation)
Ministry of Agriculture, Department of Agriculture,
Krishi Bhavan,New Delhi 110 001

103. Ms Binoo Sen
Secretary (Animal Husbandry and Dairying)
Krishi Bhavan,
New Delhi 110 001

(x) *Secretary, Planning Commission*

104. Mr N K Sinha
Secretary, Planning Commission
Yojana Bhavan, New Delhi 110 001

(xi) *Chairman, University Grants Commission*

105. Dr A S Nigavekar
Chairman, University Grants Commission
Bahadur Shah Zafar Marg, New Delhi

(xii) *Chairman, Atomic Energy Commission or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission*

106. Mr R Chidambaram
Chairman
Atomic Energy Commission and
Secretary to the Government of India
Department of Atomic Energy
Anushakti Bhavan, Chhatrapati Shivaji
Maharaj Marg
Mumbai 400 039

(xiii) *Member, Finance (Secretary/Additional Secretary in the Ministry of Finance), Government of India*

107. Mr B P Misra
Additional Secretary to the Government of India
Ministry of Finance, Department of Expenditure
New Delhi 110 001

(xiv) *Four Vice-Chancellors of the Agricultural Universities nominated by the President*

108. Dr Tej Pratap
Vice-Chancellor
Himachal Pradesh Krishi Vishwavidyalaya
Palampur (Himachal Pradesh) 176 062

109. Dr M H Mehta 25.07.2003
Vice-Chancellor
Gujarat Agricultural University
Sardar Krushinagar, Distt. Banaskantha
Gujarat 385 506

110. Dr K V Peter
Vice-Chancellor
Kerala Agricultural University

111. Dr Debbrata Das Gupta
Vice-Chancellor
Bidhan Chandra Krishi Vishwavidyalaya
Nadia (West Bengal) 741 252

(xv) *Five technical representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner, Fisheries Development Commissioner from the Union Ministry of Agriculture and Inspector-General of Forests, Government of India*

112. Dr C R Hazra — Ex-officio
Agricultural Commissioner
Department of Agriculture and Co-operation
Krishi Bhavan,
New Delhi 110 001

113. Dr H P Singh
Horticultural Commissioner, Department of Agriculture,
Krishi Bhavan, New Delhi 110 001

114. Ms Nita Choudhary
Joint Secretary and Animal Husbandry Commissioner
Department of Agriculture, Krishi Bhawan,
New Delhi

115. Mr M K R Nair — Ex-officio
Fisheries Development Commissioner
Department of Agriculture, Krishi Bhavan
New Delhi 110 001

116. Mr C P Oberai — Ex-officio
Inspector-General of Forests, Government of India
Department of Environment and Forests
CGO Complex, Lodi Road, New Delhi 110 003

(xvi) *Fifteen scientists from within and outside the Council, including one from the Indian Council of Medical Research nominated by the President*

117. Dr S S Katiyar — 25.07.2003
Vice-Chancellor
General President Elect. ISCA
Chhatrapati Sahu Ji Maharaj University
Kanpur 208 024

118. Dr J S Kanwar — 25.07.2003
Dy. Director General (Emeritus)
ICRISAT, 17, Krishi Nagar Colony
Phase II, Hashmetpet Road
Seconderabad (A P) 500 009

119. Dr D N Borthakur — 25.07.2003
Former Vice-Chancellor
Assam Agricultural University
'SWAPANAALAYA' Apartments
Narikel Basti,
Guwahati (Assam) 781 024

120. Mr Sidhir Bhargava — 25.07.2003
Director
Agroman System Pvt. Ltd.
25/2, Tardeo Ac Market
Mumbai 400 034

121. Dr M S Gangwar — 25.07.2003
Professor & Head
Department of Soil Science, Faculty of Agriculture
GBPNU, Nainital (U P) 263 145

122. Mr Chander Bhushan Prasad — 25.07.2003
Former University Professor of Micro Biology
Bihar College of Veterinary
B-45, Indira Puri Colony, Patna (Bihar) 800 014

123. Prof M R Verma — 25.07.2003
Dean
Dept. of Agricultural Engineering
Narendra Deva University of Agriculture & Technology
Narendra Nagar
P.O. Kumarganj (U P) 224 229

124. Dr A S Khera — 25.07.2003
Former Vice Chancellor (PAU)
983, Phase 3 B-2,
Mohali (Punjab) 160 060

125. Padmashree Dr N Balakrishnan Nair — 25.07.2003
Ex-Chairman
Science & Technology, Kerala State
'Swathi' Residency Road
Thycad, Trivandrum 695 014

126. Dr N A Jan — 25.07.2003
Commissioner of Fisheries
J&K State Tourist Reception Centre
Deptt. of Tourism, Srinagar (J&K)

127. Dr S P Arora — 25.07.2003
Former Professor Eminence
Former Addl. Dir. Res. (HPKV)
Formerly Head, Nut & Phys (NDRI)
H.No. 48, Secvtor 13, Urban Estate
Karnal (Haryana) 132 001

128. Prof N Panda — 25.07.2003
Former Vice-Chancellor
Sambalpur University
Ex-Dean of Agriculture & Orissa University of Ag. & Tech.
62/63, 1st Floor, Opp. Unit 8, Boys High School
Bhubaneswar 751 003

129. Dr D K Dasgupta — 25.07.2003
Former Vice-Chancellor
BCKVV, 32, Serryghat Street, Telinipara
Hooghly (West Bengal) 712 215

130. Dr P C Kesavan — 25.07.2003
DAE, Homi Bhabha Chair and
Executive Director
M.S. Swaminathan Research Foundation
Third Cross Road, Taramani Institutional Area
Chennai 600 113

Representatives of the ICMR

131. Dr Sarla Subba Rao — 30.5.2000
Director, Malaria Research Institute
Indian Council of Medical Research
22, Sham Nath Marg,
Delhi 110 054

(xvii) *Three representatives of Commerce and Industry, nominated by the President*

132. Mr Suresh Neotia 3.10.2003
7/21, Queens Park,
Calcutta 700 019

133. Mr Nikhil Gandhi 3.10.2003
Group Chairman
SEAKING Infrastructure Ltd
PIPANAV House
209 Bank Street, Cross Lane, Fort
Mumbai 400 023 and
Sagar Villa
38, Bhulbhai Desai Road
Mumbai 400 023

134. Mr Jugeshwar Pandey 3.10.2003
Lalji Tola, Patna GPO
Patna (Bihar) 800 001

(xviii) *One farmer from each region of the country as mentioned in Rule 60 (a) and four representatives of rural interest, nominated by the President*

135. Shri Major Jai Pal Singh 25.07.2003
Village and Post Jaspur
Uddham Singh Nagar (Uttaranchal)

136. Mr Thenucho 25.7.2003
Former Speaker
Old Minister's Hill
Kohima (Nagaland) 797 001

137. Prof Janardan Prasad Singh 25.7.2003
Quarter No. 4, HIG Housing Colony
Block-8, Sector-7 (West)
Bahadurpur, Patna (Bihar)

138. Mr Suresh Pujari 25.7.2003
Sakhipura, P.O. Distt. Sambalpur
Orissa

139. Mr Gopal Pacharwal 25.7.2003
Ex-Member of Parliament
"Keshav Rao Patan"
Distt. Bundi (Rajasthan)

140. Dr S A Khanvilkar 25.7.2003
Sheetal Niwal, Post Dhutroli
Tehsil Mandangad 415 203
Distt. Ratnagiri (Maharashtra)

141. Dr George Paul 25.7.2003
Synthetic Industrial Chemical Ltd.
Ajay Vihar, M.G. Road
Cochin (Kerala) 682 016

142. Mr Rajendra D Pawar 23.12.2003
Chairman
Baramati Agricultural Trust
Baramati Distt., Pune (Maharashtra)

Representatives of Rural Interest

143. Mr D P Tripathi 25.07.2003
B-2/2041, Vasant Kunj
New Delhi 110 070

144. Mr Lawrence V Fernandes 25.07.2003
No. 30, Old No.3, Leonard Road,
Richmond Town
Bangalore (Karnataka) 566 025

145. Mr Bibhuti Bhushan Pradhan 25.07.2003
Village & P.O. Pangatira
Via-Parganj
Distt. Dhenkaral (Orissa)

146. Mr Sant Kumar Chaudhary 25.07.2003
Ved Kutir
141, Sukhdev Vihar, Mathura Road
New Delhi 110 025

(xix) *Four Directors of the ICAR Research Institutes, nominated by the President*

147. Dr S Nagarajan
Director
Indian Agricultural Research Institute
New Delhi 110 012

148. Dr M P Yadav 25.07.2003
Director
Indian Veterinary Research Institute
Izatnagar 243 122 (Uttar Pradesh)

149. Dr B N Mathur 25.07.2003
Director
National Dairy Research Institute
Karnal 132 001 (Haryana)

150. Dr C D Mayee 25.07.2003
Director
Central Institute for Cotton Research
Nagpur (Maharashtra) 440 010

(xx) *Secretary, Indian Council of agricultural Research*

151. Ms Shashi Misra
Member-Secretary
Indian Council of Agricultural Research
Krishi Bhawan,
New Delhi 110 001

APPENDIX 2

GOVERNING BODY

Chairman

1. Dr Panjab Singh
   Director-General
   Indian Council of Agricultural Research,
   Krishi Bhavan, New Delhi 110 001

Ex-officio Members

Member-Finance

2. Mr B P Misra
   Additional Secretary to the Government of India
   Ministry of Finance, Department of Expenditure
   New Delhi 110 001

Secretary, Planning Commission

3. Mr N K Sinha
   Secretary
   Planning Commission
   Yojna Bhavan, New Delhi 110 001

Secretary, Agriculture

4. Mr J N L Srivastava
   Secretary (Agriculture and Co. op),Government of India Ministry of Agriculture, Department of Agriculture, Krishi Bhavan, New Delhi 110 001

Chairman, University Grants Commission

5. Dr A S Nigavekar
   Chairman
   University Grants Commission
   Bahadur Shah Zafar Marg, New Delhi

Chairman, Atomic Energy Commssion or Director, BARC, if nominated by Chairman (AEC)

6. Mr R Chidambaram
   Chairman, Atomic Energy Commission and Secretary, Government of India, Department of Atomic Energy
   Anusakti Bhawan Chatrapatishivaji Marg, Trombay,
   Mumbai 400 039

Members

Four scientists (including one Management Expert) who are not employees of the ICAR and are nominated by the President

Management Expert — *Up to*

7. Mr Sudhir Bhargava — 25.07.2003
   Director
   Agroman Pvt. Ltd.
   25/2, Tardeo Market, Mumbai 400 034

Scientists

8. Dr S S Katiyar — 25.07.2003
   Vice-Chancellor and
   General President Elect. ISCA
   Chhatrapati Sahu Ji Maharaj University
   Kanpur 208 024

9. Dr J S Kanwar — 25.07.2003
   Deputy Director-General (Emeritus)
   ICRISAT
   17, Krishi Nagar Colony
   Phase II, Hashmetpet Road
   Secunderabad (AP) 500 009

10. Dr D N Borthakur — 25.07.2003
    Former Vice-Chancellor
    Assam Agricultural University, Jorhat
    'SWAPANALAYA' Apartments
    Narikol Basti
    Guwahati (Assam) 781 024

Three Vice-Chancellors

11. Dr Tej Pratap — 30.04.2005
    Vice-Chancellor
    Himachal Pradesh Krishi Vishwa Vidyalaya
    Palampur
    Himachal Pradesh 176 062

12. Prof Debabrata Das Gupta — 25.07.2003
    Vice-Chancellor
    Bidhan Chandra Krishi Vishwa Vidyalaya
    P.O. Krishi Vishwa Vidyalaya
    Distt. Nadia
    West Bengal 741 252

13. Prof K V Peter — 25.07.2003
    Vice-Chancellor
    Kerala Agricultural University
    Vellanikkkara P.O.
    Thrissur 680 656
    Kerala

Three Members of Parliament (Two from Lok Sabha and one from Rajya Sabha) nominated by the President

14. Mr Jagannath Mallik — 07.07.2002
    Member of Parliament (Lok Sabha)
    At. Mohanti Patna
    P.O. Jajpur, Jajpur (Orissa) and
    32, Mahadev Road New Delhi

15. Mr Shivaji Mane — 15.12.2002
    Member of Parliament (Lok Sabha)
    AT. Khemegoan
    P.O. Shiwala, Tal. Kalmanuri
    Distt. Hingoli (Maharashtra) and
    68 North Avenue,
    New Delhi

16. Mr S S Ahluwalia — 03.05.2003
    Member of Parliament (Rajya Sabha)
    Boring Canal Road
    Ward No. 4, P.S. Shri Krishna Puri, P.O.,
    GPO Patna and
    10, Gurudwara Rakab Ganj Road
    New Delhi 110 001

Three Farmers

17. Mr D P Tripathi 25.07.2003
    B-2/2041, Vasant Kunj, New Delhi 110 070
18. Mr Lawrence V. Fernandes 25.07.2003
    No. 3 (Old No. 3), Leonard Road,
    Richmond Town,
    Bangalore 566 025 (Karnataka)
19. Prof. Janardan Prasad Singh 25.07.2003
    Qr. No. 4, HIG, Housing Colony
    Block 8, Sector 7 (West), Bahadurpur, Patna (Bihar)

Three Directors

20. Dr S Nagarajan
    Director
    Indian Agricultural Research Institute
    Pusa, New Delhi 110 012
21. Dr M.P. Yadav 25.07.2003
    Director
    Indian Veterinary Research Institute
    Izatnagar 243 122
    (Uttar Pradesh)
22. Dr B N Mathur 25.07.2003
    Director
    National Dairy Research Institute
    Karnal 132 001
    (Haryana)

Member-Secretary

23. Ms Shashi Misra
    Secretary,Indian Council of Agricultural Research
    Krishi Bhawan
    New Delhi 110 001

APPENDIX 3

STANDING FINANCE COMMITTEE

Chairman, **Director-General**	1. Dr Panjab Singh Director-General Indian Council of Agricultural Research, Krishi Bhavan New Delhi	
Ex-officio Members **Member-Finance**	2. Mr B P Misra Additional Secretary to the Govt. of India Ministry of Finance Department of Expenditure New Delhi	Ex-officio
Secretary, **Agriculture**	3. Mr J N L Srivastava Secretary (Agriculture & Coop.) Govt. of India Ministry of Agriculture Department of Agriculture Krishi Bhawan, New Delhi	Ex-officio
	SCIENTISTS	
Seven members of the Governing Body of the ICAR Society (viz. one Management Expert, two Scientists, one Vice-Chancellor, one Director, one Farmer & one Member of Parliament elected by the Governing Body in its 188th Meeting (18th Dec, 2001) on the Standing Finance Committee for a fresh period of one year from 18.12.2001 to 17.12.2002.	4. Dr D N Borthakur Former Vice-Chancellor Assam Agricultural University Jorhat SWAPANALAYA Apartments Narikol Basti Guwahati 781 024 Assam	17.12.2002
	5. Dr S S Katiyar Vice-Chancellor & General President-Eelect. ISCA, Chhatrapati Sahu Ji Maharaj University Kanpur 208 024	17.12.2002
	DIRECTOR	
	6. Dr M P Yadav Director Indian Veterinary Research Institute Izatnagar 243 122	17.12.2002
	FARMER	
	7. Shri D P Tripathi B-2/2041, Vasant Kunj New Delhi 110 070	17.12.2002
	MEMBER OF PARLIAMENT	
	8. Mr Shivaji Mane Member of Parliament (LS) At. Khemegaon P.O. Shiwala, Tal. Kalmanuri Distt. Hingoli (Maharashtra) and 68, North Avenue, New Delhi	17.12.2002
	MANAGEMENT EXPERT	
	9. Mr Sudhir Bhargava Director Agroman System Pvt. Ltd 25/2, Tardeo Ac Market, Mumbai 400 034	17.12.2002
	VICE-CHANCELLOR	
	10. Vacant	

APPENDIX 4

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. Dr Mangala Rai
   Director-General, ICAR and
   Secretary to the Government of India
   Department of Agricultural Research and Education

1a. Dr Panjab Singh up to 31.12.2002
   Director-General, ICAR, and
   Secretary to the Government of India
   Department of Agricultural Research and Education

2. Ms Shashi Misra
   Secretary, ICAR and
   Additional Secretary to Government of India
   Department of Agricultural Research and Education

Deputy Directors-General

1. Dr Puranjan Das (Agricultural Extension)
2. Dr J C Katyal (Education)
3. Dr V K Taneja (Animal Sciences)
4. Dr J S Samra (Natural Resource Management)
5. Dr G Kalloo (Horticulture and Crop Sciences)
6. Dr Mangala Rai (Crop Sciences) up to 8.1.2003
7. Dr S Ayyappan (Fisheries)
8. Dr A Alam (Agricultural Engineering)

Assistant Directors-General

Crop Sciencces

1. Dr O P Dubey (Plant Protection)
2. Dr N B Singh (Oilseeds and Pulses)
3. Dr K C Jain (Commercial Crops)
4. Dr S P Tewari (Seeds)
5. Dr S N Shukla (Food and Fodder Crops)

Horticulture

1. Dr B S Dhankar (Vegetable Crops)

Natural Resource Management

1. Dr Gurubachan Singh (Agronomy)
2. Dr P D Sharma (Soils)
3. Dr B R Sharma (Integrated Water Management)
4. Dr K R Solanki (Agroforestry)

Engineering

1. Dr N S L Srivastava (Engineering)

Animal Sciences

1. Dr Sushil Kumar (DAP&T)
2. Dr Lal Krishna (Animal Health)
3. Dr Arun Varma (Animal Nutrition)

Fisheries

1. Dr A D Divan (Marine Fisheries)
2. V S Chitranchi (Fisheries) (*Officiating*)

Education

1. Dr N L Maurya (Accreditation)
2. Dr Tej Verma (Home Science)
3. K S Nainawatee (AHRD II)
4. B S Bisth (HRDI)

Extension

1. Dr A N Shukla (Krishi Vigyan Kendras)
2. Dr B S Hansra (Extension)

Others

1. Dr R C Maheshwari (Technical Co-ordination)
2. Dr J P Mishra (Planning and ESM)
3. Dr K S Khokhar (PIM)

Principal Scientists

Crop Science

1. Dr A K Sharma (Food Crops)
2. Dr C P Singh (Seeds)
3. Dr S Mourya (Commercial Crops)
4. Dr (Ms) P Kaur (Plant Protection)
5. Dr S Kochar (Intellectual Property Rights)

Horticulture

1. Dr K C Garg

Natural Resource Management

1. Dr D K Paul (Engineering)
2. Dr O P Sharma (Agronomy)

Animal Sciences

1. Dr (Ms) P P Bhat (Animal Genetics)

Education

1. Dr G D Diwakar (Accreditation)
2. Dr G C Tewari

Fisheries

1. Dr Anil Agarwal (Marine Fisheries)
2. V S Chitranchi

Engineering

1. Dr S K Tandon
2. Dr A K Jain
3. Dr R P Jain

Extension

1. Dr G Appa Rao (Extension)
2. Dr (Mrs) Usha Anand (Social Science)
3. Dr P C Sharma
4. Dr A M Narula

Others

1. Dr V S Upadhyay
2. Dr K L Jagiasi
3. Dr D B S Sahra
4. Dr R K Mittal
5. Dr P C Sharma

National Agricultural Technology Project

1. Dr S L Mehta, National Director
2. Dr J P Mittal, Principal Scientist
3. Dr K P Agarwal, Principal Scientist
4. Dr D P Singh, Principal Scientist
5. Dr R L Yadav, Principal Scientist
6. Dr A Bandyopadhyay Principal Scientist

Administration

Directors

1. Mr K K Bajpai, Director (P)
2. Mr B L Jangira, Director (F)
3. Mr H C Pathak, Director (F), NATP
4. Mr A K Dubey, Director (Hindi)
5. Mr V P Kothiyal, Director (Works)

Deputy Secretaries

1. Mr K L Bakolia
2. Mr A K Chaturvedi
3. Mr Sodhi Singh

Deputy Directors

1. Dr D C Saxena, Deputy Director (F)
2. Mr D P Yadav, Deputy Director (F)
3. Mr J Ravi, Deputy Director (P)
4. Mr Davendra Kumar, Deputy Director (F), NATP

Others

1. Mr Anil K Sharma, Chief Publicity and Public Relations Officer
2. Mr R P Mangla, Exhibition Officer

Directorate of Information and Publications of Agriculture

1. Mr A Chakravarty, Director
2. Mr V K Bharti, Chief Production Officer
3. Mr Kuldeep Sharma, Chief Editor (Hindi) I/C
4. Mr C S Vishwanath, Chief Editor (English) I/C
5. Mr S K Joshi, Business Manager
6. Mr Hansraj, Information System Officer
7. Dr R P Sharma, Editor (E)
8. Ms Shashi Varma, Editor (E)
9. Mr B C Mandal, Senior Artist

Agricultural Scientists' Recruitment Board

1. Dr A G Sawant, Member
2. Dr S A H Abidi, Member
3. Mr Sukh Pal, Secretary
4. Mr P Bapaiah, Controller of Examinations

APPENDIX 5

ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr S Nagarajan
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   New Delhi 110 012
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2. Dr M P Yadav
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   E-mail: ivri@x400nicgw.nic.in
3. Dr Nagendra Sharma
   National Dairy Research Institute
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   E-mail: ndri@x400nicgw.nic.in
4. Dr S C Mukherjee
   Central Institute of Fisheries Education
   Jaiprakash Road, Seven Bungalow (Versova)
   Mumbai (Maharashtra) 400 061
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Agricultural Sciences

5. Dr R B Rai
   Central Agricultural Research Institute
   Andaman and Nicobar Group of Islands
   P B 181 Port Blair (Andamans) 744 101
   E-mail: cariagi@x400nicgw.nic.in
6. Dr Pratap Narain
   Central Arid Zone Research Institute
   Jodhpur (Rajasthan) 342 003
   E-mail: cazri@x400nicgw.nic.in
7. Dr Nawab Ali
   Central Institute of Agricultural Engineering
   Berasia Road, Nabi Bagh,
   Bhopal (Madhya Prdesh) 462 018
   E-mail: ciae@x400nicgw.nic.in
8. Mr D G Dhandar
   Central Institute for Arid Horticulture
   Bikaner (Rajasthan) 334 003
9. Dr C D Mayee
   Central Institute for Cotton Research
   ICAR Housing Complex, Central Bazar Road
   Bajaj Nagar,Nagpur (Maharashtra) 440 010
   E-mail: cicr@x400nicgw.nic.in
10. Dr S M Ilyas
    Central Institute of Post-Harvest Engineering and
    Technology, Ludhiana (Punjab) 141 004
    E-mail: ciphet@x400nicgw.nic.in
11. Dr S Srinivasan
    Central Institute for Research on Cotton Technology
    PB 16640, Adenwala Road, Matunga
    Mumbai (Maharashtra) 400 019
    E-mail: circot@x400nicgw.nic.in
12. Dr R K Pathak
    Central Institute for Subtropical Horticulture
    Rehmankhera, PO Kakori
    Lucknow (Uttar Pradesh) 226 016
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13. Dr A A Sofi
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14. Dr V Rajagopal
    Central Plantation Crops Research Institute
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    E-mail: cpcri@x400nicgw.nic.in
15. Dr S M Paul Khurana
    Central Potato Research Institute
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    E-mail: cpri@x400nicgw.nic.in
16. Dr H P Singh
    Central Research Institute for Dryland Agriculture
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    Hyderabad (Andhra Pradesh) 500 659
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17. Dr H S Sen
    Central Research Institute for Jute and Allied Fibres
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    (West Bengal) 734 101
    E-mail: crijaf@x400nicgw.nic.in
18. Dr B N Singh
    Central Rice Research Institute
    Cuttack (Orissa) 753 006
    E-mail: crri@x400nicgw.nic.in
19. Dr N K Tyagi
    Central Soil Salinity Research Institute
    Zarifa Farm, Kachwa Road, Karnal (Haryana) 132 001
    E-mail: cssri@x400nicgw.nic.in
20. Dr V N Sharda
    Central Soil and Water Conservation Research and
    Training Institute,218 Kaulagarh Road
    Dehra Dun (Uttar Pradesh) 248 195
    E-mail: cswcrti@x400nicgw.nic.in
21. Dr K D Singh
    Central Tobacco Research Institute
    Rajahmundry (Andhra Pradesh) 533 105
    E-mail: ctri@x400nicgw.nic.in
22. Dr S Edison
    Central Tuber Crops Research Institute, PB3502
    Sreekariyam Thiruvananthapuram (Kerala) 695 017
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23. Dr V S Korikanthimath
    ICAR Complex for Goa, Ela Old, Goa 403 402
    E-mail: icar@goa.nic.in

24. Dr K M Bajarbaruah
ICAR Research Complex for
North-Eastern Hills Region
Umroi Road, Barapani (Meghalaya) 793 103
E-mail: rcnehr@x400nicgw.nic.in
25. Dr S D Sharma
Indian Agricultural Statistics Research Institute
Library Avenue, Pusa Campus, New Delhi 110 012
E-mail: iasri@x400nicgw.nic.in
26. Dr P S Pathak
Indian Grassland and Fodder Research Institute
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27. Dr S D Shikhamany
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28. Dr Masood Ali
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29. Dr C L Acharya
Indian Institute of Soil Science
Z-6, Zone I, Maharana Pratap Nagar
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30. Dr V A Parthasarathy
Indian Institute of Spices Research
P B 1701, P O Marikunnu, Calicut (Kerala) 673 012
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31. Dr S R Misra
Indian Institute of Sugarcane Research
P O Dilkusha, Lucknow (Uttar Pradesh) 226 002
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32. Dr K K Kumar
Indian Lac Research Institute
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33. Dr M K Banerjee
Indian Institute of Vegetable Research
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Sunderpur, Varanasi (Uttar Pradesh) 221 005
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34. Dr S K Bhattacharya
National Institute of Research on Jute and
Allied Fibre Technology
12 Reagent Park
Calcutta (West Bengal) 700 040
E-mail: jtri@x400nicgw.nic.in
35. Dr N Balasundaram
Sugarcane Breeding Institute
Coimbatore (Tamil Nadu) 641 007
E-mail: sbi-coi@x400nicgw.nic.in
36. Dr H S Gupta
Vivekananda Parvatiya Krishi Anusandhan Shala
Almora (Uttar Pradesh) 263 601
E-mail: vpkas@x400nicgw.nic.in

Animal Sciences and Fisheries

37. Dr Rajvir Singh
Central Avian Research Institute
Izatnagar (Uttar Pradesh) 243 122
E-mail: cari@x400nicgw.nic.in
38. Dr V V Sugunan
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39. Dr M Abraham
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40. Dr K Devadasan
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41. Dr K J Ram
Central Institute of Freshwater Aquaculture
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E-mail: cifa@x400nicgw.nic.in
42. Dr B S Punia
Central Institute for Research on Buffaloes
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43. Dr Nagendra Sharma
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44. Dr M J Modagil
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mdcmfri@md2.vsnl.net.in
45. Dr V K Singh
Central Sheep and Wool Research Institute
Avikanagar, District Tonk
Via Jaipur (Rajasthan) 304 501
E-mail: cswri@xnicgw.nic.in
46. Dr Khub Singh
National Institute of Animal Nutrition and Physiology
Audugodi, Bangalore (Karnataka) 560 024
E-mail: root@nainpbng.kar.nic.in

Other

47. Dr B N Mathur
National Academy of Agricultural Research and
Management, Rajendranagar
(Andhra Pradesh) 500 030
E-mail: naarm@xnicgw.nic.in

APPENDIX 6

NATIONAL BUREAUX AND THEIR DIRECTORS

Agricultural Sciences

1. Dr B S Dhillon
   National Bureau of Plant Genetic Resources
   FCI Building, Pusa, New Delhi 110 012
   E-mail: nbpgr@x400nicgw.nic.in
2. Dr K S Gajbhiye
   National Bureau of Soil Survey and Land Use Planning
   P B 426, Shankar Nagar, Amravati Road
   Nagpur (Maharashtra) 440 010
   E-mail: nbsslup@x400nicgw.nic.in

Animal Sciences

3. Dr S P S Ahlawat
   National Bureau of Animal Genetic Resources
   Karnal (Haryana) 132 001
   E-mail: nbagr@x400nicgw.nic.in
4. Dr D Kapoor
   National Bureau of Fish Genetic Resources
   Radhaswami Bhavan, 351/28,
   Dariya Pur, Talkatora Road
   PO Rajendranagar
   Lucknow
   (Uttar Pradesh) 226 002
   E-mail: nbfgr@x400nicgw.nic.in
5. Prof D K Arora
   National Bureau of Agriculturally Important Micro-organisms
   NBPGR Old Building,
   Pusa Campus
   New Delhi 110 012

APPENDIX 7

PROJECT DIRECTORATES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr S K Sharma
   Directorate of Cropping Systems Research
   Modipuram,
   Meerut (Uttar Pradesh) 250 110
   E-mail: pdcsr@x400nicgw.nic.in
2. D M Hegde
   Directorate of Oilseeds Research
   Hyderabad (Andhra Pradesh) 500 030
   E-mail: pdoilseed@x400nicgw.nic.in
3. Dr B Mishra
   Directorate of Rice Research
   Hyderabad (Andhra Pradesh) 500 030
   E-mail: pdrice@x400nicgw.nic.in
4. Dr D S Chauhnan
   Project Directorate of Wheat Research
   P B 158, Kunjpura Road,
   Karnal (Haryana) 132 001
   E-mail: dowr@x400nicgw.nic.in
5. Dr R J Rabindra
   Project Directorate of Biological Control
   Bellary Road, P.B. 2491, HA Farm Post,
   Bangalore (Karnataka) 560 024
   E-mail: pddbic@x400nicgw.nic.in
6. Dr N N Singh
   Project Directorate on Maize
   Cummings Laboratory
   Indian Agricultural Research Institute
   New Delhi 110 012
7. A P Gandhi
   Project Directorate on Soybean,
   Processing and Utilization
   CIAE Complex, T T Nagar,
   Bhopal 462 018
8. Dr A K Sikka
   Directorate of Water Management Research,
   WALMI Complex, Phulwari Sharif PO
   Patna (Bihar) 801 505
   E-mail: pdwn@x400nicgw.nic.in

Animal Sciences

9. Dr Kripal Singh
   Project Directorate on Cattle
   PH-7, Pallavpuram, Phase II, Modipuram,
   Meerut (Uttar Pradesh) 250 110
   E-mail: pdcattle@x400nicgw.nic.in
10. Dr R P Sharma
    Project Directorate on Poultry
    Agricultural University Campus
    Hyderabad (Andhra Pradesh) 500 030
    E-mail: pdpoultry@x400nicgw.nic.in
11. Dr K Prabhudas
    Project Directorate on Animal Disease Monitoring and Surveillance
    Hebbal, Bangalore (Karnataka) 560 024
12. Dr S K Bandyopadhyay
    Project Directorate on Foot and Mouth Diseases
    IVRI Campus, Mukteshwar
    Kumaon (Uttar Pradesh) 263 138

APPENDIX 8

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr P Rai
   National Research Centre for Agroforestry
   IGFRI Campus Pahuj Dam, Gwalior-Jhansi Road
   Jhansi (Uttar Pradesh) 284 003
   E-mail: nrca@x400nicgw.nic.in
2. Dr S Sathiamoorthy
   National Research Centre for Banana
   No. 4, Ramalingam Nagar, Veluyur Road
   Tiruchirapalli (Tamil Nadu) 639 103
   E-mail: nrcbanana@x400nicgw.nic.in
3. Dr E V V Bhaskar Rao
   National Research Centre for Cashew
   Kamminje, Puttur (Karnataka) 574 202
   E-mail: nrccashew@x400nicgw.nic.in
4. Dr Shyam Singh
   National Research Centre for Citrus
   Seminary Hills, Nagpur (Maharashtra) 440 006
   E-mail: nrccitrus@x400nicgw.nic.in
5. Dr P G Adsule
   National Research Centre for Grapes
   PB No. 3, Manjri Farm Post
   Pune (Maharashtra) 412 307
   E-mail: nrcgrapes@x400nicgw.nic.in
6. Dr M S Basu
   National Research Centre for Groundnut
   Ivanagar Road, Timbawadi
   PB 5, Junagadh (Gujarat) 362 001
   E-mail: nrcg@x400.nicgw.nic.in
7. Dr America Singh
   National Research Centre for
   Integrated Pest Management
   Lal Bahadur Shastri Centre for Biotechnology
   IARI, Hillside Road, Pusa
   New Delhi 110 012
   E-mail: nicipm@x400nicgw.nic.in
8. Dr Mathura Rai
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   Muzaffarpur (Bihar) 842 002
9. Dr Janardan Jee
   National Research Centre for Makhana
   Patna (Bihar) 801 506
10. Dr Satyabrata Maiti
    National Research Centre for Medicinal and
    Aromatic Plants
    Boriavi Seed Farm,Boriavi
    Anand (Gujarat) 387 310
    nrcnap@x400.nicgw.nic.in
11. Dr R P Tiwari
    National Research Centre for Mushroom Research
    and Training
    Chambaghat, Solan (Himachal Pradesh) 173 213
    nrcmrt@x400.nicgw.nic.in
12. Dr V M Reddy
    National Research Centre for Oilpalm
    Ashok Nagar, Eluru (Andhra Pradesh) 534 002
    nrcoilpalm@x400.nicgw.nic.in
13. Dr K E Lawande
    National Research Centre for Onion and Garlic
    Rajguru Nagar, Pune, Maharashtra 410 505
    E-mail: nrconion@x400nicgw.nic.in
14. Dr R C Upadhyaya
    National Research Centre for Orchids
    C/o Jt Director, ICAR Complex for NEH Region
    Regional Station, Tadong, Gangtok (Sikkim) 737 102
    E-mail: nrcorchids@x400nicgw.nic.in
15. Dr K R Kaundal
    National Research Centre on Plant Biotechnology
    Indian Agricultural Research Institute
    New Delhi 110 012
    E-mail: rps@x400nicgw.nic.in
16. Dr Arvind Kumar
    National Research Centre for Rapeseed and Mustard
    P B 41, Bharatpur (Rajasthan) 321 001
    E-mail: nrcseed@x400nicgw.nic.in
17. Dr O P Vijay
    National Research Centre for Seed Spices
    Tabiji, Ajmer 305 206
18. Dr N Seetharama
    National Research Centre for Sorghum
    Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
    E-mail: nrcsorghum@x400nicgw.nic.in
19. Dr Om Prakash Joshi
    National Research Centre on Soybean
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    Indore (Madhya Pradesh) 452 001
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21. Dr N T Yaduraju
    National Research Centre for Weed Science
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    JNKVV, Jabalpur (Madhya Pradesh) 482 004
    E-mail: nrcweed@x400nicgw.nic.in

Animal Sciences and Fisheries

22. Dr S M Lal
    High Security Animal Disease Laboratory
    101, Kalpana Nagar,
    Bhopal (Madhya Pradesh) 462 021
23. Dr M S Sahani
    National Research Centre on Camel
    Jobner PB 07, Bikaner (Rajasthan) 334 001
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24. Dr K K Vass
National Research Centre for Coldwater Fisheries
Sharv Cottage, Thandi Sarak
Naintal (Uttar Pradesh) 263 136
25. Dr S K Dwivedi
National Research Centre for Equines
Sirsa Road, Hisar (Haryana) 125 001
E-mail: nrcequines@x400nicgw.nic.in
26. Dr T R K Murthy
National Research Centre on Meat and Meat Products
CRIDA Campus
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E-mail: nrcmeat@x400nicgw.nic.in
27. Dr Chandan Rajkhowa
National Research Centre on Mithun
ICAR Research Complex
Jharnapani, Distt Kohima (Nagaland) 797 106
E-mail: nrcmithun@x400nicgw.nic.in
28. Dr K M Bajarbarauah
O S D, NRC on Pigs, C/o NRC on Mithun
Jharnapani, Kohima (Nagaland)
29. J L Karinaloo
National Resource Centre on DNA Finger Printing
NBPGR, Pusa Campus, New Delhi 110 012
30. Dr Mohan Bhattacharya
National Research Centre on Yak
West Kemeng, Dirang (Arunachal Pradesh) 797 106
E-mail: nrcyak@x400nicgtw.nic.in

General

31. Dr Mruthyunjaya
National Centre for Agricultural Economics and Policy Research,
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32. Dr (Ms) Hema Pandey
National Research Centre for Women in Agriculture
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Bhubaneshwar (Orissa) 751 001
33. Mr K N Kumar
National Centre for Values and Ethics
Krishi Bhawan, New Delhi 110 001

APPENDIX 9

ALL-INDIA CO-ORDINATED RESEARCH PROJECTS

Crop Sciences

1. Dr B Mallik
Project Co-ordinator (Acarology)
University of Agricultural Sciences
Bangalore (Karnataka) 560 024
2. Dr V Vasudeva Rao
Project Coordinator (Network on Agricultural Ornithology)
ANGRAU Veterinary College Campus
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
3. Dr D Kumar
Project Coordinator (Arid Legumes) RAU,
Beehwal, Bikaner (Rajasthan)
4. Dr S Nagarajan
Project Co-ordinator (Barley), PDWR, Karnal 132 001
5. Dr D M Hegde
Project Co-ordinator (Castor), Directorate of Oilseed Research,Hyderabad (Andhra Pradesh) 500 030
6. Dr S P Mishra
Project Co-ordinator (Chickpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
7. Dr T P Rajendran
Project Co-ordinator (Cotton), Regional Research Station (CICR), PO Lawley Road, Coimbatore (Tamil Nadu) 641 003
8. Dr D P Tripathi
Project Co-ordinator (Forage Crops)
Indian Grassland and Fodder Research Institute
PO Pahuj Dam, Jhansi-Gwalior Road
Jhansi (Uttar Pradesh) 284 003
9. Dr M S Basu
Project Co-ordinator (Groundnut)
C/o NRC on Groundnut
Ivanagar Road PB 5
Junagadh (Gujarat) 382 001
10. Dr S N Maiti
Project Coordinator (Jute and Allied fibres)
CRIJAF
Barracpore 743 101
11. Dr R K Lakra
Project Co-ordinator (Honeybees)
Division of Zoology
(Entomology), CCS Haryana Agricultural University
Hisar (Haryana) 125 004
12. Dr S A Kherkhi
I/c Project Co-ordinator (Linseed)
CSA University of Agriculture and Technology
Kanpur, (Uttar Pradesh) 208 002
13. Dr N N Singh
Project Co-ordinator (Maize)
Directorate of Maize Research
IARI Campus
New Delhi 110012
14. Dr A Seetharam
Project Co-ordinator (Small Millets)
University of Agricultural Sciences
GKVK Campus, Bangalore (Karnataka) 560 065
15. Dr D P Tripathi
Project Co-ordinator (MULLaRP)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024

16. Dr S D Mishra
Project Co-ordinator (Nematodes)
Division of Nematology
Indian Agricultural Research Institute
New Delhi 110 012
17. Dr R K Chowdhury
Project Co-ordinator (NSP)
Division of Seed Science and Technology
IARI, Pusa, New Delhi 110 012
18. Dr S K Bhatnagar
Project Co-ordinator (Pearl Millet)
Agricultural Research Station, Mandore
Jodhpur (Rajasthan)
19. Dr D B Saxena
Project Co-ordinator (Pesticide Residues)
Division of Agricultural Chemicals
Indian Agricultural Research Institute,
New Delhi 110 012
20. Dr N D Majumdar
Project Co-ordinator (Pigeonpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
21. Dr Arvind Kumar
Project Co-ordinator (Rapeseed and Mustard)
Sewar Farm, Distt Bharatpur (Rajasthan) 321 001
22. Dr R S Tripathi
Project Co-ordinator (Rodent Control)
Central Arid Zone Research Institute
Jodhpur (Rajasthan) 342 003
23. Dr D M Hedge
Project Co-ordinator (Safflower)
Directorate of Oilseeds Research
Hyderabad (Andhra Pradesh) 500 030
24. Dr S S Duhoon
Project Co-ordinator (Sesame and Niger)
JNKVV, Jabalpur (Madhya Pradesh) 482 004
25. Dr N Seetharama
Project Co-ordinator (Sorghum),NRC for Sorghum
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
26. Dr O P Joshi
Project Co-ordinator (Soybean)
National Research Centre for Soybean
Khandwa Road, Indore (Madhya Pradesh) 452 001
27. Dr S R Misra
Project Co-ordinator (Sugarcane)
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 208 002
28. Dr D M Hegde
Project Co-ordinator (Sunflower)
University of Agricultural Sciences
GKVK Campus, Bangalore (Karnataka) 560 065
29. Dr G D Sharma
Project Co-ordinator (Under-utilized and Under-exploited Crops),
NBPGR, Pusa, New Delhi 110 012
30. Dr K D Singh
Project Co-ordinator (Tobacco)
CTRI, Rajahmundry (Andhra Pradesh) 533 105
31 Dr D S Chauhan
Project Co-ordinator (Wheat and Barley)
Directorate of Wheat Research
Karnal (Haryana) 132 001
32. Dr V K Shinde
Project Co-ordinator (Whitegrubs)
Agricultural Experimental Station,
Rajasthan Agriculture University,
Durgapura, Jaipur (Rajasthan) 392 018

Horticulture

33. Dr D G Dhandar
Project Co-ordinator (Arid Fruits)
CIAH, Bikaner 334 006
34. Dr S Maiti
Project Co-ordinator (Betelvine)
NRC for Medicinal and Aromatic Plants
Boriavi (Gujarat) 387 310
35. Dr E V V Bhaskar Rao
Project Co-ordinator (Cashew)
National Research Centre for Cashew
Puttur (Karnataka) 574 202
36. Dr S K Bhattacharjee
Project Co-ordinator (Floriculture)
Division of Floriculture and Landscaping
Indian Agricultural Research Institute
New Delhi 110 012
37. Dr R P Tewari
Project Co-ordinator(Mushrooms)
National Centre for Mushroom Research and Training
Chambaghat, Solan (Himachal Pradesh) 173 213
38. Dr H Hameed Khan
Project Co-ordinator (Palms),Central Plantation Crops Research Institute, Kasaragod (Kerala) 670 124
39. Dr D S Khurdiya
Project Co-ordinator (Post-Harvest Technology),
Division of Fruits and Horticultural Technology
Indian Agricultural Research Institute,
New Delhi 110 012
40. Dr S M Paul Khurana
Project Co-ordinator (Potato),Central Potato Research Institute, Shimla (Himachal Pradesh) 171 001
41. Dr R K Pathak
Project Co-ordinator (Subtropical Fruits)
Central Institute for Subtropical Horticulture
Raebareli Road, PO Dilkusha, Lucknow
(Uttar Pradesh) 226 002
42. Dr P N Ravindran
Project Co-ordinator (Spices)
Indian Institute of Spices Research
PB 170, Marikunnu, Calicut (Kerala) 673 012
43. Dr Om Prakash
Project Co-ordinator (Fruits)
CISTH, Lucknow 226 016
44. Dr B M C Reddy
Project Co-ordinator (Tropical Fruits)
IIHR, Hessarghatta Lake Post
Bangalore (Karnataka) 560 089

45. Dr P G Rajendran
Project Co-ordinator (Tuber Crops),Regional Station of the Central Tuber Crops Research Institute
Thiruvananthapuram (Kerala) 695 017
46. Dr Mathura Rai
Project Co-ordinator (Vegetable)
Project Directorate of Vegetable Research
1 Gandhinagar, Sunderpur
P B 5002, BHU, Varanasi (Uttar Pradesh) 221 005

Natural Resource Management

47. Dr P Rai
Project Co-ordinator (Agroforestry)
NRC on Agroforestry, Jhansi (Uttar Pradesh)
48. Dr D L N Rao
Project Co-ordinator (Biological Nitrogen Fixation)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
49 Dr S K Sharma
Project Co-ordinator (Cropping Systems)
PDCSR, Medipuram
Meerut (Uttar Pradesh) 250 110
50. Dr Biplab Saha
Project Co-ordinator (Diara Lands)
Directorate of Water Management Research
WALMI Complex, Phulwari Sharif P.O.
Patna (Bihar) 801 505
51. Dr K P R Vittal
Project Co-ordinator (Dryland Agriculture)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 659
52. Dr M V Singh
Project Co-ordinator (Long-term Fertilizer Experiment)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
53. Dr Mohan Singh
Project Co-ordinator (Microbiological Decomposition)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
54. Dr. M V Singh
Project Co-ordinator (Micronutrients and Secondary Nutrients and Pollutant Elements)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 018
55. Dr A Subba Rao
Project Co-ordinator (Soil Test and Crop Response)
Indian Institute of Soil Science, Nabi Bagh
Bhopal (Madhya Pradesh) 462 038
56. Dr D K Painuli
Project Co-ordinator (Soil Physical Constraints)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
57. Dr P S Minhas
Project Co-ordinator (Management of Salt-affected Soils and Saline Water in Agriculture)
Central Soil Salinity Research Institute
Karnal (Haryana) 132 001
58. Dr R K Batta
Project Co-ordinator (Water Management)
ICAR Co-ordinating Unit
Mahatma Phule Krishi Vidyapeeth
Rahuri (Maharashtra) 431 722
59. Dr N T Yaduraju
Project Co-ordinator (Weed Control)
National Research Centre for Weed Science
PB 13, M.P. Housing Board Colony, Maharajpur
Adhartal, Jabalpur (Madhya Pradesh) 482 004
60. Dr P R Bhatnagar
Project Co-ordinator (Ground Water)
Directorate of Water Management Research
WALMI Complex, Patna (Bihar) 801 505
61. Dr Y S Ramakrishna
Project Co-ordinator (Agricultural Meteorology)
CRIDA Campus, Santoshnagar
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Engineering and Technology

62. Dr A K Bhattacharya
Project Co-ordinator (Agricultural Drainage)
Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012
63. Dr Dipankar De
Project Co-ordinator (Energy Requirements in Agricultural Sector),Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road
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64. Dr M M Pandey
Project Co-ordinator (Farm Implements and Machinery)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road, Bhopal
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65. Dr L P Gite
Project Co-ordinator (Human Engineering and Safety-Studies in Agriculture)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
66. Dr Mohan Singh
Project Co-ordinator (Organic Farming)
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67. Dr Ashwani Kumar
Project Co-ordinator (Application of Plastics in Agriculture)
Central Institute of Post-Harvest Engineering and Technology
Ludhiana (Punjab) 141 004
68. Dr S M Ilyas
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69. Dr R K Verma
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70. Dr Jaswant Singh
Project Co-ordinator (Processing, Handling and Storage of Jaggery and Khandsari)
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002

71. Dr M Shyam
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72. Dr G C Yadav
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Animal Sciences and Fisheries

73. Dr Gurmej Singh
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74. Dr R K Sethi
Project Co-ordinator (Buffalo Breeding)
Central Institute for Research on Buffaloes
Hisar (Haryana) 125 001

75. Dr Nagendra Sharma
Project Co-ordinator
(Crop Based Animal Production Systems)
Central Institute for Research on Goat
Mathura, Makhdoom, (Uttar Pradesh) 281 122

76. Dr Arun Varma
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Indian Council of Agricultural Research
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77. Dr Nagendra Sharma
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78. Dr A K Chhabra
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Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122

79. Dr A L Arora
Project Co-ordinator (Sheep Improvement)
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Arid Region Campus, Bikaner (Rajasthan) 334 002

80. S K Bandyopadhyay
Project Co-ordinator (Foot-and-Mouth Disease)
Division of Epidemiology
Indian Veterinary Research Institute
Mukteshwar Campus (Uttar Pradesh) 263 138

81. Dr V P Singh
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College of Veterinary Science
CCS Haryana Agricultural University
Hisar (Haryana) 125 004

82. Dr Arun Varma
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84. Dr V P Singh
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85. Dr Nem Singh
Project Co-ordinator
(Network on Gastro-intestinal Parasitism)
IVRI, Izatnagar
(Uttar Pradesh) 243 122

86. Dr M L Mehrotra
Project Co-ordinator
(Network on Bluetongue)
IVRI, Izatnagar
(Uttar Pradesh) 243 122

87. Dr Arun Verma
Network Programme on Micronutrients in Animal Nutrition and Production
Krishi Bhawan
New Delhi 110 001

88. Dr G R Patil
Project Co-ordinator (Process Upgradation of Indigenous Milk Products)
Network Project on R & D Support for Process Upgradation of Indigenous Milk Products for Industrial Application, NDRI, Karnal
(Haryana) 132 001

Education

89. Dr (Mrs) Tej Verma
Project Co-ordinator (Home Science)
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APPENDIX 10

AGRICULTURAL UNIVERSITIES AND THEIR VICE-CHANCELLORS

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   Assam Agricultural University, Jorhat
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   E-mail: vcc@aacc.ren.nic.in
3. Prof Debarata Das Gupta
   Bidhan Chandra Krishi Vishwa Vidyalaya
   PO Krishi Vishwa Vidyalaya
   Mohanpur (West Bengal) 741 252
   E-mail: root@bckv.wp.nic.in
4. Dr S N Pandey
   Birsa Agricultural University
   Ranchi (Jharkhand) 834 006
   E-mail: root@bau.bih.nic.in
5. Dr S B Singh
   Chandra Shekhar Azad University of Agriculture and Technology,
   Kanpur (Uttar Pradesh) 208 002
   E-mail:hau@hau.hry.nic.in
6. Dr Vinay Kumar
   Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) 125 004
   E-mail: root@hau.pnp.nic.in
7. Dr S A Nimbalkar
   Dr Punjabrao Deshmukh Krishi Vidyapeeth
   Akola (Maharashtra) 444 104
8. Dr S S Negi
   Dr Yashwant Singh Parmar University of Horticulture and Forestry
   Nauni, Distt Solan, (Himachal Pradesh) 173 230
   E-mail: yspuhf@ren.nic.in
9. Dr P L Gautam
   Govind Ballabh Pant University of Agriculture and Technology
   Pantnagar (Uttar Pradesh) 263 145
   E-mail:root@gbpuat.ernet.in
10. Dr M H Mehta
    Gujarat Agricultural University
    Sardar Krushinagar, Distt Banaskantha
    (Gujarat) 385 506
11. Dr Tej Pratap
    Ch Shravan Kumar Himachal Pradesh Krishi Vishvavidyalaya
    Palampur (Himachal Pradesh) 176 062
12. Dr V K Patil
    Indira Gandhi Krishi Vishwavidyalaya
    Raipur
    (Madhya Pradesh) 492 012
13. Dr D P Singh
    Jawaharlal Nehru Krishi Vishwa Vidyalaya
    Jabalpur (Madhya Pradesh) 482 004
    E-mail: root@jnu.mp.nic.in
14. Dr K V Peter
    Kerala Agricultural University
    Vellanikkara, Distt Thrissur (Kerala) 680 654
    E-mail: kauhgr@ren.nic.in
15. Dr S S Magar
    Dr Bala Sahib Sawant Konkan Krishi Vidyapeeth
    Dapoli (Maharashtra) 431 712
16. Dr S N Puri
    Mahatma Phule Krishi Vidyapeeth
    Rahuri (Maharashtra) 431 722
17. Dr V M Pawar
    Marathwada Agricultural University
    Parbhani (Maharashtra) 431 402
    E-mail: mau@ren.nic.in
18. Dr A A Faroda
    Maharana Pratap
    University of Agriculture and Technology
    Udaipur 313 001
19. Dr B B Singh
    Narendra Deva University of Agriculture and Technology,
    Faizabad (Uttar Pradesh) 224 001
20. Mr Sahadeva Sahoo
    Orissa University of Agriculture and Technology
    Bhubaneshwar (Orissa) 141 004
    E-mail: root@uat.cri.nic.in and snp@uat.cri.nic.in
21. Dr K S Aulakh
    Punjab Agricultural University
    Ludhiana (Punjab) 141 004
    E-mail:root@pace.chd.nic.in and issohal@pau.chd.nic.in
22. Dr C P S Yadav
    Rajasthan Agriculture University
    Bikaner (Rajasthan) 334 002
    E-mail: root@ raub.raj.nic.in
23. Dr S R Singh
    Rajendra Agricultural University
    Samastipur, Pusa (Bihar) 848 125
    E-mail: rau@bih.nic.in
24. Dr M Y Kamal
    Sher-e-Kashmir University of Agricultural Sciences and Technology
    Srinagar (Jammu and Kashmir) 191 001
25. Mr H Khan
    Sher-e-Kashmir University of Agricultural Sciences and Technology
    45-B, Gandhinagar, PB 37
    Jammu Tawi, (Jammu and Kashmir) 180 004

26. Dr S Kannaiyan
    Tamil Nadu Agricultural University
    Coimbatore (Tamil Nadu) 641 003
    E-mail:root@ tnau.tn.nic.in
27. Dr R Kadirvel
    Tamil Nadu Veterinary and Animal Sciences
    University, Chennai (Tamil Nadu) 600 007
    E-mail: root@tnasu.tn.nic.in
    biomtn@iitm.cinet.in
    btismvc@giasmdol.vsnl.net.in
28. Dr A M Krishnappa
    University of Agricultural Sciences
    Bangalore (Karnataka) 560 065
    E-mail:root@usab.kar.nic.in
29. Dr S A Patil
    University of Agricultural Sciences
    Dharwad (Karnataka) 580 005
    E-mail:root@usad.kar.nic.in
30. Dr A K Bhattacharya
    West Bengal University of Animal and
    Fishery Sciences, Belgachia, Calcutta (West Bengal)
31. Dr A T Sherikar
    Maharashtra Animal and Fishery Sciences University
    Nagpur (Maharashtra) 440 006
32. Dr M Zaka-ur-Rab
    Director
    Faculty of Agriculture
    Aligarh Muslim University
    Aligarh (Uttar Pradesh) 202 002
33. Dr Ramachandra Rao
    Banaras Hindu University, Varanasi 221 005
34. Dr S K Basu
    Viswa Bharati, Santiniketan
    (West Bengal)
35. Dr G K Garg
    Sardar Vallabhai Patel University of Agriculture and Technology
    Meerut (Uttar Pradesh) 250 110
36. Dr S N Maurya
    U P Pt Deen Dayal Upadhyaya Pashuchikitsa Vigyan
    Vidyalaya Evam Go Anusandhan Sansthan
    Mathura (Uttar Pradesh) 281 001
37. Dr S K Brahmachari
    Uttar Banga Krishi Vishwavidyalaya
    Pundibari
    Cooch Beher
    (West Bengal) 736 165
38. Dr G K Garg
    Sardar Vallabhai Patel University of Agriculture and Technology
    Meerut (Uttar Pradesh) 250 110
39. Dr S N Maurya
    U P Pt Deen Dayal Upadhyaya Pashuchikitsa Vigyan
    Vidyalaya Evam Go Anusandhan Sansthan
    Mathura (Uttar Pradesh) 281 001
40. Dr S K Brahma Chari
    Uttar Banga Krishi Vishwavidyalaya
    Pundibari
    Cooch Behar (West Bengal) 736 165

Central University

1. Dr S S Baghel
   Central Agricultural University
   Imphal (Manipur) 795 001

Deemed-to-be Universities

1. Dr S Nagarajan
   Indian Agricultural Research Institute
   Pusa,
   New Delhi 110 012
2. Dr B Balaraman
   Indian Veterinary Research Institute
   Izatnagar (Uttar Pradesh) 243 122
3. Dr B N Mathur
   National Dairy Research Institute
   Karnal (Haryana) 132 001
4. Director
   Central Institute of Fisheries Education
   Jaiprakash Road,
   Seven Bungalows, Versova
   Mumbai (Maharashtra) 400 061
5. Prof R B Lal
   Allahabad Agricultural University
   Allahabad (Uttar Pradesh) 211 007

APPENDIX 11

TOTAL NUMBER OF EMPLOYEES IN THE ICAR AND ITS RESEARCH INSTITUTES AND NUMBER OF SCHEDULED CASTES, SCHEDULED TRIBES AND OTHER BACKWARD CLASSES*

Sl.no.	Class of posts	Total posts sanctioned	Total employees in position	Total scheduled castes among them	Percentage to total employees	Total scheduled tribes among them	Percentage to total employees	Total OBC	Percentage total employees
1.	**Scientific Post**								
	Scientist	3,745	2,972	268	9.01	28	0.94	172	5.78
	Senior Scientist	1,587	1,212	89	9.34	13	1.07	62	5.11
	Prinicipal Scientist	661	523	34	6.50	2	0.38	13	2.48
	RMP Scientist	107	89	2	2.24	1	1.12	6	6.74
	Total	**6,100**	**4,796**	**393**	**8.19**	**44**	**0.91**	**253**	**5.27**
2.	**Technical Posts**								
	Category I	4,744	4,158	872	20.97	278	6.68	364	8.75
	Category II	3,489	3,089	581	18.80	144	4.66	238	7.70
	Category III	664	512	94	18.35	23	4.49	41	8.00
	Total	**8,897**	**7,759**	**1,547**	**19.93**	**445**	**5.73**	**643**	**8.28**
3.	**Administration Posts**								
	(a) Directors/ Under Secretaries/ Sr. Admn. Officer/ Sr. Accounts Officer/ Admn. Officer/ F&AO/Legal etc.	301	262	55	20.99	18	6.87	14	5.34
	(b) Asstt. Fin. & Accounts Officer/ Accounts Officer/ Section Officer/ Hindi Officer/ Desk Officer/PRO	607	556	104	18.70	30	5.39	16	2.87
	(c) Assistants	1,279	1,198	208	17.36	66	5.50	48	4.00
	(d) Stenographers	863	737	110	14.92	27	3.66	33	4.47
	(e) UDC/Senior Clerk	1,343	1,310	270	20.61	77	5.87	80	6.10
	(f) LDC/Junior Clerk	1,233	1,098	268	24.40	68	6.19	149	13.57
	Total	**5,626**	**5,161**	**1,015**	**19.66**	**286**	**5.54**	**340**	**6.58**
4.	**Supporting Staff**								
	Grade I	5,613	4,423	1,164	26.31	277	6.26	484	10.94
	Grade II	3,377	3,386	930	27.46	168	4.96	106	3.13
	Grade III	1,991	1,950	501	25.69	151	7.74	58	2.97
	Grade IV	970	960	272	28.33	92	9.58	31	3.22
	Total	**11,951**	**10,719**	**2,867**	**26.74**	**688**	**6.41**	**679**	**6.33**
5.	**Supporting Staff (*Safaiwala*)**	**347**	**340**	**315**	**92.64**	**8**	**2.35**	**12**	**3.52**
6.	**Auxiliary Posts**	**155**	**122**	**35**	**28.68**	**5**	**4.09**	**18**	**14.75**

*Based on the report of 2001-2002

APPENDIX 12

AWARDS

AWARD	AWARDEES
Sardar Patel Outstanding Institution Award (2001)	*State Agricultural University* University of Agricultural Sciences, Bangalore *ICAR Institutes* (i) Indian Veterinary Research Institute, Izatnagar *NRC/Project Directorates* (i) Project Directorate on Animal Disease, Monitoring and Surveillance, Bangalore
Jawaharlal Nehru Awards for Outstanding Post-graduate Agricultural Research (2001)	*Crop Improvement* (i) Dr G.S. Mangat, PAU, Ludhiana (ii) Dr C Vishwanathan, IARI, New Delhi *Biotechnology* (i) Dr Bijoya Bhattacharjee, ICAR Research Complex, Barapani and Dr Yashpal Malik, JNKVV, Jabalpur (*jointly*) *Plant Protection* (i) Dr P Lavakumar, ICRISAT, Patancheru (ii) Dr M Mohan, TNAU, Coimbatore *Natural Resource Management* (i) Dr S K Sharma, RAU, Bikaner (ii) Dr P Gurumurthy, ANGRAU, Hyderabad *Horticulture* (i) Dr S E Apshara, CPCRI Regional centre, Thrissur (ii) Dr N S Pathania, University of Horticulture and Forestry, Solan *Engineering Technologies* (i) Dr Man Singh, IARI, New Delhi (ii) Dr Alok Jha, NRC for women in Agriculture, Bhubaneshwar *Animal Sciences* (i) Dr H D Deore, Bombay Veterinary College, Mumbai (ii) Dr Bhawna Poonia, HAU, Hisar (iii) Dr I P Devadason, NRC on Meat, Hyderabad *Fisheries* (i) Dr P K Sahoo, CIFA, Bhubaneshwar *Social Sciences* (i) Dr R Venkatakumar, NRC Cashew, Puttur (ii) Dr S J Karkannavar, UAS, Dharwad
Jagjivan Ram Kisan Puruskar (2001)	(i) Mr Bahadur Singh Verma, Village Kailar, Solan (H.P.)
N.G. Ranga Farmer Award for Diversified Agriculture (2001)	(i) Mr Haricharan Das, Fish Breeding Centre, Vidyasagar Patti, Agartala, Tripura
Panjabrao Deshmukh Women Scientist Award (2001)	(i) Dr Ravindra Kaur, IARI, New Delhi (ii) Usha R Mehra, Nuclear Research Laboratory, IVRI, Izatnagar

AWARD	AWARDEES
Vasantrao Naik Award for Research Applications in Agriculture (2001)	(i) Dr R C Srivastava & Associates, WTC for Eastern region, Bhubaneshwar, Orissa)
Chaudhary Devi Lal outstanding AICRP Project Award (2001)	(i) AICRP on Micro and Secondary Nutrients, IISS, Bhopal and AICRP on Rice Improvement, (DRR) Hyderabad (*jointly*)
Fakhruddin Ali Ahmed Awards for Outstanding Research in Tribal Areas for Biennium (2000–2001)	*Agricultural Science* (i) Dr S K Dwivedi, Field Research Laboratory, DRDO, Ladakh *Animal Science* (i) Dr S Dam Roy & Associates, CARI, Port Blair
Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research & Development (2001)	(i) Mr Surinder Sud, Agricultural Editor, Business Standard, New Delhi
ICAR Awards for Outstanding Multidisciplinary Team Research in Agriculture and Allied Sciences (1999–2000)	*Crop Improvement* (i) Dr H N Pandey & team, IARI Reg. stn. Indore (ii) Dr C R Bainiwal & team, CCSHAU, Hisar *Natural Resource Management* (i) Dr P S Pathak & team, ICFRI, Jhansi *Engineering & Technology* (i) Dr Appannan Dakshinamurthy & team, Paddy Processing Research Centre, Thanjavur *Horticulture* (i) Dr V A Parthasarathy & CPCRI, Kasargod *Fisheries* (i) Dr T K Srinivasa Gopal & team, CIFT, Cochin *Animal Production & Health* (i) Dr Malleshappa Rajasekhar & team, PD, ADMAS, Bangalore (ii) Dr Khub Singh & team, NIANP, Bangalore *Social Sciences* (i) Dr H C Sharma & team, CPRI, Shimla
Bharat Ratna C Subramanian Awards for Outstanding Teachers for the Biennium (2000–01)	*Crop Sciences* (i) Dr R K Behal, CCSHAU, Hisar and Dr M B Chetti, UAS, Dharwad (*Jointly*) (ii) Dr V Prakasam, TNAU, Coimbatore *Horticulture* (i) Dr Y N Reddy, College of Agriculture, Hyderabad *Resource Sciences* (i) Dr M R Paramathma. Forest College & Research Institute, TNAU, Coimbatore *Fisheries* (i) Dr A D Diwan, ICAR, New Delhi *Veterinary & Animal Sciences* (i) Dr J M Kataria, IVRI, Izatnagar *Social Sciences* (i) Dr Lali Yadav, CCSHAU, Hisar
Best Krishi Vigyan Kendra Awards for the Biennium (2000–01)	(i) Krishi Vigyan Kendra, CARI, Port Blair (ii) Krishi Vigyan Kendra, JNKVV Zonal Research Centre, Chindwara (H.P)

AWARD	AWARDEES
Rajendra Prasad Puraskar for Technical Books in Hindi in the field of Agriculture and Allied Sciences (1999–2000)	*Crop Sciences* (i) Late Dr R A Agrawal and Dr Prem Kishore, IARI, New Delhi *Soil and Agronomy* (i) Dr S P Bharadwaj & others, CSWCR & TI, Dehradun *Horticulture* (i) Dr D P Abrol, Jammu *Engineering* (i) Dr S K Mishra & others, Roorkee *Animal Health* (i) Dr Ramswaroop Singh Chauhan, GBPUAT, Pantnagar *Animal Production* (i) Dr Brijpal Singh, CARI, Izatnagar *Fisheries* (i) Dr S A H Abidi, ASRB, New Delhi (ii) Dr Sudhir Raizada, CIFE, Rohtak (iii) Mr Rajeshwari Uniyal, CIFE, Mumbai *Social Sciences* (i) Dr Krishna Murari Singh, Sheikhpura, Bihar