# DARE / ICAR

# Annual Report

## 2005-2006

सत्यमेव जयते

Department of Agricultural Research and Education
Ministry of Agriculture
Government of India

Indian Council of Agricultural Research
New Delhi

भाकृअनुप
ICAR

## Indian Council of Agricultural Research

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| President, ICAR Society and Minister of Agriculture | **Shri Sharad Pawar** | |
| Minister of State for Agriculture | **Shri Kanti Lal Bhuria** | |
| Direcor-General (ICAR) and Secretary (DARE) | **Dr Mangala Rai** | |
| Secretary (ICAR) and Additional Secretary (DARE) | **Smt Shashi Misra**<br>**Smt Sushama Nath** | (Up to 31.8.2005)<br>(Since 1.9.2005) |
| Financial Adviser (ICAR) (*Additional Charge) and Additional Secretary (Agriculture) | **Shri P P Mathur** | (*Up to 18.4.2005) |
| Financial Adviser (ICAR) and Additional Secretary (DARE) | **Dr (Smt) Rita Sharma** | (Since19.4.2005) |

# Foreword

A perfect agricultural scenario in India in 2030 – adequate foodgrains production, assured good quality seeds, optimized water management, flourishing livestock and poultry farming to supplement farmers' income, remunerative horticultural and plantation crops, thriving fisheries sector, appropriate food processing infrastructure, sensitive extension system and effective marketing facilities – is the target of research of the Indian Council of Agricultural Research. The ICAR is in the forefront and taking revolutionary steps to mark a qualitative change in agricultural technology, education and frontline extension. Agriculture in India is not only an employment but also a means of livelihood for rural masses, and steps have to be taken to make their livelihood secure.

During the year, 150 varieties and hybrids of different crops including horticultural crops were released/identified for cultivation in different parts of the country. Insecticide-resistance management strategies were formulated for sustainable pest management. Signature markers were identified for the first time in castor to establish hybrid purity. National Test Guidelines for Distinctness, Uniformity and Stability for 35 economically important crops were developed. Voracious feeding of isabelline chat bird on *Helicoverpa armigera* on pigeonpea crop has been recorded for the first time. Tommy Atkins mango was found as a potential donor for red peel and precocity characters, and release of predator of mealy bug reduced 80% bunch damage in grapes. Transgenic tomato cultivars with combined resistance to viruses, and organic farming protocols for vegetable-based cropping systems were developed. A high-yielding, single spore selection SSI 4035 of mushroom, *Agaricus bisporus,* was recommended for commercial release. In potato, post-transcriptional gene silencing (PTGS) transgenic lines of Kufri Badshah were developed that have resistance to bacterial wilt and late blight, and transgenic lines tolerant to cold-induced sweetening were identified. Eco-friendly and sustainable land-use models were identified for 16 watersheds. Salt-affected soil database of Rajasthan, Madhya Pradesh, Gujarat and Andhra Pradesh were digitized. A model OPTALL was developed for canal-water management.

Crop diversification options proved beneficial in mitigating drought in rainfed uplands of eastern India. Zero tillage practices significantly reduced population and dry matter of weed in rice-wheat system.

Genetic resource database was prepared for livestock and poultry, which also provides raw data for further analysis. Phenotypic characterization of several indigenous breeds of cattle, buffaloes, sheep, goats, poultry, camels and horses was completed in their home tract. Under field progeny testing programme, a decreasing trend was observed in calving age of Frieswal daughters born from first to fourth set of bulls. Sensitive diagnostic techniques and effective vaccines for several prevailing diseases were developed. District-wise compilation of information on feed resources was complied for use in livestock development

activities. Several techniques were developed for commercial production of different milk products and improvement in their shelf-life.

In marine fisheries, the first phase of the National Marine Fisheries Census, 2005, was completed in all the coastal states excepting Tamil Nadu. Endangered yellow catfish was successfully bred under captive conditions. In coldwater fisheries, a computerized database of upland fishes of India was developed. A nested RT-PCR diagnostic kit for *Macrobrachium rosenbergii* nodavirus was released. In Andaman and Nicobar Islands, fibre glass reinforced plastic boats were introduced to help fishermen facing losses due to tsunami. Pedal-operated peeler was developed for rural level production of potato chips. Gender-friendly motor-operated lac grader and winnower were developed for village level processing. Memorandum of Understanding (MoU) with the IGNOU for co-operation in agricultural education in distance mode, and co-operation with the ISRO, IGNOU and MHRD for utilization of EDUSAT by the ICAR and SAUs for agricultural education are new initiatives. A core germplasm collection set was established for the first time in fingermillet at the National Active Germplasm site at Bangalore, which represents 98% of the variability present in the entire world collection. Agricultural markets in India need to attract big business to invest and operate in bulk buying and selling, which would give better deal to consumers as well as producers.

At present, 503 Krishi Vigyan Kendras (KVKs) are working, where technologies are being taken up for on-farm testing. Involvement in the activities of self-help groups gave confidence and decision-making ability to women. Due attention was paid on agricultural research planned specially for tribal and hilly regions to meet needs of farmers of these regions. Besides, impact of tsunami tidal waves was assessed on agricultural lands and suitable technologies were suggested for rehabilitation of the affected farmers. MoUs/ Agreements were signed between the ICAR and Brazilian Agricultural Research Corporation, the Government of India and Government of the Republic of Afganistan, and Government of India and United States Department of Agriculture. A magnum opus publication *Handbook of Agriculture* was brought out after complete revision and updating.

Surveys have revealed that adoption of technologies by farmers reduced the cost of production of crops leading to improved benefits, which are further improved by better market facilities. Information technology is going to play a vital role at every stage of food production process. The whole web of national agricultural research system having scientists at one-end and information seeker — the farmer — on the other end, will change the face of rural India.

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 and optimization of resources, commercialization of technologies and biotechnology. It is hoped that this report would be useful for policy-makers, planners and development agencies.

**(SHARAD PAWAR)**
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 objectives of the Society.

# Overview

The Indian Council of Agricultural Research (ICAR), in pursuance of its mandate, remains actively engaged in generation of farmworthy technologies to achieve science-based growth and development of the agriculture and also to develop competent human resources through its institutions of higher agricultural education. An overview of the important activities, research achievements and new initiatives taken during the year is presented here.

The year witnessed late arrival of south-western monsoon over the peninsular and eastern India but early in north-western parts of India. The season ended with an all India area weighted rainfall at 99% of the long period average (LPA). Out of 36 meteorological sub-divisions, monsoon rainfall was normal in 25, excess in 8 and deficient in 3 sub-divisions. The output of foodgrains is expected to be 209.3 million tonnes, which is about 5 million tonnes more than in the previous year and the overall agricultural growth is about 2.3%. The Agriculture at present contributes about 22% to India's GDP and the agri-exports valued at Rs 39,863 crore constitute nearly 11.2% of the total national exports.

In agriculture, quality seed and planting material are essential to realize optimum production potential of other inputs. Nearly 7,500 tonnes of breeder seed of different crops including potato were produced and distributed as per the state indents so that farmers could get the quality seed at the appropriate time. A new programme on seed production in crops and fisheries has been approved by the Government for a total amount of approximately Rs 200 crore.

The ICAR organized for the first time a national conference of the Krishi Vigyan Kendras (KVKs) to improve their relevance and effectiveness in the process of technology assessment, refinement and dissemination. The Hon'ble Prime Minister of India inaugurated the event and also released on this occasion a set 44 CDs and 28 technical bulletins on agricultural technologies. The Council has sanctioned 62 new Krishi Vigyan Kendras (KVKs) during the year. The total number of KVKs now stands at 503 in fulfillment of the target of establishing KVKs in each of the rural districts.

A National Research Centre on Pomegranate at Sholapur was established to provide necessary boost to the process of diversification of agriculture towards enhancing farm production, income and nutritional security.

A new National Agricultural Innovation Project (NAIP) with the support of World Bank has been planned, and is likely to be launched from July 2006. The main features of the project include research on production to consumption system (market), sustainable livelihood security in disadvantaged areas (poverty) and basic and strategic researches at the frontiers of science (productivity).

India and the USA have signed an agreement to launch an India-US Knowledge Initiative on Agricultural Education, Research, Service and Commercial linkages. The Knowledge Initiative Board from the Indian side visited the USA in December 2005, and a reciprocal visit of the US Board took place in February 2006.

Efforts were made to provide fresh thrust to organizational and systemic reforms of ICAR through rationalization of manpower strength, commercialization, public-private linkages, delegation of powers etc. Further, the Score Card System has been introduced for objective and quality assessment of scientists on direct recruitment and on career advancement. An empowered committee to operationalize the National Fund for Strategic Agricultural Research has been set up under the chairmanship of Dr C N R Rao with eminent scientists as members of the board.

*Crop improvement:* Germplasm being basic and essential for crop improvement, 5,846 accessions of crops and their wild relatives were collected through 85 explorations in different parts of the country. And 22,964 accessions were added to the National Genebank. More than 785 varieties/landraces of 12 crops have been fingerprinted.

During the year, 11 varieties of rice, 16 varieties of wheat, four varieties of barley, 11 cultivars of maize, one variety each of fingermillet and foxtail millet, one variety of grain-amaranth and two varieties of buckwheat have been released for cultivation in different parts of the country. In forage crops, three varieties of oats and one variety each of cowpea, *anjan* grass and berseem have been released for cultivation.

In oilseeds, one variety of sesame has been recommended for cultivation in rainy season. A protocol has been standardized for anther culture in groundnut. And identified signature markers for the first time in castor to establish hybrid purity, besides establishing transformed pigeonpea plantlets by rooting and micro-grafting. In pulses, one variety each of mothbean, horsegram and cowpea have been released and notified for commercial cultivation. Among commercial crops, two varieties of jute and one variety each of mesta and sunnhemp have been released and notified for cultivation. Two *arboreum* varieties of cotton and one hybrid each of intra-*arboreum* and intra-*hirsutum* cotton have been notified for commercial cultivation.

During the year, 4,341 tonnes of breeder seeds of main crops were produced. National Test Guidelines for Distinctness, Uniformity and Stability for economically important crops were developed raising their number to 35. To promote biocontrol of crop pests, *Crytolaemus montrouzieri* could be mass reared successfully on *Sitotroga cerealella* eggs and *Puccinia spegazzinii,* a fungal biocontrol agent, is ready for release in Kerala and Assam.

The production of major horticultural crops during 2005–06 is estimated to be 178 million tonnes with a share of nearly 57 million tonnes of fruits and 99 million tonnes of vegetables. The spices, plantation crops and flowers comprise a little over 20 million tonnes. Our country has emerged as the second largest producer of fresh fruits and vegetables in the world, besides being the largest exporter of spices and cashew.

Udhayam (ABB) variety of banana has been released that yields 40% more than Kapuravalli. Fruit production in arid zone is important to improve nutritional security, promote agricultural diversification and supplement farmers' income. The research efforts have led to development of eight cultivars of ber with tolerance to frost, and storage of aonla for 30 days at 6–7°C with negligible loss of total phenols and flavonoids. In temperate fruits and nuts, apple cultivars Oregon Spur, Golden Spur and Prima gave good yields in rainfed areas at Mukteshwar (Uttaranchal). Walnut landrace LG 5 has potential for commercial exploitation.

In vegetables, 26 varieties (five each in tomato, okra and pea, two each in cowpea and radish and one each in brinjal, chilli, Frenchbean, cauliflower, muskmelon, ash-gourd and pumpkin) have been identified for release. Besides, a tomato hybrid Arka Ananya, a brinjal hybrid Arka Anand and two chilli hybrids Arka Meghana and Arka Sweta have been identified for release. A high-yielding, single spore selection SSI 4035 of *Agaricus bisporus* has been recommended for commercial release. High-yielding *Pleurotus flabellatus* hybrids have been developed. Cultivation technologies of *Lentinula edodes* and *Flammulina velutipes* and techniques for modified atmosphere packaging to improve shelf-life of *Agaricus bisporus* have been standardized.

Potato hybrids Kufri Himalini and Kufri Chipsona 3 have been recommended for release. Six varieties of tuber crops (Goutam, Sourin and Kishan of sweet potato; Panisaru 1 and Panisaru 2 of colocasia, and Orissa Elite of greater yam) have been recommended for release for general cultivation in Orissa. Perfection of cold water miscible starch technology from cassava and release of its product as 'Texcool', preparation of instant gulab-jamun mix from sweet-potato and its release as 'Nutrigulab jamun mix', and characterization of musilages from taro, tannia and yams having pharmaceutical effects, are other important findings.

Floriculture is an upcoming sector with export potential. The research efforts led to development of an interspecific hybrid of carnation CS1, between *Dianthus caryophyllus* and *D. chinensis* for field cultivation. In jasmine, four pruning treatments prolonged flowering and staggered pruning at monthly intervals resulted in continuous flowering during lean period. DAS ELISA method has been standardized for detection of CMV infection in vanilla plants. Six new varieties of coriander, cumin, fennel and fenugreek; six varieties of black pepper and turmeric and five entries of nigella, dill and *ajowan* have been identified and recommended for state release.

*Natural resource management:* The management of natural resource is essential for sustainable food and nutritional security. Safeguarding environment implies overall well-being of the people. Soil-resource survey and mapping of 12 districts of nine states was done for land-use planning, and a detailed soil survey of 15 watersheds/farms has been completed for their land-use planning. Eco-friendly and sustainable land-use models have been identified for 16 watersheds, covering 5,258 hectares from dry semi-arid to sub-humid. Salt-affected soil databases of Rajasthan, Madhya Pradesh, Gujarat and Andhra Pradesh have been digitized, which would help in planning salinity management.

The resource conservation technologies are now spread to over 2 million

hectares of the Indo-Gangetic plains. Direct-seeded rice and sesbania co-culture (brown manuring), followed by zero-till wheat and other upland crops (chickpea/lentil/mustard) have exhibited tremendous scope for their acceptability in rice-wheat production system. Continuous contour trenches with *Stylosanthes scabra* + *Gliricidia maculata* as vegetative barriers proved most effective in minimizing run-off and soil loss in coastal Goa. An indigenous cost-effective technique has been evolved for preparing broad-bed and furrow (BBF) that has replaced costly BBF maker.

Research in integrated water management resulted in development of OPTALL model for canal-water management, improvement in quality and yield of banana with drip irrigation coupled with fertilizers, better fruit yield and quality of kinnow with supplemental irrigation and *sal*-leaf mulching, and economically viable participatory water management in foot-hills of western Himalayan region.

A new PGPR strain *Bacillus megaterium* isolated from rhizosphere of apple seedlings could fix atmospheric N, solubilize P and inhibit white rot of apple caused by *Dematophora necatrix*.

Under cropping or farming system, groundnut gave about 160% higher yield than check in Goa and showed promise for hilly terrains or as an intercrop in cashew plantation. Khedbrahm accession of henna has been found high yielding with 1.87% lawsone content. More than 500 cuttings of *guggal* (*Commiphora wightii*), a gum-resin yielding shrub, after dipping for a few seconds in 5,000 ppm IBA solution, have been transplanted successfully in field. Zero tillage significantly reduced population and dry matter of weed in rice-wheat system. Integration of 2, 4-D (1.5-2.0 kg/ha) or glyphosate (2.0–2.5 kg/ha) with bioagent (*Neochetina* sp.) controlled two waves of water hyacinth and significantly reduced herbicide load in aquatic environment.

*Animal sciences:* India continues to enjoy the position of world leader in milk production with 90.7 million tonnes in 2004–05, and with a production of 45 billion eggs, India ranks among the top six egg-producing nations. Poultry today is one of the fastest growing agricultural segments. Under the livestock and poultry improvement and management, genetic resource database was prepared, and this system also provides raw data for further analysis. Phenotypic characterization of several indigenous breeds of cattle, buffaloes, sheep, goats, poultry, camels and horses was completed in their home tract. DNA polymorphism revealed high genetic variability in Marwari equine population which may be exploited by equine breeders.

Genetic selection and breeding showed superior juvenile body weight of Naked Neck to normal birds. Embryo culture system was studied to make hatching observations, as its understanding has relevance to both medical and poultry sciences. The HSRBC and HCMI lines of poultry showed higher Newcastle disease vaccine response among different divergent immune-response lines.

In Frieswal cattle, farm, season of calving and year of birth were the main factors affecting age at first calving, highest milk yield 300 days, peak yield etc. Under field progeny testing programme, a decreasing trend was observed in calving age of Frieswal daughters born from first to fourth set of bulls. Nili Ravi

buffalo showed an improvement over the years in wet average, herd average and 300-day-milk yield. A survey was conducted to document the status of pigs in eight states of North-east including Sikkim. Duroc breed was used to produce pigs having lean meat with 60–70% less fat than Large White Yorkshire breed.

The field situation demands a need to change vaccine strains in case of FMD type A. Complete nucleotide sequence of several Asia 1 field isolates of FMD was determined. Immune response was assessed in sheep for early diagnosis of haemonchosis. Other achievements in animal health are: development of *Babesia equi* specific ELISA, reliability of abortus bang ring test for detecting brucellosis in mithun, sequencing of matrix gene of Indian isolate of avian influenza virus (H9N2), and development of sensitive diagnostic techniques and effective vaccines for several prevailing diseases.

The work carried out under animal nutrition led to transfer of technology for detoxification of castor-cake for commercialization, increase in cattle-milk yield on feeding of encapsulated choline-chloride, reduction in methane production on addition of brono-chloromethane capsule in diet of rams, and improvement in micronutrients and mineral-dependent enzymes in sheep on inclusion of Cu and Zn in appropriate amounts in diet.

*Fisheries:* India is the third largest producer of fish and second largest producer of inland fish in the world and provides livelihood to 11 million people in the country. In marine fisheries, the first phase of the National Marine Fisheries Census, 2005, was successfully completed in all the coastal states except Tamil Nadu. In inland sector, a river and reservoir database management module system was developed.

In area of culture fisheries, a portable fiberglass reinforced plastics (FRP) hatchery for carp production was developed that could be easily operated by small fish-farmers. Success has been achieved in breeding of an endangered yellow catfish *Horabagrus brachysoma* and of spiny eel *Mastacembelus aculeatus* under captive conditions. Breeding and culture technology of an endangered catfish pabda (*Ompak pabda*) has been developed. A highly nutritious starter-M, a weaning feed was developed for baby magur.

In coldwater fisheries, a computerized database of upland fishes of India was developed for proper management and conservation of native fish germplasm. Development of broodstock of rainbow trout *Onchorynchus mykiss* and formulation of feed for golden mahseer (*Tor putitora*) are significant achievements in upland aquaculture. The research carried out under brackishwater aquaculture led to improvement in traditional culture of tiger shrimp, molecular characterization and diagnosis of Indian strain of white muscle disease virus of giant freshwater prawn, and release of a nested RT-PCR diagnostic kit for *Macrobrachium rosenbergii* nodavirus.

Development of a low-cost mussel seeder for seeding mussels and a mussel harvester to strip mussels from culture ropes, preparation of a national mussel seed calendar, formulation of a cost-effective, bio-enriched feed for ornamental fish, and development of an economically viable, eco-friendly, easy-to-transport pellet feed for mud crab fattening are expected to give further boost to mariculture.

In fish harvest and processing technology, a corrosion-resistant, light weight LOA aluminium boat for reservoirs and rivers and a fish tunnel dryer using solar energy were developed. The process parameters for curing jelly fish were standardized. The activities undertaken in R&D programme in North-Eastern region include survey of fish fauna in river and lakes in Arunachal Pradesh, demonstration of cage culture in NEH states, training to rural artisans of NEH region on harvest and post-harvest technology. In Island development programmes, technical details were given to the Directorate of Fisheries, Andaman and Nicobar Islands in introducing FRP boats to help fishermen in the wake of the destruction caused by tsunami.

*Agricultural engineering:* In agricultural engineering a number of implements such as check-row planter, semi-automatic three-row plug-type vegetable transplanter, turmeric digger, rotary field shredder for sugarcane, and two-row pit digger for ring planting of sugarcane for high cane productivity, multi-purpose implement for sugarcane and banana stem-shredder have been developed as tractor-operated machinery. Under power tiller-operated machinery, PAU light-weight power tiller, earthing-cum-fertilizer applicators, manure spreader and shredder-cum-*in-situ* incorporator have been fabricated. In case of self-propelled machinery, PAU light-weight boom sprayer, tree climber and a prototype of simple manually-operated machine for making bamboo sticks have been developed.

Paddy sowing in hills with six-row manual type rice transplanter saved 68% in cost of transplanting including nursery raising. Recovery of high quality low fat degermed maize on pearling, evolvement of a technology for processing of wild pomegranate for quality *anardana*, fabrication of integrated paddy dryer for fast drying, development of pedal-operated peeler for rural level production of potato chips, standardization of process and recipe for soy-fingermillet-based biscuit, preparation of tofu-based vegetarian *kabab*, development of copra dryer, and commercialization of arecanut dehusker are significant achievements in post-harvest engineering technology.

An operator-friendly improved double roller gin has been developed which consumes 30% less energy than conventional machine for cotton. Stick machine and saw band cleaner could effectively improve cotton-lint grade without any deleterious effect on fibre attributes. Particle boards have been prepared from date-palm leaves—a viable substitute of wood or plywood products—for multiple uses. A portable sunflower threshing device has been developed that saves 25% in time and reduces drudgery of women-worker. Gas-fuelled automatic control dryer was designed and developed and found most suitable for maintaining natural colour and quality of products of aonla, curry leaf, drumstick leaves, medicinal and dye-yielding plants like senna and henna.

An electronic weighing machine for animals having capacity of 1,500 kg that can be transported easily on a jeep trailer is ready for commercial use. Dewatering machine for digested slurry from biogas plants and pilot plant for anaerobic digestion of rice straw have been developed.

In irrigation and drainage engineering, a low-cost equipment for nutrient management through micro-irrigation system has been developed, besides

fabrication of screen filter for micro-irrigation system in greenhouse. Technical feasibility and economic viability of mole drainage technology for enhancing productivity of soybean in Vertisols was assessed.

*Agricultural education:* Under agricultural human resource development, Memorandum of Understanding (MoU) with the IGNOU for co-operation in agricultural education in distance mode and co-operation with the ISRO, IGNOU and MHRD for utilization of the EDUSAT by the ICAR and SAUs for agricultural education are new initiatives which have immense potential for enriching agricultural education as well as to reach the unreached. The ICAR has provided financial support to the State Agricultural Universities (SAUs) for development of under-graduate (UG) and post-graduate (PG) programmes to expand and improve quality and utility in agricultural education and training. During the year, 151 students from 25 foreign countries were admitted to various degree programmes in ICAR-Deemed-to-be Universities (DUs) and SAUs. In diverse disciplines of agriculture and allied sciences, 3,305 scientists or faculty members were trained in Centres of Advanced Studies and Summer/Winter Schools/Short Courses. Best Teacher Award was given to 27 faculty members of SAUs and ICAR-DUs.

On the basis of the merit, National Talent Scholarship (NTS), Senior Research Fellowship, Junior Research Fellowship were awarded to 1,204, 202 and 475 candidates. For the first-time 2% of the total seats were reserved for candidates from 11 underprevileged states, not having any agricultural university, and the NTS of Rs 800 enhanced to Rs 1,000/month was awarded to all candidates who joined universities outside their state of domicile.

Under *Social Sciences and Policies*, present situation of agricultural markets in India has indicated a need to attract big business to invest and operate in bulk buying and selling, which would give better deal to consumers as well as producers. WTO agriculture negotiations vis-à-vis South Asia countries were studied and it was suggested that measures like export credit guarantee and insurance should be allowed only to developing countries. Stagnation in public investment in agriculture is affecting agriculture growth. Determinants of capital formation and agriculture growth were discussed and it was found that GDP agriculture is affected by both capital formation and subsidies, besides terms of trade.

*Agricultural extension:* For assessment and refinement of technology through the demonstration of technologies/products, the Council has established a network of 503 Krishi Vigyan Kendras (KVKs) in SAUs, ICAR institutes, NGOs, state governments and other institutions. At KVKs, 1,318 technologies were taken up for on-farm testing. A large number of demonstrations of production technologies on various aspects of crop production in oilseeds, pulses, cotton, other crops and dairy, sheep, goats, poultry, piggery etc. were organized. The KVKs also organized 37,963 training programmes, benefiting 680,000 farmers and farmwomen, 163,000 rural youth and 84,925 in-service personnel. And to accelerate the process of dissemination of technologies, extension activities such as field-days, *kisan melas* and discussion fora, film shows and diagnostic services

etc. were also organized, covering 2.43 million farmers. Advisory services were also provided to 127,594 farmers and other users. At KVKs, 5,322.5 tonnes of seed of major crops; 5.225 million saplings/seedlings of fruits, plantation crops and forest species; and 23,321,176 livestock strains were produced for availability to farmers.

Organizing self-help groups, followed by skill development trainings helped farmwomen to set up different enterprises in agriculture. Nearly 212,000 farmwomen and 64,394 rural girls were given training on crop production, horticulture, home science, livestock production/management etc, besides 27,076 farmwomen and rural girls trained through sponsored training programmes. Ten nutritious recipes based on cereals, pulses and nuts were developed and evaluated for their acceptability.

*Hill and tribal areas:* Due attention was paid on agricultural research planned specially for tribal and hilly regions to meet needs of farmers of these regions. Two hybrids and one composite in maize were released from the Vivekananda Parvatiya Krishi Anusandhan Shala, Almora. Besides, four varieties in rice, two varieties in tomato and one variety each in maize, fingermillet, fieldpea, lentil, soybean, horsegram, toria and vegetable pea were identified for release. Popularization of polyhouses for year-round cultivation of high-value vegetables, identification of different crop varieties suitable for organic-farming conditions, development of light-weight, rust-proof, pedal-operated paddy-thresher-cum pearler, and identification of new bacterium *Paenibacillus koreensis* possessing vast potential for white-grubs management in hill region are other findings worth-mentioning.

At the ICAR Research Complex for NEH Region, Umiam, a protocol was developed for *in-vitro* conservation and cryopreservation of wild rice. Soft-wood grafting was standardized in Khasi mandarin with a success rate of more than 90%. The other achievements are establishment of hatcheries in three stations to popularize Vanaraja birds in NEH region, development of DOT-ELISA-based diagnostic kit for identification of specific gastro-intestinal parasitic infection in goat and cattle and preparation of cost-effective package of practices for commercial production of exotic ornamental fishes.

The research efforts made at the Central Agricultural Research Institute, Port Blair, led to the development of putative transgenics in rice, allocation of indigenous collection numbers to 26 species of underutilized fruits, 15 orchids and 10 ferns and ornamental plants, and standardization of technology of composting coir pith and dried leaves using *Pleurotus* and urea. Fabrication of coconut dehusker for Nicobari tribals and solar dryer to trap solar energy and to improve quality of copra, achievement of captive breeding in *A. ocellaris* fish in laboratory are some of the other significant findings. Besides, impact of tsunami tidal waves was assessed on agricultural lands and suitable technologies were suggested for rehabilitation of affected farmers.

To improve working environment and to make research effective, efficient and relevant, the Council has taken several initiatives under the organization and management. The ICAR has decided to delegate powers to Directors of the

ICAR institutes to file patent applications under the Intellectual Property Rights. Forty new patent applications have been filed with Patent Office, New Delhi.

The Budget Estimates (BE) and Revised Estimates (RE) of the DARE and ICAR (Plan and Non-Plan) for 2004-2005 were Rs 17,533.10 million and Rs 16,750 million respectively. The BE for 2005–2006 (Plan and Non-Plan) is Rs 19,420 million. The Council announced 53 awards in 12 categories to honour 46 scientists, four farmers, one journalist and one co-ordinated research project. Financial assistance was given to 65 scientific societies and 12 academic universities/institutions for publication of journals and for conducting seminars/ symposia/conferences.

The DARE and ICAR have been operating partnership and linkages at the national and international level in agricultural research and education through the Memoranda of Understanding (MoUs), Agreements, Work Plans, Projects, Training Courses, Exchange Visits etc. Three MoUs/Agreements were signed between the ICAR and Brazilian Agricultural Research Corporation, the Government of India and Government of the Republic of Afghanistan, and Government of India and United States Department of Agriculture.

Under the international linkages, 18 projects have been approved/initiated. Delegations led by Vice Minister of Education of Ethiopia; President of the Walloon Parliament at Nimur, Belgium; Deputy Minister of Agriculture, Planning and Finance, Government of Islamic Republic of Iran; Deputy Minister of Agriculture, Chile; Deputy Minister of Food and Agriculture, Ghana; Minister for Rural Rehabilitation and Development, Afghanistan; Minister of Agriculture, Water and Forestry, Namibia; Director-General, IRRI, Manila; Director-General, FAO, Rome, besides others visited India. Indian scientists visited foreign countries for participating in international conferences/trainings to understand recent developments in agriculture and allied subjects.

The Directorate of Information and Publications of Agriculture (DIPA) brought out 40 publications in English and 15 Hindi. Two research journals, viz. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, and semi-technical magazines/newsletters, viz. *Indian Farming, Indian Horticulture, ICAR News, ICAR Reporter, ARIS News, Kheti, Phal-Phool* and *Krishi Chayanika,* were also brought out. A new expanded edition of *Handbook of Agriculture* with several new topics has been published. The two quarterly periodicals, *Indian Horticulture* (English) and *Phal-Phool* (Hindi), have been made bimonthly, w.e.f. January 2006. On the occasion of 75th anniversary of the two research journals (which are indexed in AGRIS, *Science Citation Index*, *Current Contents* etc.), research review articles were included in each issue. The *Indian Farming* and *Kheti* brought out special issues on World Food Day. Keeping the mandate of the Directorate for dissemination of information on the latest developments in agriculture, the semi-technical magazines also published accent numbers/dedicated issues on themes such as subtropical fruits, vegetable cultivation, flowers. The DIPA earned more than Rs 5 million through sale of its publications, advertisements etc., and also participated in various exhibitions.

The DIPA has developed CDs containing full text of articles of 60 issues of *Indian Farming* and 40 issues of *Indian Horticulture*. Two abstract journals, viz. *Abstracts of Indian Journal of Agricultural Sciences* and *Abstracts of Indian Journal of Animal Sciences,* were also published. *Directory of Conferences, Seminars, Symposia; Workshops in Agriculture and Allied Sciences*, *ICAR Telephone Directory 2006*, etc. are available on ICAR website.

Increased productivity, greater value-addition and cost and quality competitiveness will definitely provide to our farm exports. In addition, it is also necessary to give priority to strengthening the input delivery system, scientific water management, expansion of irrigation facilities, improving agronomic practices etc. The country can sustain growth rate with equity only when rural incomes rise, as 60% of the population earns their livelihood from farm and related activities. Substantial and innovative production system research on farmers' fields has made a greater impact on productivity enhancement, cost effectiveness, profitability and employment and income generation.

A detailed account of the DARE/ICAR activities, carried out during the year are given in this report. It is sincerely hoped that the information provided in this publication would find use with the stakeholders in the national endeavour of strengthening agriculture in the country and making it an instrument of economic transformation particularly in rural areas.

(MANGALA RAI)
Secretary, DARE and Director-General, ICAR

# Salient Achievements

# 2. Salient Achievements
## Crop Improvement and Management

**Germplasm exploration and collection**

Total of 5,856 accessions were collected through 85 explorations undertaken. These accessions comprise cereals and pseudocereals (930), millets and minor millets (255), pulses (1,073), oilseeds (503), vegetables (1,449), horticultural crops (608), fibre crops (60), spices and condiments (23), forages (53), medicinal and aromatic plants (736) and other crops (156) – representing 4,671 cultivated and 1,185 wild accessions. Herabarium specimens 1,186, comprising 164 taxa, were added to the National Herbarium of Cultivated Plants.

Accessions, totalling 16,900, including 43,885 samples of international trials and transgenics, were introduced from various countries, and 5,409 accessions were exported. Inland supply of germplasm comprised 7,217 samples.

*Hippophae rhamnoides* collected from Ladakh region

**Plant quarantine**

Trial materials and germplasm lines 43,885 were processed for quarantine clearance. Of the 3,232 samples found infested/ infected with pests, 2,992 have been salvaged.

Transgenic planting sample materials totalling 6,690 (*Gossypium* spp., *Oryza sativa*, *Solanum tuberosum* and *Zea mays*) were processed for quarantine clearance. Pests intercepted in *Oryza sativa* from Singapore were *Cryptolestes ferrugineus*, *C. pusillus*, *Sitotroga cerealella*, *Drechslera oryzae* and *Phoma glumarum*.

Phytosanitary certificates numbering 136 were issued for germplasm export.

Indigenous 2,902 seed samples were processed for pest-free conservation. Of the 225 samples found infested/ infected with insects and pathogens, 200 were salvaged, and total of 2,887 samples have been released.

In the field surveys in Haryana, Madhya Pradesh and Uttaranchal,

*Lavender* (Lavendula angustifolia) *IC-212822*. This has been introduced in Uttaranchal for extraction of essential oil, apiculture and various other medicinal purposes. So far, more than 20,000 plants have been supplied to progressive farmers of the Central Himalayan Region by the Regional Station, Bhowali, NBPGR

- Salvaged 2,992 samples, out of 3,232 infested samples
- Phytosanitary certificates 136 issued for germplasm export
- At the National Seed Gene Bank added 22,964 accessions of orthodox-seed species for long-term conservation at –18°C
- RAPD and ISSR analyses indicated genetic stability of *in-vitro* conserved *Colocasia* spp., *Curcuma* spp. and *Zingiber* spp.
- Varieties/landraces 787 of 12 crops fingerprinted using AFLP, microsatellite and ISSR markers
- PCR-based detection protocols standardized for *Cry* IA(c) gene in Bt cotton; *Barnase*, Barstar gene for male sterlity in transgenic mustard and *EPSPS* gene for herbicide tolerance in transgenic soybean
- Produced 100 transgenic lines of tomato Pusa Ruby and Pusa Uphar

through group ELISA of leaf samples, bean common mosaic virus infection was found in 1.4–16.34% samples of mungbean and 1.3–28.3% of urdbean, and soybean mosaic virus infection in 0.7–36.0% of soybean samples.

**Germplasm conservation**

At the National Seed Gene bank, for long-term conservation at

EC 530886 *Phaseolus* has been identified for high-podding, is dwarf, and is early in maturing

*Abelmoschus pungens* (wild okra) is being maintained at the Regional Station, Bhowali, NBPGR

Snake-gourd collections

–18°C, 22,964 accessions of orthodox-seed species of cereals (8,294), pseudocereals (481), millets (2,207), forages (630), fibre crops (136), grain-legumes (3,558), oilseeds (4,560), vegetables (1,862), medicinal and aromatic plants (208), spices and condiments (530), narcotics (166) and agroforestry species (332) have been added. In addition, 4,973 accessions have been stored in medium-term storage; 2,856 have been sent for multiplication and 2,420 have been stored for 10 years, besides monitoring for seed viability. Passport data were reviewed for 2,476 accessions. Germination protocols and dormancy breaking methods have been standardized in *Citrullus*, wild species of okra and brinjal, and medicinal plants, *Tephrosia jamnagarensis*, *Desmodium motorium*, *Chlorophytum borivilianum* and *Kigelia pinnata*.

Total of 639 accessions as seeds, embryonic axes, dormant buds and pollen have been cryopreserved. About 100 accessions of fruits and nuts, black-pepper, medicinal and aromatic plants and agroforestry species, cryostored for 1 to 18 years, on retesting have showed that their original viability values are still retained. About 140 accessions of fruit crops, tuber crops, bulbous crops, spices and medicinal and aromatic plants have been added to *in-vitro* gene bank and 1,685 accessions of 47 genera belonging to 125 species are being maintained. Germplasm of *Allium fistulosum*, *Bacopa monnieri*, *Centella asiatica*, *Colocasia esculenta*, *Curcuma longa* and *Mentha* spp. could be conserved *in vitro* up to 6, 15, 10, 17, 11 and 48 months, respectively. RAPD and ISSR analyses indicated genetic stability of *in vitro*-conserved germplasm of *Colocasia* spp., *Curcuma* spp. and *Zingiber* spp.

**Germplasm characterization, evaluation and maintenance**

Accessions 14,685 of various crops have been evaluated/ characterized and maintained. Germplasm accessions identified as promising include pearl millet for basal tillers, spike length and 1,000 grain weight; lentil for earliness; pea for earliness and pod length; *Phaseolus* for high podding, dwarf and early maturity; Indian mustard for long pods and high-oil content; *toria* for earliness and high-oil content; sunflower for broad head size and high-oil content; tomato for higher fruit weight/ plant; *methi* for early green-leaf harvest; *palak* for long and broad leaves and coriander for early green-leaf harvest.

Quality traits analyses have reflected presence of wide variability in percentage oil content in *Brassica* (28.28–44.22%), safflower (25.5–37.4%), perilla (38.72–48.55%), walnut (62.57–73.20%) and sunflower (24.27–51.00%); and percentage protein content in amaranth, (13.91–17.81%), barley (9.89–16.14%), wheat (10.41–19.81%), pigeonpea (17.38–21.50%), chickpea (17.53–28.83%) and cowpea (17.34–26.43%).

**Monitoring Global Plan of Action**

The FAO funded project on "Establishment of Information Sharing Mechanisms for Monitoring the Implementation of Global Plan of Action (GPA)" for conservation and sustainable use of plant-genetic resources was initiated in January 2005. Stakeholders comprising 110-institutes/departments/NGOs in three regions of the country have been identified for providing information.

## DNA fingerprinting

***Cereals and millets:*** Rice varieties 132 have been fingerprinted, employing 30 microsatellite markers. One-hundred-twelve wheat varieties are being DNA fingerprinted using microsatellite markers. Ninety-four accessions of fingermillet have been fingerprinted using ISSR markers.

### Phylogenetic analysis of brinjal

AFLP analyses of *Solanum melongena* and its related wild and weedy taxa have established close relationship between cultivated brinjal and its wild species *S. incanum* and *S. insanum*. And *S. macrocarpon*, *S. sysimbrifolium* and *S. viarum* have showed distant relationship.

***Pulses and oilseeds:*** Released 26 varieties of Frenchbean were analyzed with 12 AFLP and 28 microsatellite markers. STMS profiling of 75 released varieties of soybean and 32 landraces has been completed with 18 microsatellite markers. Ninety-six germplasm lines of pigeonpea have been fingerprinted using selected 12 AFLP primer pairs. Forty-one cultivars and landraces of lentil have been fingerprinted with 5 AFLP primer pairs.

***Medicinal plants:*** DNA fingerprinting has been completed in 21 accessions of *Chlorophytum borivilianum*, 34 accessions of palmarosa and 24 accessions of vetiver, using ISSR markers.

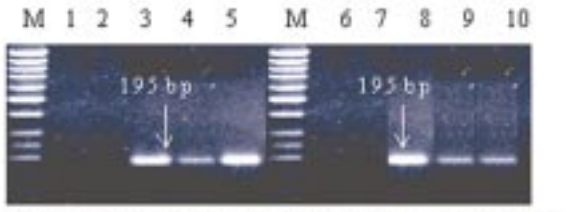
## Plant biotechnology

***Cloning of novel genes and promoters:*** This includes: (i) characterization of genes for protease inhibitor and lectin proteins for insect resistance/tolerance; (ii) identification of several new *cry* genes from native strains of soil bacterium, *Bacillus thuringiensis;* (iii) isolation of defence response genes from mustard; (iv) isolation and cloning of drought stress-responsive transcription factors (*TaCBF5* and *TaCBF9*) from drought-tolerant wheat variety C 306 and (v) cloning of LEA1 cDNA from mustard, which is expressed in response to drought.

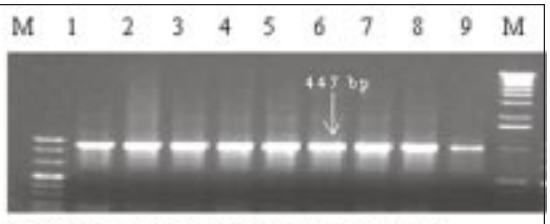
In addition, green tissue-specific promoters (*rbcS3A* and *rbcS*) have been isolated from green-pea and pigeonpea, and characterized by fusion with ß-glucuronidase (GUS) reporter gene expression in transgenic tobacco.

*Productivity enhancement in mustard:* Pusa Jai Kisan and BIO 322-93 are identified as best heterotic female and RLM 198, CSR 499, JMG 401, BIO YSR, BIO 467-95 as best male parents in mustard. Now both CMS and fertility-restoring lines of mustard with alien cytoplasm of *Moricandia arvensis* have been diversified into above-said parents, respectively, by backcross procedure, and BC4 generations could be obtained. Using these diversified heterotic parents, five experimental mustard hybrids have been produced.

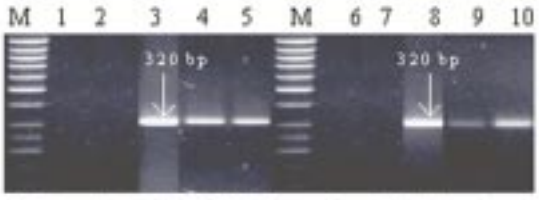
***Genomics and molecular markers:*** Bacterial artificial chromosomes (BACs) 46 of rice were sequenced and submitted to GenBank. Out of these, 44 finished to Phase III (PLN) quality, and 2 BACs have been submitted as Phase I.



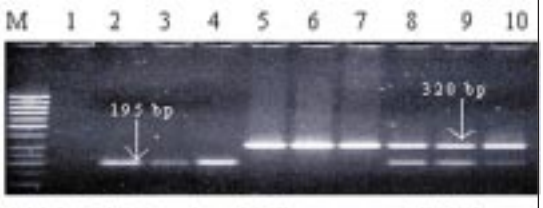

PCR detection of *35S* promoter in GM soybean and GM maize
Lane M-Marker; Lane 1, 2, 6, 7- Negative controls; Lane 3, 8-Positive controls; Lane 4-5, GM soybean and Lane 9-10, GM maize samples




PCR based detection of *Cry1Ac* gene in Bt cotton
Lane M-Marker; Lane 1, Positive control; Lane 2-9, Bt cotton samples

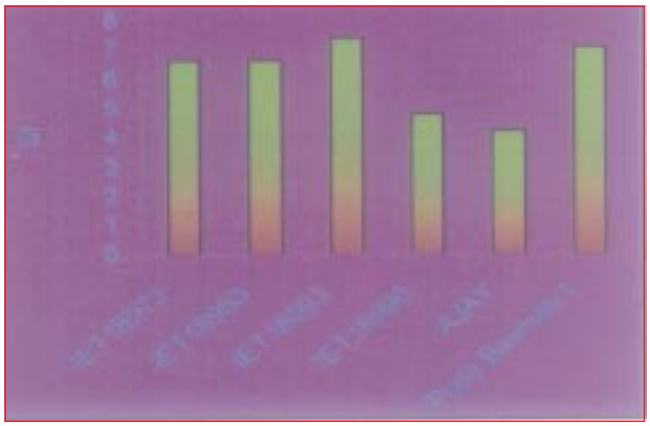



PCR based detection of *EPSPS* gene for herbicide tolerance in GM soybean and GM maize
Lane M-Marker; Lane1, 2, 6, 7- Negative controls; Lane 3, 8-Positive control; Lane 4-5, GM soybean and Lane 9-10, GM maize samples




Multiplex PCR detection of *35S* promoter and *EPSPS* gene in GM soybean
Lane M-Marker; Lane1, Negative control; Lane 2-4, samples with *35S* promoter, Lane 5-7, samples with *EPSPS* gene; Lane 8-10, samples with both *35S* promoter and *EPSPS* gene

A comparative analysis of rice and wheat genes on rice chromosome 11 has revealed common origin of wheat group 4 chromosomes and rice chromosome 11. The Biotechnology centre has also made significant progress in tagging and mapping of important genes in crop-plants and their application in crop variety improvement through molecular breeding. This includes: (i) molecular marker assisted pyramiding and development of varieties (IET 18990) with bacterial leaf-blight resistant genes *xa13* and *Xa21* in rice variety Pusa Basmati 1; (ii) evaluation of molecular markers in *Brassica*; (iii) fine mapping of aroma gene on rice chromosome 8; (iv) identification of candidate gene for fertility restoration in rice; (v) development of microsatellite markers in sugarcane; (vi)use of rep-PCR for identification of



Mean bacterial-leaf-blight disease reaction of aromatic rice line IET 18990 and 3 others with susceptible Pusa Basmati 1 and resistant non-Basmati check

**Comparative yield performance of bacterial-blight resistant rice selection IET 18990**

| Characters | IET 18990 | | Pusa Basmati 1 (Check) | |
|---|---|---|---|---|
| | Delhi | Kaul | Delhi | Kaul |
| Days to 50% flowering | 110 | 117 | 110 | 114 |
| Plant height (cm) | 109.0 | 117 | 119.35 | 127 |
| Grains/panicle | 118.0 | – | 75.0 | – |
| Grain yield (kg/ha) | 4,563 | 4,479 | 3,333 | 3,489 |
| % yield increase over Pusa Basmati1 | 37.50 | 28.37 | – | – |

CMS lines in mustard; (vii) tagging of *Moricandia* fertility restorer locus by AFLP technique; (viii) mapping of QTLs for Basmati quality traits in rice variety Pusa 1121; (ix) mapping of QTL for salinity tolerance in rice line CSR 27; and (x) high resolution mapping and map-based cloning of blast resistant gene *Pik*$^{h}$ in rice variety Tetep.

**Development of transgenics in tomatoes**

Presently more than 100 transgenic lines have been produced of tomato Pusa Ruby and Pusa Uphar using different constructs

Development of transgenic tomato harbouring plasmid PA4 A2 AB: (i) shoot and callus from cotyledon explant of Pusa Ruby (ii) shoot generation after 6 weeks of subculturing (iii) putative transgenic shoots after 8–10 weeks of culture (iv) putative transgenic in rooting medium (v) rooted transgenic in pot (vi) fertile transgenic of Pusa Ruby and Pusa Uphar (vii) wild plant with ripened fruits (viii) putative transgenic with delayed ripening

of anti-sense ACC synthase gene with fruit-specific and constitutive promoters for delayed ripening. Transgenic tomato with expansin gene (*LeExp1*), driven by *LeACS4* promoter, has also been developed with improved texture.

*Plant-microbe interaction:* Microbes are known to synthesize compounds that control plant pathogens naturally in all agricultural ecosystems. With the advent of genetic engineering, it is now possible to isolate genes for antifungal properties and manipulate them for better efficacy against the target pathogen. Microbes were isolated from the soil samples from the IARI rice field (New

**Antagonistic microbes isolated from different soil samples**

| Region | No. of microbes inhibitory isolated ($10^{-2}$) | Microbes showing effect |
|---|---|---|
| Rice field, IARI, Delhi | 45 | Nine |
| Banks of river Ganges, Allahabad | 68 | Nil |
| Bank of river Yamuna, Delhi | 56 | Seven |

**Intellectual property rights**

New patent applications 40 in number have been filed with the Patent Office, New Delhi. Thus, a total of 175 applications for patents have been filed up to December 2005. National Phase applications of the Patent Co-operation Treaty (PCT) application entitled 'Rapid detection of Bt-cry toxin' of the CICR, Nagpur, has been filed for the IPR protection in China, South Korea, South Africa, Uzbekistan and Mexico.

Seventy (70), First Examination Reports (FERs) of patent applications, were received and were examined in the Council, and replies thereof were submitted to the Patent Office within the stipulated time during the year.

Twenty Six (26) Formal Scrutiny Reports (FSRs) were received from the Patent Office Branch, New Delhi, and replies thereof were submitted with the Patent Office Branch, New Delhi within the stipulated time.

A three-day conference on the IPR and Management of Agricultural Research was organized during 27–29 August 2005 at the NASC Complex, New Delhi. Its recommendations have been circulated to all the ICAR Research Institutes/NRCs/PDs/Bureaux.

Delhi), river Yamuna bank (New Delhi) and river Ganga bank (Allahabad) by serial dilution technique effective against the hyphal growth and sclerotial germination of *Rhizoctonia solani*, pathogen of rice, causing sheath-blight disease. Based on their effectiveness, out of 169 isolates, 16 have been found to inhibit growth of fungal pathogen. The IARI isolates were more effective in inhibiting the pathogen as compared to from other regions. Isolates 2w and 2o from the IARI inhibited mycelial growth by more than 40%, and sclerotial germination inhibition was 100%. None of the microbes isolated from river Ganga bank (Allahabad) were effective in inhibiting the pathogen.

## Rice

***Crop improvement:*** Eleven varieties have been released for different ecosystems

*Hybrid rice technology:* PA 6201, EXPH 664, and PHB 71 and KRH 2 hybrids have recorded 12–16% yield advantage over check variety in rainfed uplands. Hybrid MPH 5401 (Suruchi) performed better under moderate sodicity at Karnal (0.8 tonne advantage) and at Lucknow (1.5 tonnes advantage). Three mid-early duration hybrids CRHR 7, CRHR 5 and CRHR 4 are found superior to check Tapaswini by 10–22% under rainfed, shallow lowlands.

***Crop production:*** *Agronomic efficiency of cultivars:* IET 17648 and IET 17655 under rainfed direct-seeded condition and IET 18033 and IET 18004 under transplanted conditions have been found promising in their response to applied nitrogen.

- Released 11 varieties of rice, 5 of wheat, 1 of barley, 11 of maize and 2 of small millets
- Rice hybrids PA 6201, EHPH 664, PHB 71 and KRH 2 recorded 12–16% yield advantage over check variety in rainfed uplands
- Both, System of Rice Intensification and Integrated Crop Management, found equally good with mean grain yield increase of 18% and 17% over normal transplanting
- Identified donors genotypes of wheat and barley for diseases and insect-pests
- In pearl millet, 50% N through urea and 50% N through FYM yielded maximum
- Grain-amaranth BGA 2 for Karnataka, Orissa and Tamil Nadu, and buckwheat Shimla B 1 and Sangla B 1 for mid and high hills of Himachal Pradesh and Uttaranchal identified for release

ADTRH 2 and CNR 3 exhibited tolerance to low P, as these produced some grains even at zero P level during *rabi*, while other test-cultures failed to flower. In *kharif*, IET 14554, PRH 122, Dhanarasi, IET 15358, IET 17467 and IET 17475 could tolerate low P.

*Crop establishment:* As crop establishment methods, System



*CRHR 5 and CRHR 7 rice*. These are mid-early duration hybrids found superior to check Tapaswini by 10–22% under rainfed, shallow lowlands

**Rice varieties released**

| Variety | Days to 50% flowering | Grain type | Ecosystem | Yield (tonnes/ha) | Reaction to pests/ diseases | Recommended state/region |
|---|---|---|---|---|---|---|
| **Central releases** | | | | | | |
| Sugandhamati | 114 | LS | Irrigated | 4.13 | R-NBL, BS | Aromatic, traditional basmati-growing areas of Haryana, Punjab, Delhi and Jammu and Kashmir |
| Pusa Sugandh 5 | 102 | ELS | Irrigated | 4.75 | MR-BLB, ShR, BS, LF | Aromatic, traditional basmati-growing areas of Delhi, Haryana and Jammu and Kashmir |
| Richa | 98 | LS | Irrigated | 4.10 | R-WBPH, LBl, NBl; MR-BS, ShBl | Irrigated and rainfed lowlands of Madhya Pradesh and Chhattisgarh |
| Suruchi (Hybrid) | 100-105 | MS | Irrigated | 5.90 | R-LBl; MR-WBPH | Suitable for irrigated areas of Haryana, Andhra Pradesh, Karnataka, Mahrashtra, Gujarat, Orissa and Chhattisgarh |
| **State releases** | | | | | | |
| Rajendra Sweta | 105 | MS | Irrigated | 4-5 | MR-PH, LF, SB, BLB, ShBl, ShR, BS, Bl | Aromatic, irrigated, medium lands of Bihar plains |
| Lunglinaphou | 85-90 | LS | Rainfed/ Irrigated lowlands | 6.5 | R-LBl, BLB; MR-GM, SB | Suitable for rainfed/irrigated lowlands of Manipur and also for organic cultivation, has good cooking quality |
| Bhogawati | 100 | LS | Irrigated | 4.5 | MR-SB, LBl, BLB | Aromatic, irrigated areas of Maharashtra |
| Kadamba | 105-110 | MS | Irrigated | 6.5-7.0 | MR-LBl, SB | Irrigated areas of southern transition zone of Karnataka |
| Pant Sankar Dhan 3 | 92 | LS | Irrigated | 6.20 | MR-LBl, BLB, BS, RTD, SB, BPH, WBPH | Plains of Uttaranchal (Udham Singh Nagar, Naini Tal, Haridwar and Dehra Dun) |
| Pant Sugandh Dhan 17 | 105 | LS | Irrigated | 4.5 | MR-LBl, NBl, SB Uttaranchal | Basmati-growing areas of Uttaranchal (Udham Singh Nagar, Naini Tal, Haridwar and Dehra Dun) |
| NDR 2026 | 80-85 | LS | Irrigated | 4.5-5.0 | R-BS, ShR; MR-ShBl SB, WM, LF | Uttar Pradesh |

R-Resistant, MR-Moderately resistant, MS-Moderately susceptible; BL-Blast, BLB-Bacterial blight, BPH-Brown planthopper, BS-Brown spot, GLH-Green leaf hopper, GM-Gall midge, LB-Long bold, LF-Leaf folder, LS-Long slender; MB, Medium bold, NBL-Neck blast, SB-Short bold, ShBl-Sheath blight, ShR-Sheath rot, RTV-Rice tungro virus, WBPH-White backed planthopper

Rice Intensification (SRI) and Integrated Crop Management (ICM), were equally good with a mean grain-yield increase of 18 and 17% over normal transplanting. With SRI, hybrids PHB 71, DRRH 1 gave 46–48% higher yield and varieties Tulasi, Rasi, Krishnahamsa and Jaya 5.2 to 17% higher yield.

*Weed control:* Bensulfuron-methyl and Triasulfuron were found highly effective in controlling all types of weeds; being least toxic in transplanted rice. In *kharif*, Triasulfuron alone (0.012 kg a.i/ha) or in combination with Pretilachlor (0.012 + 0.60 kg a.i/ha) have been found effective.

*Post-harvest processing:* Out of the four threshing methods, beating against stone platform, threshing with cylindrical drum, tractor treading and conventional thresher with electric motor, highest percentage of broken rice was observed in treading with tractor. For parboiling, soaking paddy in hot water at 60°C for 3 hours, followed by steaming for 14 minutes and drying increased head rice recovery from 3.2 to 12% over raw rice from all varieties.

***Crop protection:*** Clothianidin at 15ga.i/ha and a combination product of Acetamiprid + Chlorpyriphos at 510 g a.i./ha against brown planthopper; two formulations of Flubendiamide at 24 and 25 g.a.i/ha against leaf folder and stem borer; and acaricide Milbemectin

at 4.5 g a.i./ha against leaf mite have been found effective.

Neem-cake or *Simaruba*-cake at 5 g/kg of soil and root dip + soil drench with 5% and 2.5% seed extract of *Simaruba* effectively checked root-knot nematode population in pot-culture study in greenhouse. Among new fungicide formulations, Azoxystrobin and Kresoxi-methyl are found effective in checking blast severity and increasing grain yield. Propiconazole and Difenconazole combination product was effective in checking blast, sheath blight and glume discoloration at most of the test locations.

*Integrated pest managment:* Pusa Basmati as trap crop in 9 : 1 row ratio reduced stem-borer damage in main crop of Swarna during *kharif* and Krishnahamsa during *rabi* as compared to sole crops.

**Bacterial leaf-blight resistant gene(s) pyramided line(s) of rice**

Bacterial leaf-blight resistant genes (*xa 5, xa 13* and *xa 21*) lines developed in the background of BPT 5204 and Triguna were evaluated for resistance reactions under controlled glasshouse conditions. Cultures B 189, B 226, B 197, and B 210 have exhibited high level of resistance against all isolates tested at five-leaf and maximum tillering stages.

**Wheat and barley**

***Crop improvement:*** Five of wheat varieties and one of barley have been released and notified by the Central Variety Release Committee (CVRC). In wheat, 3 are bread wheat and 2 are durum wheat.

*Varieties released by State Variety Release Committee:* Eleven varieties of wheat and three varieties of barley have been released by the State Variety Release Committee (SVRC).

Wheat HD 2864 developed by the IARI is a late sown, irrigated bread wheat

**Wheat and barley varieties released by the CVRC**

| Variety | Year of release | Developed by | Production conditions | Area of adaptation | Average yield (tonnes/ha) |
|---|---|---|---|---|---|
| | | | **Bread Wheat (*Triticum aestivum*)** | | |
| HD 2864 | 2004 | IARI, New Delhi | Late sown, irrigated | Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh | 4.18 |
| MACS 6145 | 2004 | ARI, Pune | Timely sown, rainfed | Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of north-eastern states | 2.55 |
| SKW 196 | 2005 | SKUAT, Srinagar | Timely sown, rainfed/restricted irrigation | Higher hills of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim and north-eastern states | 2.29 |
| | | | **Durum Wheat (*Triticum durum*)** | | |
| PDW 291 | 2005 | PAU, Ludhiana | Timely sown, irrigated | Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), west Uttar Pradesh (except Jhansi division), Kathua and Jammu districts of Jammu and Kashmir, Una and Paonta Valley of Himachal Pradesh and *tarai* region of Uttaranchal | 4.85 |
| HI 8627 | 2005 | IARI Regional Station, Indore | Timely sown, rainfed/restricted irrigation | Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh | 1.67 |
| | | | **Barley (*Hordeum vulgare*)** | | |
| NDB 1173 | 2005 | NDUAT, Faizabad | Alkaline/saline soils | Entire country | 3.52 |

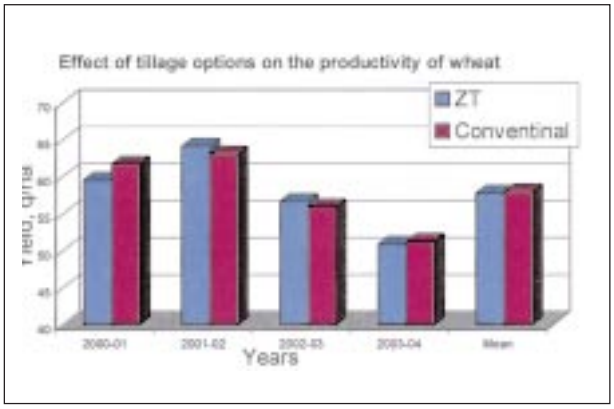
### Wheat and barley varieties released by the SVRC

| Variety | Production conditions | State |
|---|---|---|
| | **Wheat** | |
| K 9423 (Unnat Halna) | Irrigated late and very late sown | Uttar Pradesh |
| HD 2851 (Pusa Vishesh) | Irrigated, timely sown | Delhi |
| WR 544 (Pusa Gold) | Irrigated late and very late sown | Delhi |
| PBW 509 | Irrigated, late sown | Punjab |
| Raj 6560 (durum wheat) | Irrigated, timely sown | Rajasthan |
| Raj 4037 | Irrigated, timely sown | Rajasthan |
| VL 746 (Kailash) | Rainfed, timely sown in high altitudes (above 5500') | Jammu and Kashmir |
| HS 342 (Mansarovar) | Rainfed, timely sown in high altitudes (above 5500') | Jammu and Kashmir |
| SWL 8 (Singchen) | Summer sown in very high altitudes | Jammu and Kashmir |
| NW 1067 | Irrigated, timely sown in saline-alkaline soils | Uttar Pradesh |
| VL 802 | Irrigated and rainfed sown in mid-altitudes | Uttaranchal |
| | **Barley** | |
| NBL 4 (Nurboo) | Summer sown in very high altitudes | Jammu and Kashmir |
| NBL 11 (Sindhu) | Summer sown in very high altitudes | Jammu and Kashmir |
| VL Jau 56 | Rainfed, timely sown in mid-altitudes | Uttaranchal |

Barley NDB 1173 is found suitable for alkaline/saline soils

### Tillage requirement in rice-wheat system

Tillage in rice had no effect on the equivalent wheat yield and tillage in wheat affected mean equivalent wheat yield. For the rice-wheat systems' productivity, rotary tillage in wheat in combination with any of the four tillage options in rice was the best, followed by zero and conventional tillages, and the lowest yield was recorded in FIRBS. The rotary tillage that required single tractor pass for field preparation or puddling resulted in saving on tillage costs with similar yields of rice. The results were converted into equivalent wheat yield by considering a price of Rs 5,600 per tonne for rice and Rs 6,400 per tonne for wheat.




Equivalent wheat yield of rice-wheat system under various tillage options of rice and wheat (mean of 4 years)

| Tillage options in wheat | Tillage options in rice | | | | Mean equivalent wheat yield, tonnes/ha |
|---|---|---|---|---|---|
| | Dry field preparation | | Puddling | | |
| | Rotary tillage | Harrow | Rotary tillage | Harrow | |
| ZT | 12.424 | 12.241 | 12.342 | 12.455 | 12.365 |
| Rotary | 12.765 | 12.637 | 12.633 | 12.740 | 12.694 |
| FIRBS | 11.581 | 11.757 | 11.857 | 11.776 | 11.743 |
| Conven-tional | 12.330 | 12.152 | 12.485 | 12.498 | 12.366 |
| Mean | 12.275 | 121.96 | 12.329 | 12.368 | |

**Bread and durum wheat varieties identified for quality parameters**

***Triticum aestivum* (Bread wheat)**

**Sedimentation Value (>50 ml):** HS 240, HS 420, K 9107, HUW 468, NW 1014, K 8027, HUW 533, GW 273, Lok 1, HW 2004, HI 977, NIAW 34, HI 1500, Lok 45, HD 2781, NI 5439
**Glu-1 Score 4 with HMWGS '20':** C 306, HUW 533, Sujata, HW 2004, MACS 6145
**Glu-1 Score 10 with HMWGS '5+10':** Lok 1, HI 977
**Extraction rate (>72%):** VL 738, HS 277, HS 295, HD 2285, UP 2425, K 8027, Lok 1, GW 322, HW 2004, HD 2189, HI 977, HD 2501, HUW 234, MP 4010, PBW 343, K 9107, HUW 468, DL 788-2
**Iron (>75 ppm):** HUW 533, NIAW 34, HW 1085, NW 1014, HW 2044
**Zinc (>50 ppm):** NW 2036, K 8027, GW 322
**Copper (>5.5 ppm):** HD 2687, HD 2285, GW 173, NW 1014, HW 533, NIAW 34
**Manganese (>50 ppm):** VL 616, HS 277, VL 829

***Triticum durum* (Durum wheat)**

**Sedimentation Value (>35 ml):** WH 896,HI 8498, A 9-30-1
**ß-carotene (>6.0 ppm):** PDW 233, WH 896, NIDW 295
**Iron (>40 ppm):** HD 4672, HI 8627, NIDW 295, A 9-30-1
**Zinc (>40 ppm):** HI 8627, HD 4672
**Copper (>5.5 ppm):** PDW 291, HD 4672, HI 8627
**Manganese (>30 ppm):** PDW 291, A 9-30-1, HD 4672, MACS 1967

**Superior wheat varieties identified for various products**

**Chapati (Score 8.0/10.0):** C 306, Raj 3765, HD 2285, PBW 226, PBW 175, PBW 373 (NWPZ); C 306, K 8027, K 9107, MACS 6145, UP 262, NW 1014, HUW 234, HUW 533 (NEPZ); LOK 1, C 306, Sujata, HI 1500, HW 2004, DL 788-2,GW 173, GW 273, GW 322, Raj 3077 (CZ); LOK 1, HD 2833, GW 496 (PZ)
**Bread (Loaf Volume ~ 575 cc):** HS 240, VL 738 (NHZ); HD 2285, PBW 396 (NWPZ); HD 277, HD 2733, NW 2036 (NEPZ); Lok 1, GW 120, GW 173, GW 190, GW 496 (CZ); HI 977, HD 2189, HD 2501, HD 2781, DWR 162, DWR 195, MACS 2496, Lok 1, NI 5439 (PZ)
**Biscuit (Spread Factor ~ 7.5):** Sonalika (NHZ); UP 2425 (NWPZ)
**Pasta (Score ~ 6.5/9.0):** PDW 233, WH 896, PBW 34, PDW 291 (NWPZ); HI 8498, HD 4672, RAJ 1555, A 9-30-1 (CZ); MACS 2846, DDK 1009, NP 200 (PZ)

NHZ, North Hills Zone; NWPZ, North Western Plains Zone; NEPZ, North Eastern Plains Zone; CZ, Central Zone; PZ, Peninsular Zone

***Crop production:*** In a manually harvested rice field, almost free from rice stubbles, a 4-year study has showed that mean yield of wheat under zero tillage was marginally lower compared to conventional tillage. The yield under ZT was higher for 2 years,

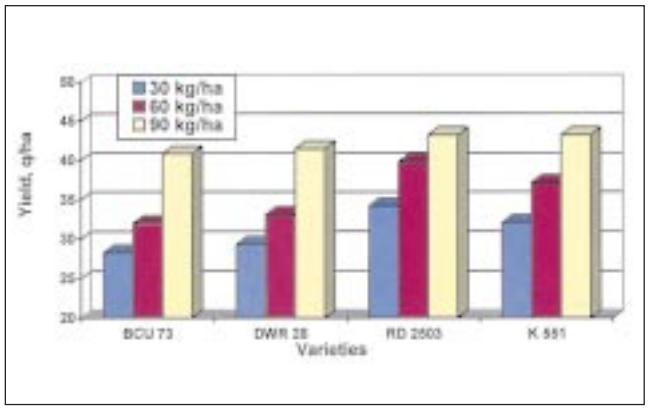
**Resistant genotypes of wheat and barley against diseases and insect-pests**

| Resistance | Varieties |
|---|---|
| **Wheat** | |
| Resistant to stem, leaf and stripe rusts + leaf blight | HD 2867 |
| Resistant to stem, leaf and stripe rusts +moderately resistant to leaf blight | NIDW 295, HPW 217, HPW 224, HPW 228, HS 443, HS 456, HS 460, VL 867, VL 868, HD 2865 |
| Resistant to stem, leaf and stripe rusts +moderately resistant to leaf blight + resistant to karnal bunt | NIDW 309, NIDW 29 |
| Resistant to stem, leaf and stripe rusts +powdery mildew + karnal bunt | TL 2930 (Triticale) |
| Resistant to stem, leaf and stripe rusts+ root aphids + brown wheat mite + moderately resistant to leaf blight | HS 443, HD 2865 |
| Resistant to stem, leaf and stripe rusts+ root aphids + brown wheat mite | UP 2594, HD 2834 |
| Resistant to stem, leaf and stripe rusts+ shoot fly+root aphids | PBW 525, NIDW 295 |
| Resistant to leaf and stripe rusts+ brown wheat mite + shoot fly+root aphids | Raj 6566 |
| Resistant to leaf and stripe rusts+ shoot fly+root aphids | HD 2830, AKDW 2997-16 |
| Resistant to stem, leaf and stripe rusts+ root aphids | HPW 224, HS 456, HS 460, VL 868, PBW 530 |
| **Barley** | |
| Highly resistant to three rusts | BH S355, BH S357, BHS 362, RD 2637, RD 2657, RD 2658, RD 2660, BH 646, RD 2666, RD 2667, RD 2669, RD 2670, BH 364, RD 2658 RD 2552, BH 657, VLB 91, DWRUB 52, |
| Resistant to stripe rust+ stem rust+ leaf rust+ leaf blight | RD 2624, DWR 47, DWR 49 |
| Resistant to leaf blight +cereal cyst nematode | RD 2035 |
| Resistant to stripe rust +moderately resistant to cereal cyst nematode | RD 2624 |

and for other two years, yield marginally higher was recorded in conventional tillage. It can be concluded that zero tillage gives as high yield as realized in the conventional tillage but at lower costs; due to savings of 7% in production cost.

Barley 2-rowed, BCU 73, DWR 28 and 6-rowed, RD 2503 and K 551, evaluated at 30, 60 and 90 kg N/ha have showed that all excepting RD 2503 responded to nitrogen application up to 60 kg/ha only.

*Effect of tillage practices on weeds:* Zero tillage reduced *Phalaris minor* infestation significantly compared to conventional tillage in wheat. Integration of tillage (zero tillage and FIRBS) practices with chemical control proved effective and economical. In long-term trials, reduction in the population of *Phalaris minor* but build up of *Rumex* sp. and *Malva parviflora* was observed. Carfentrazone (new), has been found effective against these weeds. None of the Sulfonylurea herbicides (Metsulfuron, Iodfosulfuron) were effective against *Malva parviflora*.



Effect of nitrogen on barley 2-rowed BCU 73, DWR 28 and 6-rowed RD 2503 and K 551

## Maize

***Crop improvement:*** Eleven cultivars of maize have been released by the Central Variety Release Committee.

**Maize cultivars released**

| Cultivars | Maturity | Grain colour | Area of adoption |
|---|---|---|---|
| Pratap Composite Makka 4 | Early (80–85 days) | White semiflint | Released for Jammu and Kashmir, Himachal Pradesh, hills of Uttaranchal, hills of West Bengal, north-eastern region |
| Pusa Early Hybrid 5 | Early (80–85 days) | Yellow orange, semi-flint | Single-cross hybrid released for Delhi, Haryana, Punjab and Uttar Pradesh |
| Pragati | Early (80–85 days) | Orange semi-flint | Released for eastern Uttar Pradesh , Bihar, Assam, Orissa, West Bengal and Jharkhand |
| Deccan Hyb. 115 | Early (80–85 days) | Orange, flint | Single-cross hybrids released for eastern Uttar Pradesh, Bihar, Assam, Orissa, West Bengal and Jharkhand, Jammu and Kashmir, Himachal Pradesh, hills of Uttaranchal, hills of West Bengal, north-eastern region, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra for *kharif* |
| PRO 345 | Medium (90 days) | Orange, semi-flint | Hybrids released for eastern Uttar Pradesh, Bihar, Assam, Orissa, West Bengal and Jharkhand |
| JKMH 68-2 | Full season (100–110 days) | Orange-yellow, flint | Hybrids released for Jammu. and Kashmir, Himachal Pradesh, hills of Uttaranchal, hills of West Bengal, north-eastern region, Andhra Pradesh, Karnataka, Tamil Nadu, and Maharashtra for *kharif* |
| BIO 9682 | Medium season | Orange-yellow, flint | Released for Delhi, Haryana, Punjab and Uttar Pradesh |
| Pratap Maize Hybrid 1 | Early | White semi-flint | Rajasthan |
| Vivek Comp. Maize 11 | Early | Orange, flint | Uttaranchal |
| Comp. Girija | Medium | Orange, flint | Himachal Pradesh |
| Comp. Sharadhamani | Medium | Orange, flint | Uttar Pradesh |

***Crop production:*** To reduce waterlogging impact 25% nitrogen, 10 days after sowing plus 50% at knee-high stage + 25% at tasselling stage or in combination with 3% urea spray 45 days after sowing is recommended.

Nitrogen at 120 kg and plant spacing of 15 cm has been found optimum for sweet-corn production in peninsular zone and 180 kg N and 10 cm spacing for baby-corn production. For popcorn, 120 kg N and 20 cm spacing has been found profitable for quality production.

***Crop protection:*** Maize genotypes 6 have been identified for tolerance to biotic stresses.

**Maize genotypes tolerant to biotic stress**

| Genotypes | Tolerant to |
|---|---|
| Bio 22060 | MLB, TLB, BSDM, CR |
| JH 10655, IC 0301 | RDM, SDM, BSDM, CR, BS |
| BIO 31006 | RDM, DM, ESR, CR |
| PHS 79 | BSDM, ESR, CR, BS |
| JKMH 1701 | MLB, BSDM, PFSR |

BS, Brown spot; BSDM, Brown striple downy mildew; CR, Common rust; DM, Downy mildew; ESR, *Eriwinia* stalk rot; MLB, Maydis leaf blight; RDM, Rajasthan downy mildew; SDM, Sorghum downy mildew; TLB, *Turcicum* leaf blight; PFSR, Post-floweing stalk rot

**Sorghum**

***Crop improvement:*** *SPV 1616 (dual-purpose variety):* This variety has been identified for release in Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh and Uttar Pradesh (Bundhelkhand), where both grain and fodder (stover) are equally important.

*SPH 1398 (JKSH 528):* This hybrid has been identified for release for the northern Karnataka, Maharashtra, Madhya Pradesh and Gujarat.

***Crop production:*** Sorghum + safflower at 2 : 1 and sorghum + chickpea at 12 : 3 ratio have resulted in higher sorghum equivalent yield (1,501 and 1,527 kg/ha) compared to sole sorghum (1,434 kg/ha).

***Crop protection:*** Among bioagents *Trichoderma viride*, *T. harzianum* and *Pseudomonas fluorescens* have showed promise in enhancing seed germination and seedling vigour and the effect

SPV 1616 is a dual-purpose sorghum variety identified for Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh and Uttar Pradesh (Bundelkhand)

was superior to chemical control (spray with Propiconazole (Tilt) at 0.02%).

Of the 46 entries of sorghum tested at Port Blair, 11 entries GMRP 97, GMRP 86, GMRP 13, GMRP 78, GMRP 9, GMRP 91, GMRP 65, GMRP 88, GMRP 84, GMRP 94 and BN 1480 are found resistant (disease score of < 2) against grain-mould.

**Pearl millet**

***Crop improvement:*** Two hybrids of pearl millet have been identified for release at the national level.

***Crop production:*** Intercropping of pearl millet with pigeonpea exhibited higher grain and fodder yields over sole crop in South-Central India. Application of 50% N through urea and 50% N through FYM in pearl millet gave maximum grain yield.

***Crop improvement:*** Fingermillet GPU 48 for Karnataka and foxtail millet TNAU 186 for Tamil Nadu have been released. Kodo millet RK13 has been identified at the national level for Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Karnataka, Tamil Nadu and Uttar Pradesh.

**Pearl millet cultivars released**

| Hybrids/Varieties | Areas of recommendation | Mean grain yield (tonnes/ha) | Salient features |
|---|---|---|---|
| HHB 67 Improved | Western Rajasthan and drier parts of Gujarat and Haryana | 2.02 | Extra early maturity, high resistance to moisture stress, resistant to downy mildew |
| Sagar 205 | Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh | 3.24 | Late maturing, superior in grain and fodder yields, resistant to downy mildew |

GPU 48 fingermillet has been released for Karnataka. It matures in 95–100 days and is suitable for late sowing

***Crop production:*** With continuous farmyard manure at 7.5 tonnes /ha, inorganic fertilizer dose could be reduced to half of the recommended without any reduction in the fingermillet yield. In the hills of Uttaranchal,application of only organic manure was sufficient to realize sustainable yield. Intercropping/border hedge cropping of niger along with fingermillet enhanced natural predators, and thus helped minimizing problem of pests in fingermillet.

***Crop protection:*** In foxtail millet SIA 1513, 1535, 1538 and 1548 accessions were tolerant to shoot fly. In barnyard millet VL 196, VL 200, VL 201, K1, TNAU 8 and VL 205 were free from shoot-fly incidence.

***Crop improvement:*** Identified 3 varieties for cultivations: Grain amaranth BGA 2 with a yield of 1.326 tonnes/ha for cultivation in Karnataka, Orissa and Tamil Nadu, and buckwheat varieties Shimla B 1, extra early maturing and Sangla B 1 with a yield of 1.265 tonnes/ha and of medium maturity for mid and high hills of Himachal Pradesh and Uttaranchal.

***Crop improvement:*** Forage crop varieties, one of cowpea, anjan grass and berseem and 3 of oats have been released.

***Crop production:*** Guinea grass + Desmenthus intercropped in 3 : 1 ratio in banana plantation gave higher green fodder (198.43 tonnes/ha) and highest net monetary returns (Rs 93,558/ha/yr) than other combinations.

**Forage crop varieties released**

| Forage crops | Variety | Adaptation region/Agroecology | Green forage yield (tonnes/ha) | Important characteristics |
|---|---|---|---|---|
| Cowpea | UPC 618 | Irrigated summer and rainfed *kharif* in North-West, North-East and Central Zones comprising Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Uttaranchal, Jharkhand, West Bengal, Assam, Orissa, Gujarat and Maharashtra | 30–35 | Resistant to yellow mosaic virus, bacterial blight, collar/root rot and aphids; better crude protein content, drymatter digestibility– non-digestible fibres (%) and acid digestible fibres (%) |
| Anjan grass | Bundel Anjan 3 | Arid and semi-arid tracts comprising Rajasthan, western Uttar Pradesh, Haryana, Punjab, Maharashtra and Andhra Pradesh | 10–12 (dry-matter yield) | Superior in drymatter content and highly suitable for arid and semi-arid situations of the country |
| Oat | Bundel Jai 2001-03 | Tropical and subtropical areas of North-West and South Zones comprising Uttaranchal, Haryana, Rajasthan, Punjab, Andhra Pradesh, Karnataka and Tamil Nadu | 50–55 | Single-cut variety, superior in per day production potential with better quality attributes and leaf-stem ratio |
| | Bundel Jai 99-01 | Temperate and sub-temperate areas in *rabi* | 30–35 | Single-cut variety for Hill Zone; resistant to leaf blight, aphids and lodging. At a par in quality with check OS 6 and Kent |
| | RO 19 | All India (In oat-growing areas) | 50–55 | Superior in forage yield and crude protein yield; has high leaf-stem ratio; is resistant to leaf-blight disease and aphids |
| to Berseem | BL 180 | North-West and Hill Zones comprising Jammu and Kashmir, Punjab, Haryana, Rajasthan, Himachal Pradesh, Uttaranchal, Uttar Pradesh | 30–35 (Hill) 600–650 (NW) | Profuse tillering type, less incidence of stem-rot and root rot; good seed yield, medium sized seeds with bright-yellow colour |

- Identified 5 groundnut varieties, 3 sesame varieties, 1 safflower hybrid and 3 niger varieties
- Developed CS19, a semi-spreading, high-yielding Virginia groundnut, which showed multi-disease resistance
- Saline water of 4 dS/m can be safely used for groundnut
- *Trichoderma* isolates T 071 and T 29 showed more than 50% inhibition of *Aspergillus flavus* growth in groundnut.
- Tingid bug found as new pest of common occurrence on all wild species of sunflower during *kharif*
- *Agrobacterium*-mediated transformation of safflower using constructs harbouring reporter (*GUS*) and selectable marker genes (hpt) optimized
- Registered at the NBPGR, a novel germplasm line B10 YSR of rapeseed-mustard with white-rust resistance and high seed yield and oil content
- In castor, 110 independent transformants are being multiplied and maintained through tissue culture
- Identified first time signature markers in castor that can unambiguously establish hybrid purity

In Faizabad, sowing of berseem in standing rice (no tillage) with seed rate of 40 kg/ha, higher net monetary returns of Rs 33,886/ha were realized as compared to normal tillage.

Fluchloralin applied at 0.90 kg a.i./ha as preplanting incorporation produced highest green fodder (65.85 tonnes/ha) and dry matter (8.48 tonnes/ha) of shaftal with remarkable weed-control efficiency (65.9%) in the north-west situations.

Pearl millet-oat-cowpea fertilized with 75% recommended dose of NPK+10 tonnes of FYM/ha in *kharif* was the best for forage yields; green fodder was 62.49 tonnes/ha and dry matter was 14.62 tonnes/ha), and net monetary returns were Rs 31,288/ha/yr.

In acidic soil, lime + recommended dose of P and K + VAM to *kharif* and *rabi* in rice-bean-oat sequence produced highest forage yield; green fodder-54.19 tonnes/ha and dry matter-11.46 tonnes/ha; and also realized highest net monetary returns of Rs 13,905/ha/yr.

Neem-seed kernel extract spray at 3% either alone or in combination with seed treatment with biocontrol agents, *Trichoderma viride* and *Paecilomyces lilacinus* at 5g/kg or neem-seed powder at 50 g/kg of seed in cowpea intercropped with sorghum/maize, reduced pests, diseases and nematode incidences in an eco-friendly way and increased fodder yields considerably.

## Groundnut

***Crop improvement:*** Germplasm accessions 789, comprising Virginia bunch (HYB): 215, Virginia runner (HYR): 133, Spanish (VUL): 306, and Valencia (FST):135, and unknown: 114, were scored for 6 qualitative and 5 quantitative traits. They exhibited variations for majority of traits. In evaluation of 48 genotypes along with two drought-tolerant check varieties in regularly irrigated and simulated drought conditions, least drought susceptibility index observed was for genotypes JUN 24, JUN 40 and JUN 15 for early-season drought; JUN 13, JUN 4, JUN 20 and JUN 42 for mid-season drought and JUN 26, JUN 34 and JUN 36 for end-of season drought.

On the basis of the desirable combinations of transpiration, transpiration efficiency and harvest-index, 181 breeding lines have been developed and multiplied for conducting further trials for identifying high water-use efficiency lines.

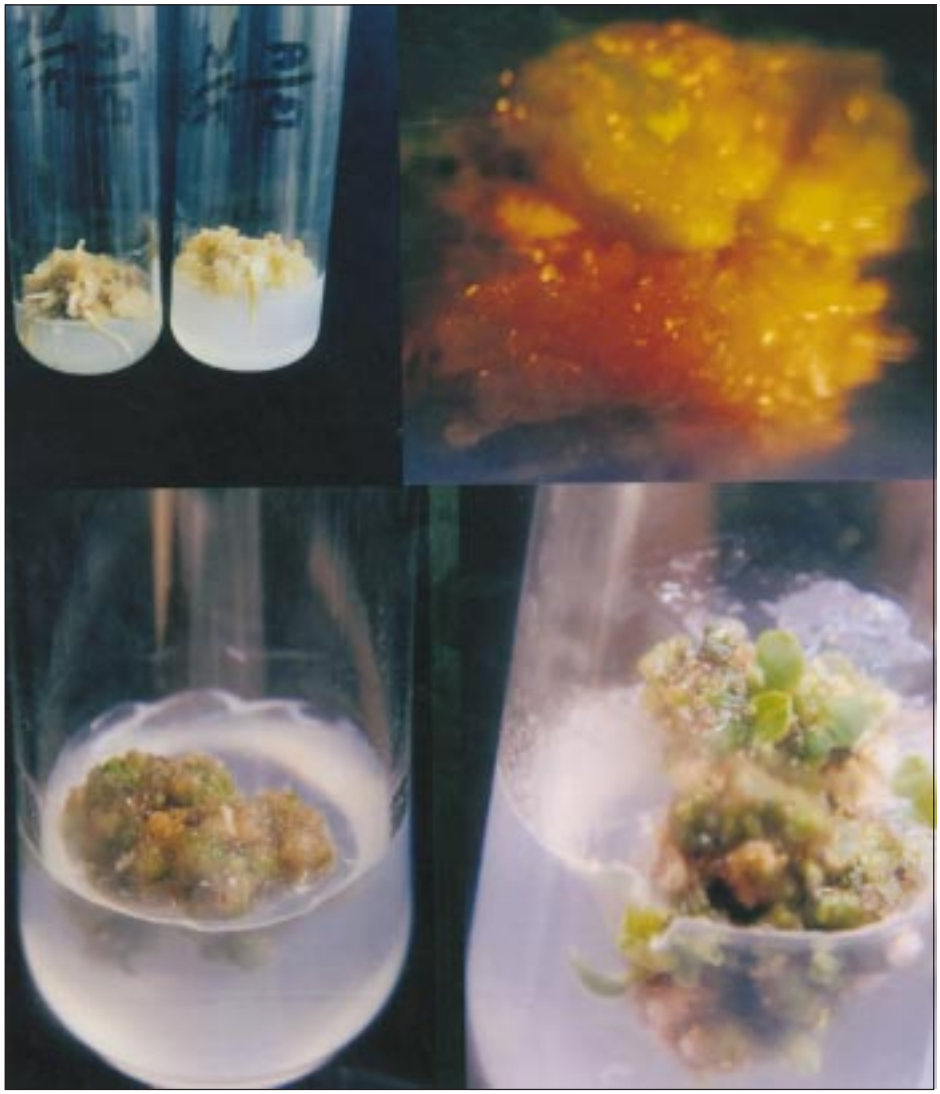
CS 19 (INGR No.04096), a high-yielding (2.0-3.0 tonnes of pod yield /ha) and multiple-disease (stem rot, collar rot, *Alternaria* blight) resistant, semi-spreading, Virginia groundnut has been developed through interspecific hybridization (cv. TMV 2 × *A. chacoense*). The culture has also showed tolerance to early leaf spot, late leaf spot, rust and moderate resistance to peanut bud necrosis disease. CS 19 matures in 120–125 days with 73% shelling out-turn and 46.9% harvest index. Kernels contain 48% oil and 26% protein.

**Groundnut varieties identified**

| Variety | Salient features | Recommended areas/seasons |
|---|---|---|
| J 53 | High-yielding (1,716 kg of pods and 1,193 kg of kernels/ha), early-maturing (106 days), erect groundnut variety | For Maharashtra and Madhya Pradesh during *kharif* |
| JSP 39 | High-yielding (1,992 kg of pods, and 1,338 kg of kernels/ha), early-maturing (119 days) and medium-bold seeded (43 g/100 kernels), spreading groundnut variety | For *kharif*-rainfed areas of southern peninsular states, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala, in addition to southern Maharashtra |
| Dh 101 | High-yielding (2,879 kg of pods and 1,980 kg of kernels/ha), diseases (stem rot, dry root-rot) resistant and insect-pests (thrips, *Helicoverpa armigera*) tolerant, erect groundnut variety | For Zone IV comprising Jharkhand, Orissa, West Bengal and north-eastern states for *rabi*/summer cultivation |
| TG 38 B | High-yielding (2,768 kg of pods and 1,984 kg of kernels/ha), high-shelling (71%) and medium-bold seeded (44 g/100 kernels), erect groundnut variety, tolerant to stem rot | For Zone IV |
| ANDG 50 | High-yielding (2,537 kg of pods and 1,988 kg of kernels/ha), high-shelling (71%) and high-oil content (53%), erect variety, tolerant to thrips | For Zone IV |

**Standardized protocol for anther culture of groundnut**

Callus induction from anthers ranged from 28% to 72% in *Arachis hypogaea* cultivars TMV 2,TAG 24, JL 24, GG 2 and CS 19 and from its wild species *A. glabrata, A. rigonii* and *A. pusilla* in MS medium. Media for shoot differentiation and root induction have also been standardized. Plants have been regenerated from anther-derived calli of GG 2 and TAG 24. Protocols are under testing for repeatability and for production of doubled haploids.



***Crop production:*** Pod yield of *kharif* groundnut was maximum (1,365 kg/ha) in groundnut–wheat–greengram sequential cropping system. Organic-carbon in soil was maximum in groundnut + pigeonpea system, and activities of phosphate solubilizing micorrhiza and fluorescent pseudomonads were higher in groundnut–wheat sequence and least in the sole groundnut; results of a long-term experiment that started in 1998. Groundnut with castor as an intercrop gave higher cost : benefit ratio (1 : 3.76), followed by with sesame (1 : 3.65) and pigeonpea (1 : 3.60). Castor gave the highest income of Rs 39, 492 followed by pigeonpea (Rs 37,848) as compared to control, which gave only Rs 28,940 /ha at Junagarh.

Irrespective of chemical treatment, dry seeding recorded 23.8% higher pod yield in groundnut as compared with sowing recorded with onset of monsoon. Controlled laboratory experiments to evaluate 48 groundnut germplasms have showed that saline water of 4 dS/m can be safely used for groundnut. On the basis of threshold salinity values and relative tolerance, these germplasms were classified into sensitive, moderately sensitive and moderately tolerant genotypes of groundnut. Field demonstrations (20) in 4 villages of Junagadh district revealed that improved method of moisture conservation gave higher pod yield (20.5%) in Spanish cultivar GG5 and in Virginia cultivar GG 13 (23.2%) compared with farmers practice. Additional oil yields of 172 kg/ha in Spanish cultivar and 225 kg/ha in Virginia cultivar were also realized.

***Crop protection:*** Groundnut cultures CS 168, CS 86, PBS 29058, CS 19 and CS 160 have been found to possess resistance against ELS; CS 168, CS 185 and PBS 12169 against LLS and CS 168, CS 151, CS 25, CS 19 and CS 157 against stem rot. CS 168 and ICR 12 have showed multiple disease resistance. NRCG breeding lines (NRCG 1 to 6) have exhibited resistance to LLS and rust at hotspot location (Aliyarnagar) of these diseases. Genotypes PBS 29071 and PBS 14010 have showed high level of resistance to leaf hopper, and NRCG 10628, NRCG 12698, NRCG 10818, ICG 12367, ICG 12620, ICG 12621, ICG 9981, ICG 7846, ICG 15119, ICG 11721, ICG 2462, ICG 3037, ICG 4032, ICG 5403, ICG 9889, ICG 2701, ICG 2748 and ICG 4248 to groundnut

leafminer in field conditions under optimum disease pressure. Seed treatment with *Trichoderma harzianum* at 4g/kg of seed and foliar application of cell-free culture filtrate of *Verticillium lecanii* (a biocontrol agent) together have been found most effective in management of early leaf spot, late leaf spot and rust diseases. Out of 17 isolates of *Trichoderma* isolates T 071 and T 29 have showed more than 50% inhibition of growth of *Aspergillus flavus*. Seed bacterization with consortia of non-fluorescent pseudomonads enhanced pod yield by 18% in JL 24 and by 16% in GG2, rainfed cultivars. Newly identified groundnut rhizobial strains, NRCG4 and NRCG9, have resulted in 14–15% increase in pod yield on inoculation and are found at a par with others, IGR6 and NC92.

**Sunflower**

***Crop Improvement:*** Maximum genetic diversity was obtained line PS 2048, a derivative from a cross involving *Helianthus petiolaris* and cultivated sunflower while maximum phenotypic diversity was detected in PS 4083 and PS 4093, derived from a tri-specific cross involving *H. argophyllus, H. annuus* (wild) and cultivated sunflower.

PKVSH 52, PKVSH 54 and PKVSH 58 at Akola; PEH Kh04-15 at Bangalore; CSFH 4014, CSFH 4032, CSFH 4038, CSFH 4043, CSFH 4089, CSFH 4164 and CSFH 4165 at Coimbatore; SCH 35, TWCH 02-11 and SCH 02-18 at Laturs PSFH 682 at Ludhiana; RSFH 130 at Raichur are identified as superior hybrids. The new populations of GAUSUF 12 and DRSF 113 are found superior for seed and oil yields in multilocation testing.

***Crop production:*** In Alfisols, highest yield of sorghum (4,998 kg/ha) in sorghum-sunflower system was recorded with 150% NPK to both the crops which was on a par with NPK-FYM, NPK-NPK+B and NP-NP. The highest seed yield (2,133kg/ha) of sunflower was obtained with NPK+FYM-NPK, followed by 150%NPK-150%NPK and NPK-NPK+B. Highest sunflower yield (1,535kg/ha) was recorded in mungbean - sunflower sequence, followed by fallow-sunflower (1,531kg/ha), which were significantly superior to sunflower – sunflower (1,253kg/ha) sequence after three cycles.

At Coimbatore and Raichur, in groundnut + sunflower (3 : 1) intercropping, pod yield of groundnut and seed yield of sunflower were significantly highest when groundnut was grown with its RDF in combination with 100% N (50% basal and 50% topdress, along with 100% PK as basal) for sunflower. Similarly in Verisols of Marathwada region of Maharashtra (Latur), fertilizing pigeonpea + sunflower (1 : 1) intercropping system with RDF of pigeonpea on an area basis along with 50% N as basal or as topdressing to sunflower was optimum for realizing higher productivity and profit.

In Vertisols of Raichur district, moisture conservation through opening furrows between rows at 30–35 DAS and with fertilizer dose of 35 : 50 : 35 kg N : $P_2O_5$ : $K_2O$/ha an yield advantage of 52.9% and 31.5%, apart from additional net returns of Rs 4,165/ha and Rs 1,662/ha was obtained over farmers' practice, in *kharif* and *rabi*.

***Crop protection:*** Tingid bug is found as the new pest of common occurrence on all wild species of sunflower during *kharif*. Wild species *Helianthus hirsutus*, *H. strumosus* and *H. tuberosus* showed resistant to highly resistant reaction and KBSH 1 was susceptible to most of the isolates of *Alternaria helianthi*.

Newer insecticides viz., Profenophos 0.05%, Thiodicarb, followed by Indoxacarb 0.015%, Spinosad 0.018% and Novaluron 0.01% are found effective for controlling *Helicoverpa* at most of the locations. Integrated pest management module developed at Bangalore (use of seed treatment with Imidacloprid 70 WS at 5 g/kg of seed + NSKE 5% + HaNPV 250 LE/ha) was eco-friendly and economical for management of *Helicoverpa*.

**Safflower**

***Crop improvement:*** A new safflower hybrid NARI-H 15 has been identified for pre-release multiplication for limited irrigation or assured rainfall regions of safflower-growing areas. Twelve interspecific derivatives derived from crosses between *Carthamus tinctorius, C. lanatus* and *C. turkestanicus* have recorded resistance reaction against *Alternaria* leaf spot under high-disease pressure. *Agrobacterium*-mediated transformation of safflower using constructs harbouring reporter (*Gus*) and selectable marker genes (*hpt*) has been optimized.

Twelve cDNA clones each of *nad3* and *atp9* genes of safflower have been sequenced along with five corresponding genomic clones to identify editing sites. This is the first report of RNA editing in safflower mitochondrial genes. Kill curves for hygromycin, phosphinothricin (PPT) and kanamycin have been worked out, and selection regime for recovery of putative transformants on hygromycin has been achieved.

***Crop production:*** For soybean-safflower sequence at Indore in irrigated areas, there is a need for 100% P to both the crops. However, at Parbhani and Phaltan in irrigated areas and at Solapur and Tandur in rainfed areas, substitution of 100% recommended P with phosphate solubilizing bacteria + 5 tonnes of FYM/ha is possible when one of the crops has received 100% recommended P. At Parbhani, application of $FeSO_4$ at 30 kg/ha resulted in highest yield, and it was comparable with application of elemental sulphur at 5.1 kg/ha.

***Crop protection:*** Germplasm lines GMU 1301, GMU 1105, GMU 1405, GMU 1101, GMU 1284, GMU 1404, GMU 1102, GMU 1364 and GMU 1409 are found tolerant to aphid infestation. Control of aphids only on the periphery of safflower crop (1.8 m all-around the field) with NSKE 5%, followed by Dimethoate 0.05% was economical, compared with complete coverage of the field with

**Improved machinery for soybean**

- A seed coverer attached with seed drill for planting soybean has been developed, refined and validated to ensure optimum emergence.
- Developed and validated BBF seed drill/Key-line furrow machine which can sow four rows of soybean and make channels on both sides of the rows facilitating *in-situ* moisture conservation.
- A tractor-drawn FIRBS seed drill has been developed that consists of an array of alternating ridges and furrows. The ridges are about 20 cm high and 75 cm apart. This tractor-drawn equipment can form two full and two half ridges on which simultaneously six row of soybean can be sown.
- A cross-mechanism attachable to seed drills for straight-row planting of soybean and other crops to facilitate subsequent mechanized cultural operations during crop growth has been developed. The use of the cross mechanism is able to minimize losses of crops from 10–15% to 3–4%.

insecticides. Newer insecticide Thiamethoxam 0.005% provided maximum protection from aphids and highest returns of safflower.

**Rapeseed-mustard**

***Crop improvement:*** Total of 760 lines of toria, 2,243 of Indian mustard, 270 of yellow sarson, 48 of gobhi sarson, 54 of karan rai, 1 of brown sarson, 104 of taramira, 6 of *Brassica tournefortii*, 3 of *B. oleracea*, 4 of *Sinapis alba*, 1 of *B. caudatus*, 12 of Banarasi rai (*B. nigra*), 1 of *Raphanus sativa* and 3 of *B. caudatus* are being maintained through appropriate mating systems. A novel germplasm line, Bio YSR (IC 443623), having white-rust resistance, yellow seed coat, high seed yield and oil content has been registered with the National Bureau of Plant Genetic Resources, New Delhi; thus bringing total germplasm lines registered up to 31 till date.

In view of the low realizable heterosis in available hybrids, attempts have been made to widen genetic base of *Rf* lines using synthetic *B. juncea* and newly introduced germplasm types.

***Crop protection:*** *B. carinata* line NPC 15 and *B. napus* lines NPN 1, PBN 2004-1 are found highly resistant to white rust on leaves as well as for staghead formation across locations, which may be utilized as donors for resistance to white rust and other diseases of mustard, and *B. carinata* line PBC 9221, *B. napus* lines PBN 2001 and PBN 2002 possess multiple (white rust, downy mildew, powdery mildew)-disease-resistant traits and may be used as donors for resistance to these diseases.

Extract of *Allium sativum* bulbs 1% (w/v) and of *Eucalyptus globosus* 1% (w/v) individually has been found to be at a par ($P < 0.05$) with fungicidal check Mancozeb in disease reduction and in increasing yield, and hence either of them can be recommended for *Alternaria* blight and white-rust disease management.

**Castor**

***Crop improvement:*** The wilt-resistant accession RG 1608 (IC 373978, INGR No. 04104) collected from Bihar and *Macrophomina* root-rot resistant accession RG 2722 (IC 306138, INGR No. 04103) collected from Andaman islands have been registered with, NBPGR.

Three hybrids with resistance to wilt (DPC 11 × JI 227, DPC 11 ×JI 258 and DPC 11 × PCS 124) yielded more than best check DCH 177 (2,229 kg/ha) . A total of 110 independent transformants are being multiplied and maintained through tissue culture. For the first time, signature markers have been identified that can unambiguously establish hybrid purity of each of the tested hybrids.

***Crop production:*** Sorghum and pigeonpea yields in intercropping were higher when they were succeeded by castor + clusterbean intercropping. Sole pigeonpea and sole soybean yields were not significantly influenced by preceding castor-based cropping systems. Integrated moisture conservation (key line cultivation and opening furrows between 2 rows at 40-45 DAS) and fertilizer (60 : 40 : 30 kg N : $P_2O_5$ : $K_2O$/ha) practice enhanced seed yield by 25.2% and oil yield by 16.9% with additional net returns of Rs 1,057/ha over farmers' practice. At Sardar Krushinagar, castor raised after *kharif* groundnut or urdbean is more productive system in terms of castor equivalent yield, and the crop responded up to 80 kg N/ha in *rabi*. At Mandor, application of 20 kg S/ha either through SSP or gypsum was found remunerative. At Sardar Krushinagar in irrigated areas, intercropping castor + mungbean and castor + sesame in 1 : 1 or 1 : 2 ratio proved more productive than sole castor. At Sardar Krushinagar, for *rabi* castor raised after clusterbean or cowpea, application of 75% N (fertilizer) + 25% N (FYM) or 50% N (fertilizer) + 50% N (FYM) gave distinctly higher seed yield than N through fertilizer alone.

***Crop protection:*** Spraying Carbendazim + Iprodione 0.1% was found superior and economical (B:C ratio of 4.1) for management of grey rot; recorded lowest disease incidence (6.9%) and maximum seed yield (1,539 kg/ha). The newer insecticides, Thiodicarb 0.075% and Indoxacarb 0.015% were very effective against semilooper and *Spodoptera*, and Spinosad 0.018% was effective against capsule borer at Hyderabad.

**Soybean**

***Crop improvement:*** Advanced breeding lines VLS 59, RKS 24, MACS 985 have exhibited lower level of Lox-I and DSb 6 1, JS 97 52, MACS 1010 and NRC 65 have showed higher level of Lox-I activity.

***Crop production:*** With *in-situ* rainwater management through broad bed and furrow method significantly increased soybean seed yield and S uptake from soils. BBF with FYM and mineral

fertilization produced significantly higher soybean seed yield and S uptake compared to traditional practice. Soybean-wheat-maize-wheat (S-W-M-W) recorded significantly higher yield of soybean compared to S-W rotation. Maize inclusion in crop rotation resulted in significantly higher wheat yield that continuous soybean.

***Crop protection:*** *Bacillus thuringiensis*, chemical insecticides and fungicides have proved effective in field without any adverse effect on the efficacy. Highest grain yield 1,950 kg/ha was recorded with Bt + Methomyl, followed by Monocrotophos alone 1,940 kg/ha and with Bt + Monocrotophos (1,939 kg/ha). The IPM module comprised recommended fertilizers dose, seed treatment with *Rhizobium*, PSB and *Trichoderma viride*, need-cake at 500 kg/ha, bird perches, removal of girdle beetle, tobacco caterpillar and Bihar hairy caterpillar infested plants or plant parts, foliar spray of *Beauveria bassiana* at 1.00 kg/ha and need-based chemical insecticides, Trizophos at 0.8 litre/ha. The IPM plots showed significant lower incidence of insect-pests and also recorded 0.75 tonne/ha more yield than non-IPM plots.

**Sesame**

***Crop improvement:*** *CST 2001-3:* It is a high-yielding, white, bold-seeded, early-maturing variety suitable for *kharif*. It is recommended for Rajasthan, Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Bihar.

*PKDS 11 and OSC 24-95-2-1-3:* These have been identified for summer for Andhra Pradesh, Tamil Nadu, Chhattisgarh, West Bengal and Madhya Pradesh.

***Crop production:*** Technology has been developed for organic cultivation with FYM at 3.75 tonnes/ha + neem-cake at 800 kg/ha+wood-ash at 75 kg/ha + bone-meal at 75 kg/ha + elemental sulphur 20 kg/ha+PSB (5 kg/ha)+ *Azotobacter* (5 kg/ha) + *Trichoderma viride* (0.04%) seed treatment + 3 neem-oil spray (neem oil 2% at 15 and 45 days after sowing), Azadrichitin (0.3%) at 30 DAS.

Sesame intercropped with blackgram 3:1 at Mauranipur and Vrindhachalam has been found promising.

***Crop protection:*** Seed treatment with Thiram (0.3%) or Thiram (0.2%) + Bavistin (0.1%) or *Trichoderma viride/T. harzianum* (0.4%), Bavistin (0.1%) or Apron 35 SD (0.6%); seed soaking in Streptomycin (500 ppm) or Agrimycin 100 (250 ppm) or Streptocycline (500 ppm) for 30 minutes and hot-water treatment at 52°C for 10 minutes, controlled effectively fungal (*Macrophomina*, *Rhizoctonia* and *Fusarium*) and bacterial root-root diseases. Spray Endosulfan 0.07% at 30 days after sowing for control of leaf-roller/capsule-borer and gall-fly (repeat spray at 15 days interval, if need arises), Ridomil MZ (0.2%) or Mancozeb (0.25%) for control of *Phytophthora* blight and Agrimycin 100 (250 ppm) or Streptocycline (500 ppm) bacterial blight.

**Niger**

***Crop improvement:*** JNS 26, JNS 18 and IGPN 9628 have been identified as high-yielding entries.

***Crop production:*** Niger responded up to 20 kg S/ha through different sources at Semiliguda, lgatpuri and Kanke.

Two sprays of NSKE 5% and one spray of Endosulfan 0.07% at Tikamgarh proved effective in controlling leaf-roller/capsule-borer and bud-fly, starting from 15 days after sowing.

**Linseed**

***Crop production:*** For rainfed and irrigated areas many cropping systems have been recommended.

***Crop protection:*** Endosulfan 4% dust at 20–25 kg/ha or Endosulfan 35 EC at 0.07% or Daltamethirin 2.8 EC at 0.002% or Imidacloprid 200 LS at 100 ml/ha have been found promising for leafminer, leaf-eating caterpillar and budfly.

**Linseed cropping systems**

| Areas recommended | Intercropping |
|---|---|
| Rainfed | Linseed + Chickpea (3 : 1) |
| | Linseed + Chickpea/lentil (3 : 1) or (1 : 3) |
| | Linseed + Wheat (1 : 3) |
| | Linseed + Safflower (different ratios) |
| | Linseed + Chickpea/lentil (3 : 1) or (1 : 3) |
| Irrigated | Linseed + Mustard (5 : 1) |
| | Linseed + Wheat (4 : 1) |
| | Linseed + Wheat (4 : 2) |
| | Linseed + Mustard (5 : 1) |
| | Linseed + Potato (3 : 3) |

**Chickpea**

***Crop improvement:*** A mutant BGM 547 of chickpea variety BG 256 and a *desi* variety Phule G 9425 with yellowish-brown seeds have been identified for cultivation in the late-sown areas of north India. Another kabuli variety BGD 128 having resistance to *Fusarium* wilt, dry root rot and stunt has been identified for cultivation in Madhya Pradesh, Maharashtra, Gujarat, parts of Rajasthan and Bundelkhand region of Uttar Pradesh.

Resistant donors for *Fusarium* wilt (IPC 97-29) and dry root rot (IPC 2K-25) have been identified. IPC 2000-17, IPC 2001-20 and IPC 2002-36 have exhibited moderate resistance against *Botrytis* grey mold. A kabuli genotype IPCK 00-112 having resistance to *Fusarium* wilt has been developed through *desi*-kabuli introgression. It has yield potential of 2,182 kg/ha with 100-seed weight of 36 g. Osmotic adjustment with small leaflets, and large number of leaves and branches has been identified as an additive factor contributing towards higher yield stability in chickpea in terminal drought situations.


A mutant BGM 547 of BG 256 chickpea and a *desi* variety Phule G 9425 with yellowish-brown seeds have been identified for cultivation in late-sown areas of north India. Kabuli variety of chickpea BGD 128 has showed resistance to *Fusarium* wilt, dry root-rot and stunt, and has been identified for Madhya Pradesh, Maharashtra, Gujarat, parts of Rajasthan and Uttar Pradesh (Bundelkhand)

- In chickpea idenfied resistant donors for *Fusarium* wilt and dry root-rot
- In terminal drought situations, osmotic adiustment with small leaflets and large number of leaves and branches identified as additive factor contributing towards higher yield stability in chickpea
- Mungbean CO4, ML 515, BM 4 and TM 98-50 identified as resistant to *Cercospora* leaf-spot disease
- Lentil PL 01, PL 02 and L 4666 identified as multiple-disease-resistant donors
- Released and notified CAZRI Moth 3 (mothbean), Pratap Kulthi 1 (horsegram) and Co (CP) 7 (cowpea) for commercial cultivation

***Crop production:*** In rice–chickpea cropping system, medium-duration genotype of rice NDR 359 recorded higher yield (13.7%) than short-duration genotype Pant Dhan 12 (3,387 kg/ha). A preceding crop of rice decreased nodulation in chickpea. Nodule number per plant reduced by 20–45% due to rice as compared to urdbean/mungbean in *kharif*.

In DCP 92-3 planted on 18 December, foliar application of 2% urea or DAP at branching and pre-flowering stages increased productivity by 15–20%. Foliar spray of 2% urea at flower initiation and 10 days thereafter improved grain yield significantly in rainfed areas, and gave 12% higher yield over no spray. Sowing two rows of chickpea 30-cm apart on 67.5 cm wide-raised beds proved highly beneficial than flat-bed sowing in heavy soils. Combined use of *Rhizobium* + PSB + plant-growth promoting rhizobia proved beneficial chickpea.

***Crop protection:*** Out of 838 genotypes screened in sick wilt plot, 17 were found resistant and 25 moderately resistant. Resistant genotypes are GNG 1488, GNG 1515, GNG 1581, GNG 1594, GNG 2136, H 00104, H 00216, IPC 97-29, 2K-3-20, 2000-52, 2100-04,

NDGH 3-31, H 82-2, HK 00290, RSG 963, CSJ 103 and P 9425-9. NIC 18852, NIC 18865 and NIC 18878 exhibited resistance to bruchids (*Callosobruchus chinensis*) under free-choice conditions. New insecticides like Emamectin Benzoate 5 SC at 8–9 a.i./ha and Novaluron 10 EC 50–75g a.i./ha proved effective over Endosulfan.

**Pigeonpea**

***Crop improvement:*** Genetic transformation using *bar* (marker gene) and *bt* (*Cry* 1 Ab, *Cry* 1Aa) genes via *Agrobacterium* has been optimized with two explants. Apical shoot meristems showed more transformations than decapitated embryonic axes. Among genotypes, T 7 has showed better response (2.45%) as compared to Bahar (0.86%). Transformed plantlets could be established by rooting as well as micrografting method into the pot/field.

Thirty early- and medium-duration genotypes have been converted into CMS lines. About 232 fertility restorers have also been identified against these CMS lines.

***Crop production:*** Pigeonpea + sorghum intercropping system was the most beneficial and productive system in hill planting (3 seeds of pigeonpea and 2 seeds of sorghum placed in each hill in 1 : 1 row ratio with 60 cm row-to-row spacing and 20 cm plant-to-plant spacing). CCC application after sowing shortened plant height, and enhanced primary and secondary branches, chlorophyll content and nitrate-reductase activity, resulting in higher biomass production. Higher pod number, seed set/pod and seed size were noted in treated plants. Translocation efficiency was enhanced that resulted in higher harvest index. One row of rice in furrows between two rows of pigeonpea sown on ridges with 100% recommended dose of fertilizers to rice was found beneficial. Among the *Rhizobium* strains tested, RGR-10 gave maximum grain yield in all varieties and at Khargone, PH-9022 gave maximum grain yield of JKM 7 variety. Among PGPR strains tested, combined inoculation of CRB-3 with *Rhizobium* produced more number of nodules with high nodule dry weight and grain yield at Gulbarga and CRB-1 performed better at Coimbatore.

***Crop protection:*** Based on the morphological characters, 22 isolates of *Fusarium udum* from Kanpur Dehat and Fatehpur districts of Uttar Pradesh were categorized in 3 distinct groups. Another 27 isolates from central Uttar Pradesh (Bundelkhand) were categorized as low, moderate, high and as strong pathogenic. Isolates from IIPR Kanpur and Kanpur Dehat were highly pathogenic, while those from Bundelkhand were moderately pathogenic.

Among recommended donors, 19 genotypes have showed stable resistance against Kanpur isolate of *Fusarium* wilt. These are AWR 74/15, BDN 1, BDN 2, BWR 377, Banda Palera, GPS 33, JAW 5-6A, IPA 38, ICP 8858, ICP 8859, ICP 8862, ICP 8863, ICP 9046, ICP 9174, ICP 89048, ICP 89049, ICP 93012, Sujata and PI 397430 Sel. Germplasm lines IPA 7-1-1, IPA, 7-1-7, IPA 7-2-2, IPA 8-1-1, IPA 8-1-5, IPA 8-1-9, IPA 8-1-11, IPA 8-1-17, IPA 8-1-19, JJA 33-2 and BSMR 55-2 showed stable resistance to *Phytophthora* blight.

Study on biotic potential of gram pod borer (*Helicoverpa armigera*) in north India revealed that the pest could multiply 362.75 times in a generation time of 54.54 days with intrinsic rate of increase of 0.1081/day (November-January). Emergence from diapause pupae (37.5%) occurred mostly during 1–9 March, after a lapse of 44–93 days, as against normal duration of 16–28 days, leading to severe damage to pigeonpea and chickpea. Short-duration genotypes, ICPL 98005, ICPL 98008 and DSLR 120 exhibited tolerance to borer complex with pest susceptibility rating value of 2–3 (4–6% pod damage). Long-duration genotypes, SL 21-7-2-3, ICPL 7542, IPA 04-11, MA 2, PDA 88-2E, 92-1E, 92-3E and 93-2E were moderately resistant to pod fly.

A new species of entomopathogenic nematode (EPN) *Steinernema seemae* has been identified from sandy-loam soils in pigeonpea fields in Madhopura village of Hamirpur district; collected from 40 to 45°C temperature regimes. This species can be multiplied at room temperature (35°C) and can be effective as one of the components of integrated pest management.

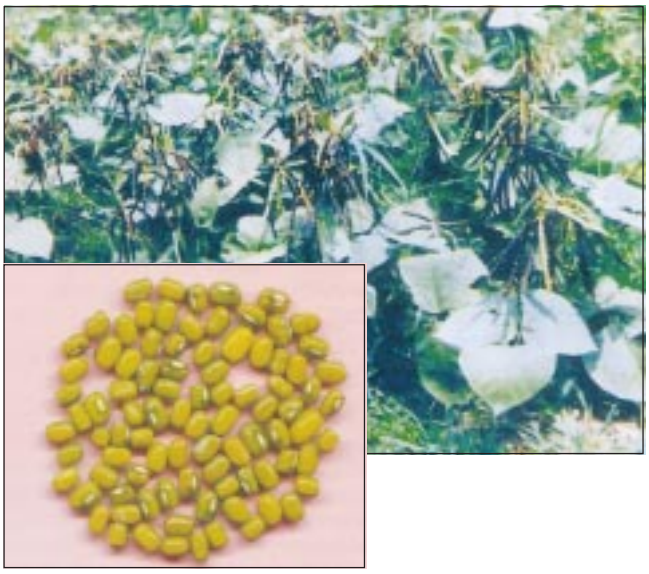
Among newer insecticides tested, Emmamectin (Proclaim) 5 WSG at 11 g a.i./ha, Flubendiamide (RIL 038) 20 WG at 50 g a.i./ha, KN 128 15 EC at 50 g a.i./ha and Spinosad (Tracer) 45 EC at 73 g a.i./ha showed good control of pod borer.

**SUCCESS STORY**

**Rural entrepreneurship through value-addition of pulses**

To promote post-harvest management technology among rural-youth and for their taking up employment, especially in rural area, Self Help Group (SHG) of 6 members was formed in the first week of May 2005 at Helapur village of Hamirpur district in the name of IIPR *Dal Samuh*. The SHG was motivated to purchase and install IIPR mini *dal* mill and *dal*-processing machine in participatory mode with 15% cost to be borne by the SHG and the remaining 85% by the ICRISAT. The SHG is actively involved in preparation of quality *dal* (dehusked split) of chickpea, pigeonpea and lentil as well as other products. On an average, 300 kg of pigeonpea, 200 kg of chickpea and 150 kg each of lentil and blackgram are processed for *dal* in a month. This provides a sizable income to the group with a processing fee of Rs 2/kg of grains.

With local processing, farmers are able to generate additional income of Rs 6,000 to Rs 7,000 per tonne. For instance, pigeonpea-grain is usually sold in the market at Rs 17 per kg and *dal* at Rs 30 to Rs 32 per kg. Farmers sell their *dal* at Rs 27 per kg; benefiting them and consumers. Besides, farmers retain husk and broken *dal* as cattle-feed.



*Mungbean Hum 16.* This has been developed from Pusa Bold 1 × Hum 8 and matures in 60 days. It is large-seeded, weighing 5.7 g/100 seeds

**Mungbean**

***Crop improvement:*** HUM 16, developed from the cross Pusa Bold 1 × HUM 8, has been identified for cultivation in Uttar Pradesh, Bihar, West Bengal and Assam. It has large, green seeds (5.7 g/100-seed weight) with average yield of 1,017 kg/ha during summer. It matures in 60 days.

Variety NDM 97-1 having resistance to mungbean yellow mosaic virus (MYMV) has been identified for cultivation in eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam. It has average yield of 1,100 kg/ha and has showed yield advantage of 25% over best check variety in North Eastern Plains Zone.

***Crop production:*** Mungbean biomass incorporation as green manure after grain harvest considerably improved productivity of rice in rice–wheat system. Chopping mungbean-straw and its incorporation gave highest available N (206–304 kg/ha) as compared to without chopping (170–195 kg available N).

***Crop protection:*** The crop could be protected from the onslaught of *Cercospora* leaf spot with 1–2 sprayings of 0.05% Carbendazim. CO 4, ML 515, BM 4 and TM 98-50 genotypes have been identified as resistant to disease.

**Urdbean**

***Crop improvement:*** Inheritance of plant types involving sympodial vs nonsympodial parents showed involvement of a single recessive gene. Evaluation of $F_1$ and $F_2$ generations of the cross between early insensitive genotype (PDU 103) and early sensitive (PLU 65) genotype at different dates of sowing showed insensitivity to be dominant over sensitivity and governed by a single dominant gene.

*IPFD 1-10 fieldpea.* It has showed a yield advantage of 27% over KPMR 400 in Central Zone. The variety has resistance to powdery mildew

***Crop production:*** Foliar application of humic acid was found highly beneficial to urdbean. Urdbean (var. Uttara) sown at two different spacings (45 cm and 60 cm) and sprayed with 1.5 ml/litres of humic acid yielded more than 1,000 kg/ha. The urdbean provided with recommended dose of fertilizers and sprayed with 2% urea or 1.5 ml/litres of humic acid was found the best.

***Crop protection:*** Genotypes IPU 99-3, 99-25, 99-33, 99-62, 99-186, 99-246, 99-248, 99-249, U 5, U 297 and UK 3 have been found highly resistant against mungbean yellow mosaic virus.

**Upgraded model of IIPR *dal chakki* developed**

An upgraded model of IIPR *dal* mill has been developed which has provision for grading raw-grains as well as finished products. An emery roller attachment has also been incorporated in the mill; which makes pitting process easier and this also enables production of dehusked whole, i.e. gota. Incorporation of the units in the upgraded model along with refinement in other components like disc-holding mechanism and quality of rubber-disc, has made this mill a complete mini *dal* mill, wherein grading of raw-grains, pitting of grains, milling of all types of pulses like dehusked splits (pigeonpea, chickpea, pea, lathyrus etc.), unhusked splits (greengram and blackgram), and dehusked gota (malka masoor), cleaning and separation of husks, and grading of finished products (*dal*) are done in the same machine, and all the operations can be done simultaneously also. The commercial prototype of this mill costs Rs 41,000 only (ex-works). The product quality obtained from this mill is similar to the quality of *dal* available in the market.

**Breeder seed production of pulse crops**

| Crop | Number of varieties in the seed chain | DAC indent (tonnes) | Breeder seed produced (tonnes) |
|---|---|---|---|
| Chickpea | 56 | 375.90 | 546.17 |
| Pigeonpea | 33 | 11.2 | 28.96 |
| Mungbean | 37 | 21.43 | 40.16 |
| Urdbean | 26 | 26.12 | 26.95 |
| Lentil | 18 | 20.35 | 26.52 |
| Fieldpea | 16 | 39.12 | 57.75 |
| Rajmash | 2 | 2.10 | 2.40 |

And T 65, K 116-86 have been identified as resistant to *Cercospora* leaf spot. Genotype PLU 648 has been identified as resistant against root-knot nematode (*Meloidogyne javanica* pathotype 2).

### Fieldpea

***Crop improvement:*** *IPFD 1-10:* A dwarf variety from a single cross of PDPD 8 × HUDP 7 has been identified for cultivation in Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh, Jammu and Kashmir, Uttaranchal, Himachal Pradesh and hilly regions of north-eastern states. It has an average yield of 2,104 kg/ha with 27% yield advantage over KPMR 400 in the Central Zone and 31% over HUDP 15 in the North Hills Zone.

### Lentil

***Crop improvement:*** A large-seeded variety VL Masur 507 evolved through selection from ILL 7978 has been identified for cultivation in Jammu and Kashmir, Uttaranchal, Himachal Pradesh and hilly regions of north-eastern zone states. It has an average yield of 1,204 kg/ha in the North Hills Zone with 100-seed weight of 3.32 g. It has exhibited yield superiority of 14.9% over best check DPL 62, and has also showed resistance against wilt.

**Allelopathic effect of root exudates and plant extracts on important soil pathogens of pulse crops**

EC formulation developed from the non-polar fractions (A, B and C) of sorghum root exudates was found detrimental to 7 important pathogens of pulse crops. Its LC 50 values were recorded as 17, 22, 250, 270, 182, 146 and 87.5 ppm for pathogens *Sclerotinia sclerotiorum, Sclerotium rolfsii, Fusarium udum, Fusarium oxysporum* f. sp. *ciceri, Rhizoctonia bataticola, Alternaria alternata* and *Choenephora cucurbitarum*. EW formulations developed from sesame allelo-compounds inhibited root biomass of nutsedge by 15.1, 30.5, 50.6, 51.9, 63.9, 81.3% and 15.8, respectively.

***Crop production:*** Seed priming (seed soaking in water for 6 hours) and 2% urea spray were found effective. In rice–lentil cropping system, large-seeded genotype DPL 62 outyielded other genotypes. In lentil, 60 kg $P_2O_5$, 30 kg S, 15 kg Zn and 5 kg Boron/ha were found most productive (1,646 kg/ha) and remunerative.

***Crop protection:*** PL 01, PL 02 and L 4666 have been identified as multiple-disease-resistant donors.

### Arid Legumes

***Crop improvement:*** Following varieties have been released and notified for commercial cultivation.

*CAZRI Moth 3 (mothbean):* It was induced from cv. RMO 40, following 30 kR $Co^{60}$ gamma rays. This cultivar with erect upright growth habit, flowers in 32–34 days and matures in 64–66 days. It is suited for low (250–350 mm) and erratic rainfalls in all mothbean-growing areas of India. Characterized with very high grain yield potential of 550–1,000 kg/ha, may be planted at 30–35 cm inter-row spacing in rainfed areas. It has tendency to escope yellow mosaic virus incidence.

*Pratap Kulthi 1 (horsegram):* Selected from a local germplasm of Bheelwara district (village Bemera), it is an early-maturing variety with almost 50 and 85 days taken to flowering and maturity. It has high yield potential (1,162 kg/ha); 16% more over national check AK 21 (872 kg/ha). The variety has been recommended for rainfed northern-western locations of India.

*Co (CP) 7 (cowpea):* It is developed through mutation breeding, following 20 kR $Co^{60}$ gamma-ray treatment to Co 4 cowpea variety. It being a medium maturing (67–73 days) variety has potential to yield (991 kg/ha); more than 25.0 and 41.4% over V 240 (725.0) and V 585 (643.3 kg/ha). It has field tolerance against pod-borer damage and leaf curl virus. This variety has been recommended for rainfed areas of southern states.

***Crop production:*** In guar, one spray of 0.5% $ZnSO_4$ either at 25 or at 45 DAS or in combination with 0.5% $FeSO_4$at 25 DAS gave significantly higher yield than control, but statistically at a par to soil application of $ZnSO_4$ at 25 kg/ha. Higher net returns were obtained when crop was applied with 1 foliar spray of 0.5% $ZnSO_4$ at 25 DAS (Rs 2,735/ha) or 2 spray at 25 and 45 (Rs 2,757/ha). Maximum net returns in guar were obtained when seed was inoculated with *Rhizobium* + phosphate solubilizing bacteria (PSB) at Gwalior (Rs 12,141/ha) and at Hisar (6,867/ha), and at Durgapura, maximum net income (Rs 6,238/ha) was obtained, when seed was treated only with PSB. At Hisar, *Rhizobium* the inoculation increased crude protein, and PSB alone or in combination with *Rhizobium* increased both crude protein as well as gum content in seed.

***Crop protection:*** Soil amendments with mustard residue at

*CAZRI Moth 3 (mothbean)*. It is suitable for low 250–350 mm and erratic rainfall areas, where mothbean is grown

*Pratap Kulthi 1 (horsegram)*. It is a selection from local germplasm of Bheelwara district (Rajasthan) and is recommended for rainfed north-western locations of India


*CO (CP) (cowpea)*. It has field tolerance against pod-borer damage and leaf-curl virus, and is recommended for rainfed areas of southern states

2.5 tonnes/ha along with seed treatment with *Bacillus thuringiensis* (4 g/kg of seed) and one summer irrigation was best in reducing percentage seedlings mortality (pre and post emergence) and increasing seed yield of guar. In cowpea, seed treatment with Thiram (3 g/kg), followed by three sprays of Carbendazim at 0.1% at 15, 30 and 45 days after seedling emergence were best in managing anthracnose disease during *rabi* in southern India. There was significant reduction in pod-borer damage due to spray of Profanophos 50 EC at 1 ml/litre in cowpea at Pattambi.

Zn Application to guar increased grain yield by about 13% at farmers' fields.

**Sugarcane**

***Crop improvement:*** Twenty-one Co canes (Co 0501 to Co 0521) were selected based on the evaluation made at Coimbatore, Karnal, Chagallu and Motipur, of which 6 belong to early group and 15 to midlate types. Co 98013,Co 99012 and Co 99004 are found on

*Saccharum spontaneum,* tallest collection from Mizoram

**Total sugarcane fluff supplied to various centres**

A total of 442 crosses, 843 general crosses (GCs) and 11 selfs from Coimbatore and 155 crosses, 26 GCs and 22 selfs from Agali were made, and 28,571.75 g of fluff has been supplied to 22 centres, representing Peninsular Zone (8,876.29 g), East Coast Zone (3,793.71 g), North-East Zone (898.29 g), North Central Zone (4,097.57 g) and North-West Zone (10,905.89 g).

- A reference collection of 116 sugarcane varieties has been established under the DUS project
- For good sprouting of sugarcane in winter, pre-harvest application of ethrel at 500 ppm is recommended
- A very sensitive assay, evaporative immunosorpent assay, standardized to detect ratoon-stunting bacterium infection in sugarcane
- In Maharashtra, intra-*hirsutum* hybrid of cotton Mahabeej 106 and intra-*arboreum* Mahabeet DH 986, and *G. arboreum* varieties PA 402, Phule JLA 794 notified for commercial cultivation
- In assured rainfall areas in Dharwad, sunflower intercropped with cotton in 2:1 or 3:1 resulted higher seed-cotton yield
- Released and notified S 19, JRC 80 (jute); MT 150 (mesta) and SH 4 (sunnhemp)
- Jute JRO 3352 found good donor for tolerance to *Macrophomina phaseolina*
- With *Trichoderma viride* and *Azotobacter* application in jute, highest disease control and biomass increase was noticed
- Resistant genotypes of tobacco found for tobacco aphid, whitefly, budworm and tobacco caterpillar
- In tobacco, *Nomurea rileyi* at $10^3$ spores/ha found effective in containing capsule damage caused by *Helicoverpa armigera* in the northern light soils area

a par with Co 86032 for yield; Co 98013 and Co 99012 were best clones combining yield and quality with good field stand; Co 99012 had relatively higher number of millable canes; and stalk thickness and single cane weight were higher in Co 98013. Co 99012 was the best entry for sucrose (19.55%) at 300 days. And Co99004 is found best for jaggery.

Molasses was used as a substitute for sugar in MS medium. Higher shoot multiplication was obtained at 6% concentration after two subcultures. Sucrose content in 105 *Saccharum spontaneum* clones ranged from 0.2% to 11.11%. In *Erianthus arundinaceus*, sucrose ranged from 0.16 to 3.49%.

**Mechanization of ring-pit planting technique of sugarcane**

To facilitate package for large-scale adoption, the IISR has designed and developed a two-row pit-digger for ring-pit planting of sugarcane to harness high cane productivity. The pit-digger is operated from a 35-hp tractor PTO and has a capacity of digging 175–200 pits/hr (pit dimensions: dia 75 cm, depth 30 cm, pit-to-pit distance 30 cm)

Co 86032, Co 94008, Co 94012 and Co 85019 were multiplied for breeder seed production in 0.40 hectare, and 31.73 tonnes of breeder seed was distributed to sugar mills and farmers. A reference collection of 116 varieties has been established under the DUS project.

***Crop production:*** Ratooning in sugarcane has become inevitable for reducing cultivation cost and for increasing profit margin. However, decreasing factor productivity and declining soil quality are the major concerns in sugarcane ratoon. The maximum cane yield (81 tonnes/ha) of the first ratoon was recorded on sulphitation with press-mud cake (SPMC) + *Acetobacter*, which was closely followed by 79, 78, 78, 78, tonnes/ha with vermin-compost + *Acetobacter*, NPK at 150 : 60 : 60 kg/ha, SPMC and vermin-compost, respectively.

One of the major causes of low productivity of sugarcane ratoon-crop is-poor sprouting in the winter initiated ratoon. The sprouting could be improved by pre-harvest application of ethrel (500 ppm), post-harvest application of zinc sulphate (45 kg/ha) and muriate of potash (100 kg/ha). Improvement due to these chemicals was 157.82 65.28 and 78.52% in Co Pant 90223, and 62.01, 26.0 and 21.63% in CoSe 92423.

Pre-harvest foliar spray of zinc sulphate or manganese sulphate (1,000 ppm), three day prior to harvest, reduced sucrose losses on staling in CoS 92423. There was 10% decline in CCS in Mn-treated cane after 6 days of staling as compared to over 20% in untreated control during March.


*Sugarcane tolerant varieties. Co 94012* peninsular variety tolerant to salinity (*right*); *Co 86032* tolerant to iron deficiency (left)

***Crop protection:*** Evaporative immunosorbent assay has been standardized to detect ratoon-stunting bacterium infection in sugarcane, and assay has been found more sensitive than DAC-ELISA.

The indigenous pheromones of shoot, internode and top borers have been found economical and effective in trapping moths in fields.

A set of sugarcane differentials and tropical pathotypes of red-rot pathogen have been identified. And factors responsible for *Colletotrichum falcatum* pathogenecity have also been identified. Differential accumulation of pathogenesis-related (PR) proteins have been found to be associated with induced resistance, as concomitant induction of chitinases was observed in red-rot pathogen inoculated canes pretreated with inducers of resistance.

**Cotton**

***Crop improvement:*** PSB CT8 (879), UPL C2 (699) for seed-cotton yield, MHR 11 (4.4 g.) for boll weight, PCB CT 10 (32.3 mm) and NM 970513 (31.0 mm) for mean halo length, and PSB CT 8 (41%) and PCB CT 10 (39%) for high-ginning outturn have been identified as superior genotypes.

One new GMS line CISA 2 with yellow flowers, in *desi* cotton has been identified. In *G. arboreum*, new restorer lines CIR 97 P1, CIR97 P3, CIR119 P1, CIR119 P3, CIR126 P1, CIR526 P1, CIR526 P3, CIR 920 P1, CIR 926 P2, CIR 926 P3, CIR 1169 P1 and CIR 1169 P2 have been identified. An intra-*hirsutum* hybrid CSHH 238 and a *G. arboreum* culture CISA 310 ranked first over three years, and have been recommended for agronomic trials for identification.

Intra-*hirsutum* hybrid Mahabeej 106 and intra-*arboreum* hybrid

**SUCCESS STORY**

## Sex pheromones – practical pest-management tools for sugarcane ecosystem

Though resistant varieties are best management tools against pests, complexities of sugarcane genetics and priorities of its breeding mandates make it almost impossible to develop a variety resistant to pest with all other desirable attributes. Even if such a variety is developed, it may not suit all agroclimatic regions wherever target pest is prevalent, and it may not be resistant to other key pests of the region. Pheromones on the other hand, operate across regions and simultaneously tackle different pest species in one and the same trap. Their advantage over bioagents is that, pheromones once identified, can be produced on a industrial scale. As time becomes a minimum barrier for their synthesis, mass production, modification, transportation and storage, it is much easier to handle pheromones. Pheromones are effective round the year and even at low pest densities. They are highly compatible with all components of IPM, are species-specific and safe.

**Internode borer (INB)—*Chilo sacchariphagus indicus* Kapur.** It is a major pest of sugarcane in peninsular India. In recent years, it has modified its feeding habits. It has extended its feeding region in sugarcane from the top tender internodes to the spindle across the apical meristem. In this type of attack, yield and quality loss is severe and jaggery quality is also very poor. Borer economic threshold level (ETL) has fallen below 10% from 25%. The present management practices of detrashing and inundative releases of *Trichogramma chilonis* are not sufficient to contain this pest.

Pheromone trap in sugarcane

**Advantages of pheromones in INB management**

- Economical. The cost of 10 × 4 septa with ten SBI Wuri water-traps may be Rs 400 per acre.
- Detrashing exclusively to manage INB at 5th and 7th months can be dispensed with.
- Timing of *Trichogramma* releases in accordance with moth catch will improve percentage parasitization of INB eggs.

**INB sex pheromones.** INB pheromone has been identified as Z - 13 Octadecenyl acetate and Z-13-Octadecenyl alcohol and is found effective at 7 : 1 ratio in mass attraction of male-moths of INB in field trials.

**Field application.** Synthetic pheromones are impregnated at 3mg strength in rubber septa, which act as lure. Eight to ten water-traps housing synthetic pheromone septa are required for one acre. The traps are suspended at spindle height on 5th month of crop at 30-metre grid. Well propped cane clumps are used as support for suspending traps. At 9th month, trap height is reset to the spindle height, as maximum efficiency was observed at spindle height. A thin film of engine waste oil is added to water in trap to trap and kill moths. The septa are changed at 7th and 9th months and if needed at 11th month. The water-trap is maintained by removing dead moths and recharging with water and engine waste oil at regular intervals to have maximum efficacy.

Mahabeej DH 986 and *G. arboretum* varieties PA 402 and Phule JLA 794 have been notified for commercial cultivation in Maharashtra. Similarly, intra-*hirsutum* hybrids Navkar 5 for the North Zone and Ajeet 90-2 for the Central Zone and the genetic-male sterile based hybrid NACH 6 for the Central and South Zones have been identified for release.

**SUCCESS STORY**

**Economical pest management in cotton through IRM**

Management of insecticide resistance in the American bollworm *Helicoverpa armigera* has been a challenging task. Insecticide resistance management (IRM) strategies were designed with a long-term objective of reducing intensity of resistance of insect to insecticides all-over the country. The strategies emphasize on the efficient use of insecticides to conserve ecosystem for better pest management. These reduced insecticide use by 50–90% with yield increases of 10–25% in Maharashtra, Andhra Pradesh, Tamil Nadu and Punjab.

Encouraged by the IRM strategies, the Government of India has sanctioned a massive programme to popularize IRM in 28 cotton-growing districts of 10 states, which utilize 85% of total insecticides. The IRM strategies are disseminated to farmers through street plays and folk theatre.

During 2004–05, the strategies were implemented in 59,233 hectares in fields of 20,525 farmers of 444 villages in 30 districts of 10 cotton-growing states. The overall benefit due to project implementation was estimated at Rs 4,807 lakh; due to yield increase it was, Rs 3,097 lakh and from reduced insecticide usage, it was Rs 1,710 lakh. Resistance of bollworm to insecticides was found to have decreased tremendously in almost all districts wherever the programme was implemented over a continuous period of 3–4 years. Ready acceptability by farmers has been due to simplicity of the strategies and sustainability of the technology components.

***Crop production:*** Maximum water-use efficiency (2.46 kg/ha-mm) was recorded when greengram was intercropped in cotton, closely followed by (2.40 kg/ha-mm) when blackgram was intercropped and the minimum (2.01 kg/ha-mm) was under control.

Cotton genotypes showed decline in growth and yield beyond 7EC salinity. *G.arboreum* and *G.herbaceum* genotypes exhibited better tolerance to salinity. Tolerant genotypes possessed higher accumulation of proline and higher K/Na ratio.

At Rahuri (Maharashtra), integrated nutrient-management practices in cotton-chickpea crop sequence produced maximum seed-cotton yield. Maximum net monetary returns of Rs 15,668/ha and highest B : C ratio of 1 : 1.59 were recorded with FYM at 5 tonnes/ha + green manure *dhaincha in-situ* + *Azotobacter* + *Azospirillum* + phosphate-solubilizing bacteria (seed treatment).

Sunflower intercropped in cotton in 2 : 1 or 3 : 1 ratio ensured higher seed-cotton yield in assured rainfall areas of Dharwad and cotton : sesamum (3 : 1) produced significantly higher total yield than cotton: castor in Siruguppa. At Bhawanipatna (Orissa), higher net returns ranging between Rs 20,000 and Rs 23,000 per hectare could be realized in cotton–blackgram, cotton–onion and cotton–castor intercropping systems.

***Crop protection:*** Foliar applications on cotton of Confidor (350 SC or 70 WG) and of Clothianidin 50 WDG (Water dispensable granules) were found effective against sap-sucking pests. Polo 50 SC (Diafenthiuron) was found effective in reducing white-fly population. Spinosad (75 and 100 g), NNI 0001, E 237, KN 128, RIL 038 and Karate Zion 5SC showed efficacy against bollworm complex.

Use of talc-powder formulation of *Pseudomonas fluorescens* Pf1 and CHAO at 30,60 and 90 DAS gave effective control of *Alternaria* leaf spot, grey mildew and bacterial blight in Central and South Zones.

**Jute and allied fibres**

***Crop improvement:*** Four varieties of jute and allied fibres have been released and notified for cultivation.

Genetic diversity analyses of some exotic germplasm accessions, released varieties of two cultivated jute species (*Corchorus olitorius* and *C. capsularis*) and two wild relatives of jute were carried out using RAPD, ISSR and STMS markers. All accessions of *C. olitorius* grouped with wild species *C. aestuans* and those of *C. capsularis*

**Modified CRIJAF bast fibre extractor**

The machine helps to extract fibres from canes with broken or unbroken sticks. Canes fed into the machine are subjected to impact load through pedal-activated nylon-roller against

protruded sharp edges of knife. Five to ten canes are fed into the machine, which has an extraction capacity of 25 kg of jute and 15 kg of mesta dry fibres in one hour.

The prototype of the machine has been developed, and it is being popularized now.

**Varieties released and notified of jute and allied fibres**

| Variety | Crop | Yield potential (tonnes/ha) | Salient features | Area of adoption |
|---|---|---|---|---|
| S 19 (Subala) | Jute | 3.6 | Fibre quality grade is $TD_2$, is tolerant to stem-rot, root-rot and anthracnose diseases | West Bengal, Assam, Bihar and Orissa |
| JRC 80 (Mitali white) | Jute | 3.0–3.5 | It is non-lodging type and is tolerant to waterlogging at later stage of growth | North Bengal, Assam, Uttar Pradesh |
| MT 150 (Nirmal) | Mesta | 2.56 (biomass) | It is suitable for paper pulp production | All mesta-growing areas |
| SH 4 (Sailesh) | Sunnhemp | 12 | - | All sunnhemp-growing areas |


*Jute JRC 80 (Mitali white).* It is a non-lodging type and is tolerant to waterlogging at later stage of growth

grouped with *C. trilocularis*; suggesting polyphyletic origin of two cultivated species. This study thus constitute the first report of use of STMS markers in jute and comparative analyses of three different molecular marker systems in intra and interspecific diversity analyses that suggests that germplasm of both species have a wider genetic variability; that can be used in the breeding programme. The varieties, particularly of *C. capsularis*, have a very narrow genetic base. JRO 3352 has been found a good donor for tolerance to *Macrophomina phaseolina*. Wild *Corchorus tridens* was found tolerant to *Macrophomina phaseolina* and *C. pseudo-capsularis* exhibited the finest fibres. National test guidelines for DUS testing of jute have been developed. Characterization of all notified varieties and varieties of common knowledge has been done following DUS test guidelines, and characterization digitalized online software has been developed by the NBPGR.

***Crop protection:*** A virus disease (named as yellow-vein mosaic) results in severe retardation in growth and yield in mesta. The disease is characterized by severe yellow vein mosaic symptoms on leaves of infected plants with reduction in photosynthetic area. Transmission electron microscopy from typical symptomatic leaves has revealed that the disease is associated with a geminivirus (20 nm × 30 nm). The disease is found to be transmitted by whitefly (*Bemisia tabaci*). And is transmitted by cleft grafting but not by sap and seeds of infected plant. The results indicate that associated geminivirus of yellow vein mosaic disease of mesta is a new record of a recombinant geminivirus.

In jute, the highest disease control as well as plant biomass increase was obtained with *Trichoderma. viride* + *Azotobacter*, and the highest fibre yield was obtained from *T. viride* alone, followed by *T. viride* and *Azotobacter*. In mesta, disease control was maximum with *T. viride* + *Azotobacter*, but highest biomass and fibre yield was obtained with *Pseudomonas fluorescens*. The pod formation stage has been identified as the most vulnerable stage of jute-seed infection by black-band pathogen *Botryodiplodia theobromae*.

**Tobacco**

***Crop improvement:*** Cy 135 line fared well with high cured leaf (1,590 kg/ha) with bright leaf (940 kg/ha) and grade index of 1,100 compared to check Hema and II-1624 with cured leaf yield of 1,550 and 1,480 kg/ha, and bright grade leaf of 760 and 710 kg/ha and grade index of 1040 and 780 in southern black soils of Andhra Pradesh.

Ninety lines including Island Gold and A 119 had low level of stem-borer infestation. Karedu was resistant to *Spodoptera litura*.

Genotypes/crosses CU 1097, C110, V 373 C110 × VT 1158, VT 1158 × V 373 and CU 1097 × VT 1158 were found resistant to tobacco aphid; C 110 × VT 1158 to whitefly/leaf curl, CU 1097, C 110, V 373, Hema × CU 1097, VT 1158 × V 373, CU 1097 × 1099/2/4 and C 110 × VT 1158 to budworm *Helicoverpa armigera*; CU 1097 × 1099/2/4, Hema × CU 1097 and VT 1158 × V373 to tobacco caterpillar *Spodoptera litura*.

***Crop production:*** Preparation and application of enriched organic matter utilizing high-grade phosphate rock (PR34/75) by vermicompost or biodynamic methods improved yields of FCV tobacco by 8.6% over control at Kandukur. At Vedasandur, chewing tobacco + Bellary onion intercropping increased net returns (Rs 68,859/ha), B:C ratio (2.53) and gave additional returns (Rs 24,527/ha) compared to sole chewing tobacco.

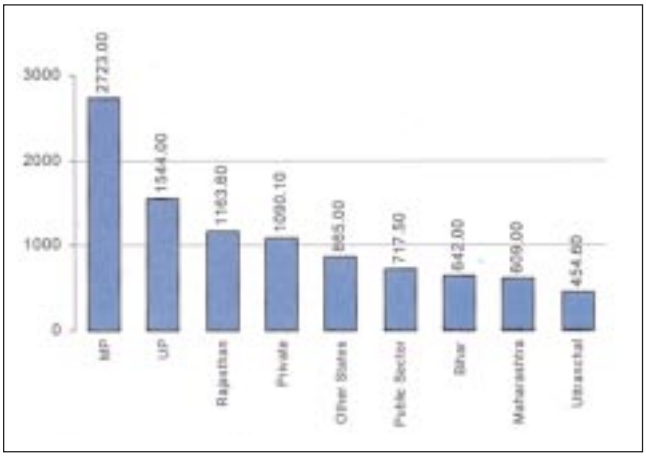
***Crop protection:*** Aqueous leaf extracts of neem, *Pongamia* and *Calotropis* at 4% on tobacco were found highly effective and were on a par with Chlorpyriphos 0.05% against *Spodoptera litura* and leaf curl virus.

*Nomurea rileyi* at $10^{13}$ spores/ha was effective in containing capsule damage (9.5%) caused by *Helicoverpa armigera* in the northern light soils tobacco and also found better than HA NPV 1.5 × $10^{12}$ PI B/ha (17.7%).

*Aspergillus niger* strain 27 ('Kalisena') and a bioagent enriched FYM to soil amended with neem-cake and soil solarization for 4–6 weeks managed soil-borne fungal diseases very well in flue-cured Virginia tobacco nursery; without any supportive fungicide in an eco-friendly way.

## Breeder seed production

In 2004–05, 4,341.21 tonnes of breeder seed were produced; major quantities belonged to oilseeds (1,855.90 tonnes) and cereals (1,701.52 tonnes), followed by pulses (712.09 tonnes), forages (51.53 tonnes) and fibre crops (20.17 tonnes). More than 1,500 tonnes of breeder seed have been produced for state released varieties directly by the centres as per the indent of the respective states.




Breeder seed indent of various indentors for *rabi* 2004–05

## Seed technology

***Seed storage:*** Seed treatment (at 10% seed-moisture content) of paddy hybrids and their parental lines with Thiram at 0.25% reduced fungal flora and maintained their germination above the Indian Minimum Seed Certification Standard (IMSCS) even after 14 months of storage in polylined bags.

Seed treatment of soybean (at 10% seed-moisture content) with Vitavax 200 at 0.25% or Thiram + Carbendazim (0.2% in 1.1 ratio) reduced fungal flora and maintained. Its germination above the IMSCS even after 7 months of storage in polylined bags.

Fabric - surface or soak treatment with Deltamethrin at 125 ppm or Bifenthrin at 125 ppm proved effective in protecting seed stored in it under ambient conditions for one sowing season (6–9 months).

For sorghum, groundnut and pearl millet, pre-sowing seed hydration (16–18 hr) and drying at room temperature to normal moisture content of seed, followed by dry dressing with Thiram at 0.2% was effective for their rapid and uniform field emergence and establishment.

***Seed health:*** In soybean, deep-freeze blotter method is recommended for detection of *Colletotrichum dematium* and *Macrophomina phaseolina* and standard blotter method for *Fusarium oxysporum*. Both the methods are in accordance with the International Seed Testing Association (ISTA) protocols.

## Seed processing

- Safflower (Bhima), sunflower (Morden, KBSH 1, its parental lines 6D 1 and CMS 234A), gram (Chaffa), mungbean (Asha, Muskan), paddy (Pusa 44, PNR 381) and maize (Early composite), must be processed through multi-stage seed

**Standardized sieve sizes for screen grading of different crop varieties**

| Crop | Genotype | Recommended screen size |
|---|---|---|
| Sunflower | KBSH 1 | 2.8 mm (s) |
| | RHA 6D1 | 1.85 mm (s) |
| Ragi | GPU 28 | *1.20 mm (r)* |
| Soybean | JS 335, MACS 13, PK 472 | |
| | MACS 124 | 3.6 mm |
| Safflower | Bhima, Girna, Tara, Sharda | 2.4 mm |
| Sunflower | CMS 2A, CMS 2B | 1.6 mm |
| | AK 1R | 1.4 mm |

processing comprising at least the seed cleaner-cum-grader and specific-gravity separator.

- Seed drying in the direct sunshine needs to be discouraged. Shade drying and mechanical drying below 40°C air temperature proved conducive in terms of reasonable drying rate, seed quality and storage performance in sunflower, groundnut-pods, paddy and pigeonpea.

***DUS project:*** National Test Guidelines for Distinctness, Uniformity and Stability (DUS) have been developed for 35 economically important crops. More than 1,000 crop varieties have been characterized as per the DUS test guidelines and the data of these crop varieties have been digitalized. The softwares for digital library and data analysis have been developed.

### *Puccinia spegazzinii*, a fungal biocontrol agent, ready for release in Kerala and Assam

Host-specificity tests involving 74 plant species have been completed for *Puccinia spegazzinii*, the rust pathogen of the weed *Mikania micrantha*. The permit was issued on 27-06-2005 for its limited field release in Kerala and Assam. The rust

*Mikania micrantha* infected with *Puccinia spegazzinii*

*Mikania micrantha* invading teak plantation in Kerala

has been bulked up on *M. micrantha* in quarantine, and is ready for transportation to Kerala and Assam. Once released, India would become the eighth country in the world to have released a fungus as a classical biological control agent against a weed.

- A website hosted on the Indian Coccinellidae and its natural enemies with image galleries of species
- Developed a computer-aided dichotomous key for 10 common Indian species of *Chilocorus*
- Recorded *Oenopia excellens* (crotch) and *Prototheа quadripunctata* (Mulsant) from north-eastern region and one new species of *Pseudoscymnus* from Bangalore
- Standardized a technique for shipping *Telenomus remus* cards
- Talc-based formulation of *Steinernema carpocapsae* found suitable and stable for surface transport
- Developed a simple magnetic stirrer technique for faster mass production of *Hirsutella thompsonii*
- Successfully produced Monocrotophos and Dicofol resistant strains of *Neoseilus longispinosus*
- Common myna, common swift and cattle egret reduced swarming caterpillar larvae, stem borers and grasshoppers by 20–30% in harvested paddy fields
- Developed a new formulation of bromadiolone that resulted 80% mortality of *Rattus rattus* within 5–10 days

### Indigenous Bt strain

A strain of *Bacillus thuringiensis* from Pantnagar among six samplex tested, has exhibited highest toxicity against *Plutella xylostella* in cabbage-leaf bioassay.

## Biological control

***Rearing and evaluation of natural enemies:*** A technique for shipping *Telenomus remus* cards in ventilated plastic boxes fixed with polystyrene strips with slits has been standardized. The total cost of 50 cards to be applied in a hectare would be Rs 200. The best parasitoid density for producing *Campoletis chlorideae* at 26–28°C and 70–80% relative humidity

### Predators of sugarcane woolly aphid *Ceratovacuna lanigera*

*Micromus igorotus* was recorded feeding on *Ceratovacuna lanigera* and could be bred on other aphid hosts. *Mallada desjardensi* (Chrysopidae), *Spalgis epeus* (Lycaenidae),

***Mass production of Cryptolaemus montrouzieri:*** *Cryptolaemus montrouzieri* could be mass reared successfully on *Sitotroga cerealella* eggs with a mean percentage pupation of 67.57% and adult emergence of 84%.

*Cryptolaemus montrouzieri* and *Synonycha grandis* (Coccinellidae) were found as other predators of sugarcane woolly aphid (SWA) recorded in sugarcane fields of Karnataka. Field multiplication technique to produce *Dipha aphidivora* has also been standardized and extensively recommended.

in cages measuring 1.7' × 1.7' × 2.5' was 5–8 with an yield of five females/female. Anthocorid *Orius tantillus* could be best reared at 24°C with a progeny production of 28.8 per female. Releases of *Trichogramma embryophagum* and *Trichogramma chilonis* against *Opisina arenosella* at 1,000 to 4,000/palm reduced larval population by 77.8 to 100%. *Trichogramma brasiliense* and *Trichogramma chilonis* evaluated against *Earias vittella* have revealed that at 5 pairs each for 50 eggs caused 46.7 and 41.3% parasitism, respectively; showing their promise for field evaluation.

***Artificial diets for parasitoids, predators and host insects:*** The anthocorid *Orius tantillus* could be successfully reared on a combination of an artificial diet with maize pollen and beans. Toddy-palm-leaf powder-based artificial diet was suitable for rearing *Opisina arenosella* with 73.2% pupation and 66.2% adult emergence. Cabbage leaf powder and defatted soya-based artificial diet could be successfully used for rearing *Plutella xylostella*.

***Insect viruses in biological control:*** NPV at $10^5$–$10^9$ POBs/ml caused up to 90% mortality of late second instar larvae of *Crocidolomia binotalis*. The virus was not cross-infective to *Bombyx mori*, *Helicoverpa armigera*, *Spodoptera litura*, *Plutella xylostella*, *Hellula undalis*, *Trichoplusia ni*, *Spodoptera exigua*, *Chilo partellus*, *Galleria mellonella*, *Corcyra cephalonica*, and was also found safe to predators, *Chrysoperla carnea* and *Cryptolaemus montrouzieri*.

Starch (1%) and crude sugar (10%) could be used as adjuvants with Ha and Sl NPVs resulting in increased mortality of *Helicoverpa armigera* (87.6%) and *Spodoptera litura* (94.3%) respectively on the first day.

***Isolation of endophytic bacteria:*** *Bacillus megaterium*, *Bacillus circulans*, *Enterobacter agglomerans* and *Erwinia herbicola* isolated from atmosphere of the plants caused 8–16% enhanced growth in chickpea and pigeonpea and also showed inhibitory activity against root-rot pathogens.

***Antagonists against plant diseases:*** Among 28 isolates of *Trichoderma harzianum*, 6 have been found inhibitory for *Sclerotium rolfsii* and four for *Macrophomina phaseolina*.

Talc formulations of *Trichoderma harzianum* and *T. viride* with 2 or 5% pure chitin had higher number of viable colony forming units (CFU) than formulations without chitin for up to 3 months of storage.

Wider C : N ratios in production medium (10 : 1 and 15 : 1) resulted in good sporulation and viable propagules during storage in *Tricboderma harzianum* and *T. viride*. Addition of glycerol in production medium at 3–9% and or heat shock at 40°C for 30 minutes during stationary phase of growth also gave more CFU counts during storage for up to 2–3 months.

Cow-dung was found ideal for multiplying *Pseudomonas fluorescens* at 32°C and 40% (w/w) moisture level. Biopriming of pea-seeds with PBA 3 improved seedling stand and increased yield of organically grown pea when applied as foliar spray. Seed treatment with different isolates of *Pseudomonas*, *Trichoderma harzianum* and *T. virens* resulted in 13.9–72.2, 4.7–52.2 and 15.5–41.3% suppression in sheath blight of rice.

***Entomopathogenic nematodes:*** Higher yield of 2.50 lakh was obtained at 1,000 ijs of *Steinernema carpocapsae* per larva of *Galleria mellonella* within 6 days, and 300 ijs of *Heterorhabditis indica* gave maximum yield of 6.50 lakh within 10 days. Two isolates of *Steinernema carpocapsae* and *Heterorhabditis indica* tested for shelf-life have been found viable for 3 months. Talc-based formulation of *Steinernema carpocapsae* was found suitable and stable for surface transport.

***Pathogens for biological suppression of phytophagous mites:*** Oatmeal agar (OMA mycelial) discs were found best inoculum in Sabouraud dextrose broth (SDB) continuous shake culture for production of *Hirsutella thompsonii*. A simple magnetic stirrer technique for faster mass production of *Hirsutella thompsonii* has been developed. Mycohit (50 g/litre) at 14 days after first and second sprays reduced population of *Tetranychus urticae* on *bhindi* by 45.65–62.72%.

***Biological suppression of plant-parasitic nematodes:*** *Pochonia chlamydosporia* from the grape vineyards around Bangalore effectively controlled reniform and root-knot nematodes.

***Biological suppression of crop pests:*** *Food crops: Trichogramma japonicum* (1 lakh/ha) was as effective as *Trichogramma chilonis* in controlling leaf folder, and so could be used both for stem borer and leaf folder in rice. Seven combined releases of *Trichogramma chilonis* and *Trichogramma japonicum* each at 100,000 per hectare at weekly interval, starting

*Encarsia flavoscutellum* has been observed as a parasitoid of sugarcane woolly aphid at Jorhat

at 30 days after transplanting proved effective against leaf folder and stem borer in organically-grown rice.

*Commercial crops: Encarsia flavoscutellum* was observed as a parasitoid of sugarcane woolly aphid (SWA) at Jorhat. *Dipha aphidivora* was predominant in parts of Andhra Pradesh, where no insecticides were used. Two releases of *Micromus igorotus* (100 pupae/release) were found sufficient in bringing down population of SWA within 45 days.

At PAU, 8 releases of *Trichogramma chilonis* at 50,000/ha at 10 days interval during mid-April to end-June, 6 of *Trichogramma japonicum* during May–June at 50,000/ha and 12–14 releases of *Trichogramma chilonis* at 7–10 days interval during July–October at 50,000/ha proved effective against sugarcane borers *Chilo infuscatellus*, *Scirpophaga excerptalis* and *Chilo auricillus* respectively.

At Rajahmundry, sequential releases of *Telenomus remus* at 50 per two square metres and *Chelonus formosanus* at 10 per two square metres resulted in higher parasitization of *Spodoptera exigua* and lesser seedling damage in tobacco nurseries.

*Pulse crops: Heterorhabditis* sp. at 1.5 billion nematodes/ha was found best in managing *Helicoverpa armigera* and blister beetle on pigeonpea. A BIPM package consisting of release of *Telenomus remus* and sprays of SlNPV against *Spodoptera litura* in soybean resulted in 17% more yield than chemical control at Rajahmundry.

*Oilseed crops: Ischiodon scutellaris* at 1,000 adults/ha (50,000 larvae/ha) reduced *Lipaphis erysimi* population on mustard and gave higher yield at Anand.

**Honeybee research**

In sesame cv. Uma, the activity of forager, *A. cerana indica*, predominated despite incessant rains during flowering stage (270.3 mm), and constituted the major proportion (11.0%) among foragers. A carpenter bee *Xylocopa fenestrata* constituted 9.0% of the total flower visitors.

***Queen rearing:*** Cells grafted in *A. mellifera* colonies, for their requeening, using vertical queen excluders, yielded 19.35% success. Half of these colonies superseded the older queen bees.

***Bee toxicity:*** Toxicity of recommended insecticides to *Apis mellifera* in *Brassica* is in the following order Imidacloprid > Chlorpyriphos > Quinalphos > Monocrotophos > Metasystox > Endosulfan.

***Studies on Trigona:*** The colonies of *Trigona irridipennis* in small wooden-box and earthern-pot were found developing appreciably than in bamboo. Foraging by bees was conspicuous between April–May in colonies hived in small wooden-box, which was found better than earthern-pot.

**Agricultural acarology**

*Polyphagotarsonemus latus* (yellow mite) severely damaged sesame in Gujarat and Punjab, and *Oligonychus oryzae* and *Stenotarsonemus spinki* were severe on rice in Tamil Nadu, Uttar Pradesh and Gujarat.

Among chilli varieties, KA 2 in Karnataka, Jwala, RHRC Erect and AEG 77 in Gujarat and Indam 10 in West Bengal have showed less susceptibility to yellow mite.

Studies on the role of plant architecture on the predatory efficiency of *Neoseilus longispinosus* revealed that bushy nature of plants aid in faster suppression of spidermites. Efforts to produce Monocrotophos and Dicofol resistant strains of *Neoseilus longispinosus* have been successful; strains resistant to recommended concentrations of pesticides have been developed.

**Nematode management**

***Hot spots of major nematode diseases:*** Hot spots for white-tip nematode, *Aphelenchoides besseyi*, infesting paddy, a seed-borne nematode in Gujarat and West Bengal; *Pratylenchus thornei* in chickpea in Uttar Pradesh; root-knot nematode infecting citrus and cotton in Gujarat and Haryana respectively have been identified.

***Management technology of root-knot nematode:*** Root-knot nematode *Meloidogyne incognita* of tomato at farmer's

**SUCCESS STORY**

**Nematodes management in various crops**

**Cotton**

An ecofriendly and economically viable nematode management technology against root-knot nematode in cotton, devised by Hisar centre by using a rhizospheric rhizobacteriun *Gluconacetobector diazotrophicus* strain 35–47 as seed treatment at 200 g of wood charcoal-based bacterial culture having $1 \times 10^8$ bacterial cells/g of charcoal powder/4–5 cotton-seeds, was effectively demonstrated at the farmer's field (Shri Jit Ram, village, Gabipur Barwala, Distt. Hisar) for 3 consecutive years 2001–03. Seed treatment with bacterium led to 56.5% mean higher cotton yield in root-knot nematode affected fields over check, and was highly cost-effective with cost: benefit ratio of 1 : 191.2. This technology is simple to apply, and has been included in the package of practices of CCS HAU, Hisar, for adoption by the farmers.

**Pigeonpea**

To minimize losses caused by pigeonpea cyst nematode (*Heterodera cajani*) in Tamil Nadu, a management technology in the form of combined treatment of *Pseudomonas flourescens* + *Trichoderma viride* at 5 + 5 g/kg of seed was demonstrated which led to 32.5% decrease in *Heterodera cajani* population in the soil and 37.1% increase in the grain yield.

field located at Madampatti village of Tamil Nadu was managed by raising crop nursery in solarized beds treated with Carbofuran 3G at 10 g/m$^2$, followed by transplanting in the main field treated with neem-cake at 500 kg/ha. This resulted in significant increase in yield 46.4% and reduced nematode population up to 56% over control.

Chickpea genotypes C 24, C 42, C 49; rajmash genotype R 7; pea genotypes FP 2, FP 12, FP 13. FP 18, FP 21, FP 28, FP 29, FP 30, FP 36 and FP 37 and lentil genotypes LE 8, LE 15, LE 16, LE 17, LE 23, LE 32 confirmed resistance against *Meloidogyne incognita* and *M. Javanica*.

Plant-parasitic nematode infecting mung crop was managed with seed soaking in Carbofuran (25 EC) at 0.1% and seed dressing at 3% w/w with Carbosulfan (25 SD) that resulted in significantly higher yield over control. Maximum yield was recorded with higher dose of Carbosulfan as seed soaking treatment. Root-knot nematode in groundnut was managed by soil application of neem-cake at 1,000 kg/ha + neem oil at 5 litres/ha + Carbofuran at 1 kg a.i./ha that reduced root-knot nematode index and registered 42.9% increase in crop yield.

**Pesticide residues management**

Supervised field trials of Oberon 240 SC (Spiromesifen) a new non-systemic insecticide and acaricide were conducted on eggplant, chilli and tea at the recommended dose (96 g a.i./ha) and its residues were found below detectable limit (BDL) on 15, 15 and 7 days, respectively. Residues in cotton-lint and seed were non-detectable after 1 picking when sprayed at 120 g a.i./ha.

Confidor 350 SC and Confider 70 WG (Imidacloprid) were sprayed on paddy at of 26.25 and 24.50 g a.i./ha. No residues were found at harvest in rice-grain, husk, straw and soil. In cotton, no residues were detected in lint and seed at 1 picking when Confidor 70 WG was applied at 35 g a.i/ha.

Nurelle-D (505, EC), a combination product of Chlorpyriphos and Cypermethrin (50% + 5%), was evaluated on chilli in different agroclimatic conditions of the country. The residues of both were non-detectable after 15 days.

Tricontanol 0.05% EC was applied on potato at of 0.25 g a.i/ha and residues were not detected at harvest in potato as well as in soil. No residues of Tracer 45 SC (Spinosad) were detected at harvest on pigeonpea when applied at 73 g a.i./ha.

**Whitegrub management and other soil arthropods**

***Management of soil arthropods by chemicals:*** In soybean at Ranichauri, Imidacloprid 200 SL (60 g a.i./ha) was found promising against whitegrubs *Holotrichia longipennis*, when applied as the standing-crop treatment.

At Durgapura, in groundnut, seed treatment with Imidacloprid 70 WS at 1.4 g a.i./kg of seed and soil-furrow application of Imidacloprid 0.75% G at 56.25 g a.i./ha were found effective against whitegrubs *Holotrichia consanguinea*. Seed treatment with Quinalphos 25 EC (4 ml/kg of seed), Thiomethoxicam 70 WS (2.0 g/kg of seed) and Thiomethoxicam 25 WG (4.0 g/kg of seed) proved promising against whitegrubs *(Brahmina coriacea)*; resulting in reduced plant mortality in off-season pea in Sangla valley (Distt Kinnaur), Himachal Pradesh.

***Effect of pesticides on non-targeted soil microarthropods:*** Pesticide application causes harmful effects on the non-targeted soil arthropods like collembola (soil insect) and soil mites. Quinalphos, Chlorpyriphos and Imidacloprid as soil treatment for whitegrub management at Palampur declined collembolan population by 30, 42 and 9%. However, at harvest, population of these micro-arthropod recovered, and reduction in all these insecticidal treatments ranged between 4 and 12%.

Chlorpyriphos 20 EC at 800 g a.i./ha and Imidacloprid 200 SL at 60 g a.i./ha) were applied in the standing crop of barnyard millet in July against whitegrubs. Adverse effects of insecticides on soil mites and collembolans were observed only for two months.

**Agricultural ornithology**

At Ludhiana, bird damage to germinating late-sown wheat-crop in fields with preceding sesame crop was to extent of 38–95%. The rose-ringed parakeet and small green barbet caused 12% damage to maturing *bhindi* cultivated as intercrop in Kerala. Koel, bulbul and barbets caused damage to the extent of 16% in pepper crop during vulnerable berry stage.

***Ecofriendly birds management:*** In field experiment at Kerala, botanicals *Andrographis paniculata*, *Annona squamosa* and *Ipomoea cornea* at 10% concentration showed 78–91% reduction in depredation rate of birds in the rice nursery and main field. In Andhra pradesh, the main crop of maize could be protected from bird damage by using fodder maize (1,995 kg/ha) and fodder sorghum (1,452 kg/ha) as border screen crop, as compared to control (1,211 kg/ha). In Andhra Pradesh, the bird management modules such as net recorded higher yield (1,458 kg/ha), followed by ribbon (1,236 kg/ha), botanical sprays (990 kg/ha), and lowest yield of 540 kg/ha was recorded in untreated control; along with 48% reduction in depredatory birds' population.

***Beneficial birds in suppression of insect/rodent pests:*** In harvested paddy fields, common myna, common swift and cattle egret reduced 20 to 30% swarming caterpillar larvae, stem borer and grasshoppers. In pigeonpea, NPV + bird perches showed higher yield (1,542 kg/ha) than control (1,094 kg/ha) in Andhra Pradesh. In the food analysis of spotted owlet, for the first time has been identified appendages of scorpion *Bufo melanosticus* and remnants of bats. In Andhra Pradesh, for the first time, range

extension of Isabelline chat (*Oenanthe isabelline*) was recorded and found feeding voraciously on *Helicoverpa armigera* on pigeonpea.

***Location-specific studies:*** Piscivorous birds, little greeb, kingfisher, cormorants and little egrets caused 15–25% damage to fingerlings of prawns in Coastal aquaculture areas of Andhra Pradesh. In Gujarat, 19% Sarus-crane juveniles were recorded in the population, which indicate successful breeding in the preceding monsoon.

**Rodent control**

***Rodent ecology and behaviour:*** *Rattus rattus* (8.09%) *Golunda ellioti* (2.94%), *Mus booduga* (2.20%) and *Millardia meltada* (0.74%) were other prevalent rodent species besides *Tatera indica* (63.97%) and *Funambalus pennati* and *M. musculus* (11.03%) in a study on effect of land-use pattern on rodent species. The truly desertic rodent fauna, *M. hurrianae* and *Gerbillus gleadowi* were not reported during this year, indicating their total replacement by other species due to changes in land-use pattern and urbanization of the study area. The sex ratio of all the species trapped was in favour of males excepting for *M. booduga*. Like previous years, the fruit orchards recorded higher rodent population of 39.71%, followed by agri-pasture (32.35%) and silva-pasture fields (27.94%). Among these, *Funambalus pennanti* was mainly trapped from *ber* and pomegranate orchards and *Tatera indica* was trapped from all the three habitats almost uniformly.

***Rodent management:*** *Rodenticidal formulation:* Developed a new formulation of bromadiolone by adding plaster of paris, wheat, sugar, oil and bromadiolone BC in ratio of 20 : 68 : 4 : 4 : 4 that yielded 80% mortality of *Rattus rattus* within 5–10 days.

*Rodenticidal evaluations:* Pearl millet-based coumatetralyl baits (0.0375%) yielded cent percent mortality of *Bandicota bengalensis* after 3 days exposure in choice and nochoice tests. Cholecalciferol, a vitamin D3-based compound, at 40–60 mg/kg dosage caused 50% mortality of house-rats within a week's time.

# Improvement and Management of Horticultural Crops

## Mango

National Active Germplasm of mango at CISH, Lucknow, maintained 735 accessions in the field gene bank. Sixty accessions were characterized for fruit characteristics. The GIS tool could be employed for identification of cultivar-specific climatological region and in developing cultivar(s) specific region(s) in the country. Tommy Atkins was found a potential donor for red peel and precocity characters. Microsatellites have been isolated from mango Alphonso using dynabead-based microsatellite enrichment method. Mango Langra, Borsha and Raspuri were differentiated using MID01F-R, MID06F-R, MID10F-R and MID26F-R. The products were separated on Polyacrylamide gel electrophorosis (PAGE) at IIHR, Bangalore.

Drip irrigation in mango orchards increased the fruit yield by 12% and saved fertilizers by 25%. High-density plantation of Arka Anmol (400 plants/ha) raised on Vellaikolumban rootstock gave more fruit yields even with 75% of recommended dose of fertilizers and 50% of evaporation rate. Alphonso mango scion grafted *in situ* on Vellaikolumban and Olour rootstocks at planting density of 1,111 (3 m × 3 m), 400 (5 m ×5 m) and 178 (7.5 m × 7.5 m) trees/ha trees indicated better field establishment at higher planting densities on Olour rootstock as compared to Vellaikolumban.

Lowering the respiration and ripening temperature to 20°C helped in reducing the incidence of spongy tissue formation. Better germination of seeds extracted from spongy tissue affected fruits in field as compared to those from healthy fruits appeared due to physiological shift in seed to enable it to act as a stronger physiological sink for water and other resources from the adjoining mesocarp resulting in development of spongy tissue. Prediction models were developed for trap catch of mango fruit fly (*Bactrocera correcta*) using all weather parameters. Antioxidant potential of Alphonso mango peel and kernels were 20 and 40 times more than pulp and hence kernels can be used as a food additive for enhancing antioxidant property in processed foods.

Use of black polyethylene mulching (100 µ) in September was found beneficial in Chausa and Langra to curtail the loss of paclobutrazol applied for flower induction @ 3.2 ml/m canopy diameter and reduced fruit drop. Application of paclobutrazol also resulted in increase in number (15.2–20.22) and size of stomatal aperture (9.8–14.17 µm) and caused higher accumulation of starch granules as compared to control in leaves of mango Chausa and Dashehari. Fruits of Langra with thinner pedicel (3.79 mm) showed more drop than Dashehari (4.18 mm), Chausa (4.99 mm) and Mallika (5.86 mm).

- The National Active Germplasm of mango was enriched
- Black polyethylene mulching was beneficial in mango
- Eighteen new cultivars and 26 seedling accessions of mango were collected
- The antagonists reduced disease incidence in mango

All the antagonists used as post-application significantly reduced the disease to 7.57–10.76% from 74.35% in the control.The antagonist from karanj (*Pongamia* sp.) leaf based organic pesticides controlled disease better (7.57%). These effective antagonists were identified as species of *Bacillus*, *Pseudomonas* and *Acenetobacter*.

A total of 18 new cultivars and 26 seedling germplasm accessions of mango were collected. Dudhia Malda produced maximum yield with good TSS at different centres. Two clones, T19 and T20, of mango Himsagar were found promising with higher yield and good TSS. Mallika showed superiority over other varieties in yield and TSS. Double hedge row system of planting recorded significantly higher yield. Mango germplasm Misrikhan recorded minimum disease incidence (0.1%), while mango Meghlanatan was found free from malformation during third year. Three sprays of carbendazim (0.1%) starting with the onset of anthracnose disease in mango followed by spraying at 15 days intervals managed the disease effectively.

## Guava

Ninety-six accessions including six species of *Psidium* were maintained in the field genebank. Twenty accessions of guava were collected from Allahabad and its surrounding areas, while 68 were characterized for fruit morphology and quality parameters. Pink-fleshed guava, HAPSI-35 and HAPSI-46/ere found suitable for nectar preparation and HAPSI-16 retained vitamin-C for longer period. Interspecific wilt resistant guava rootstock (*P. molle* × *P.*

- Ninety-six accessions of guava were maintained
- Sixty-eight accessions of guava were evaluated
- Guava HAPSI 35 and HAPSI 46 were suitable for nectar production
- Guava HAPSI 16 retained vitamin C for a longer period

*guajava*) was multiplied successfully through stem cuttings. Allahabad Safeda and Sardar were found superior in fruit yield.Double hedge row system of planting yielded more in guava. Maximum yield and best quality fruits in winter season were obtained by regulating flowering with treatment of 15% urea at 50% bloom stage in April–May followed by its second spray after 10 days.Soil application of *Trichoderma viride* along with FYM around root zone was found most effective in reducing the incidence of guava wilt.

**Papaya**

Application of 75% of recommended dose of fertilizer of 50 g each of N and $K_2O$/plant/year) at Coimbatore recorded higher yield (33.6 fruits/tree with 1.09 kg fruit weight in $CO_2$. Out of five lakh derived compounds (A, B, C, D and F) tested under *in vitro* condition for their toxic potential against egg hatching and juvenile mortality of root-knot nematode and various life stages of reniform nematode, two important pest of papaya, revealed a varying degree of toxic potential which was found to be dependent on the concentration and exposure time. Only four compounds, A, B, C and D could cause 87–100% juvenile mortality of root-knot nematode at 5,000 ppm after 264 hours of exposure. On the other hand, compound A could bring 100% mortality of reniform nematode during the same exposure period. Application of farmyard manure enriched with biopesticides, *Pseudomonas fluorescens* ($10^8$ cfu/g), *Pochonia chlamydosporia* ($10^6$ cfu/g) and *Bacillus subtilis* ($10^6$ cfu/g) @ of 2 kg/tree (5 years old) at six monthly intervals reduced root population of *R. reniformis* and *M. incognita* effectively (64 and 66%, respectively). Combined application of neem cake (250 g) + carbofuran (1g ai) + *Pseudomonas fluorescens* (4 g) gave highest fruit yield and maximum reduction of nematode population in papaya $CO_2$.

**Litchi**

Four new accessions of litchi were added. A total of 52 accessions have been maintained in the field gene bank at NRC for Litchi, Muzaffarpur (Bihar). The 15–20 years old orchards gave 24–36% higher yield. Rejuvation of old senile orchards was demonstrated at farmers' fields. Seedling SG-JAL-1 recorded maximum yield (62.0 kg/tree) at Mohanpur under AICRP on Subtropical Fruits.

**Grape**

The grape germplasm collection at NRC for Grape, Pune, was enriched by introducing eight exotic accessions from Uzbekistan, thus bringing the cumulative collection to a total of 401 accessions. Fifty-four accessions were characterized for their berry and bunch characters. Bunch weight and number of berries/bunch showed a large variability. A total of 91 accessions were characterized and grouped based on their reproductive phenological stages. The early-ripening varieties clustered in one group, whereas slow-and-late-ripening ones were grouped together. A few grape varieties were characterized based on their phenolic composition and antioxidant activity. A software has been developed to create an electronic database containing characterization data of grape germplasm available in India.

Twenty-one rootstocks were analysed with AFLP and SSR primers. Two clones of rootstock, viz. Dogridge A and Dogridge B, were distinguished. Dogridge B was grouped with *Vitis champinii*, while Dogridge A with 110R (a hybrid of *V. rupestris* and *V. berlendieri*) with 80% similarity.Several accessions resistant to thrips (*Ripiphorothrips cruentatus* and *Sertothrips dorsalis*) and downy mildew were identified through field screening. Eight AFLP and 5 SSR markers showing promising association with resistance/susceptibility to disease have been identified.

Flame Seedless grape gave more yield, when grafted on Dogridge rootstock compared to own root or St. George rootstock. A load of 45–50 bunches/vine was found to be optimum for obtaining good quality grapes in grafted Thompson Seedless. Berry quality parameters like length, diameter and weight were obtained in Thompson Seedless on Dogridge. In Tas-A-Ganesh, 35% cluster clipping with berry thinning and retention of 35 shoots and bunches/vine resulted in better yield with good quality. In Sharad Seedless, berry diameter, and berry and bunch weight were recorded more in bunches on straight canes compared to those on subcanes. The yield was highest in vines grafted on rootstock B2/56 and also found to have better salt exclusion as indicated by lower sodium content in petiole of Thompson Seedless. Black leaf disorder observed in many vineyards were attributed to low potassium content or excess sodium. Tas-A-Ganesh grafted on rootstock showed better water-use efficiency compared to own-rooted vines. Similarly, use of mulch improved water-use efficiency in grape. Subsurface irrigation resulted in 25% saving of irrigation water. Application of hydrogen cyanamide through spray resulted in budbreak, which was at par with swabbing. In grape Sharad Seedless, $GA_3$ and 6-BA improved weight of berries, diameter and length of berries; TSS and acidity of juice significantly at Bangalore. Bangalore Blue grape peel contained more phenols, flavonoids and antioxidant activity than pulp.Therefore, juice should be extracted with peels and seeds to get more antioxidants.

- Four new accessions of litchi were added
- Rejuvenation of old litchi orchards was demonstrated to farmers
- Twenty-one rootstocks were analysed with AFLP and SSR primers
- Grape germplasm was enriched with exotic accessions.
- Banana Udhayam has been released
- Sigatoka leaf spot in banana was controlled effectively.
- A wild banana species has been identified.

Release of predator *Cryptolaemus mountrouzieri* @ 10/vine 75 and 85 days after pruning resulted in 80% reduction in bunch damage of grapes by mealy bug (*Maconellicocus hirsutus*). Forecasting-based disease management of downy mildew and powdery mildew saved in number of spray, helped in giving timely application of fungicides. Several environment-friendly substances, viz. Chitosan (0.1%), fermented *gomutra* (10%) and milk (10%) were found promising in controlling powdery mildew especially under low disease risk situation. Several fungal and bacterial endophytes were isolated from Tas-A-Ganesh and 2A clone of Thompson Seedless for testing for their antagonism to various grape pathogens. A bacterium showing antagonism to *Botryodiplodia* was isolated from grape rhizosphere. Seasonal incidence of major insect pests, viz. flea beetle, thrips and jassids was observed in vineyards of Maharashtra and Andhra Pradesh. Insect incidence showed correlation with weather parameters. Rainfall, minimum temperature and humidity correlated negatively with the population of thrips and jassids. Mealybugs population was negatively correlated with humidity.

**Banana**

A new wild species of banana, *Musa swarnaphalya*, from North-East region has been identified by NRC for Banana, Truchirapalli. A new variety, Udhayam (ABB), has been released with 40% more yield than Karpuravalli.

As a first step towards development of transgenic banana for resistance to *Fusarium* wilt, regeneration protocol for banana Ney Poovan has been standardized at IIHR, Bangalore. Diagnosis and Recommendation Integrated System (DRIS) chart has been constructed for monitoring nutrient status of banana plants for Tamil Nadu. The fertilizer adjustment equations have been developed with reference to targeted yield for Nendran banana. Entomopathogenic fungi (*Beauveria bassiana*) and nematode (*Heterorhabditis*) were found effective against banana weevils under field conditions involving stem trap as delivery system. *Trichoderma viride* (T-6 strain), *Azospirillum* sp. and *Pseudomonas* sp. were found effective against cigar end disease under *in-vivo* condition. It can be mass produced in rice chaffy grains at 22°C and maintained up to 4 months. Rice husk has been successfully used as a carrier material for *Pseudomonas fluorescens* with a shelf-life of 6 months. Robusta banana can be stored up to 3 months and Rasthali for 4 months at 13.5°C and 90% RH without showing any ripening disorder in fruits. Banana stem juice beverage has been developed, which has 5 months storage life under room temperatures.

Under AICRP on Tropical Fruits, a total of 925 banana accessions were maintained and evaluated. Among the already identified Kanthali clones, clone-I and clone-II were found to be more

Banana Udhayam

potential. Planting of Nendran is remunerative during all the seasons under Kannara conditions. Combina//g/plant) and 50 g/plant each of PSB, *Azospirillum* and *Trichoderma harzianum* with 75% of recommended dose of fertilizer of 200 g N, 50 g $P_2O_5$ and 200 g $K_2O$/plant for Rajapuri, Karpurachekkarakeli and 100% recommended dose of fertilizer for Grand Naine was found better for yield. Growing single/double crop of cowpea and its incorporation into soil continued to be effective for weed control. The best crop sequence as intercrops are onion at Arabhavi, cowpea at Jalgaon and cabbage at Mohanpur. Combined treatment of *Paecilomyces lilacinus* along with organic amendment, neem cake @ 250g/plant or FYM @ 500g/plant gave maximum reduction of nematodes in banana Robusta. Effective control of Sigatoka leaf spot was achieved with three sprays of propiconazole (0.1%) at 30 days intervals with *Bacillus subtilis* or *Pseudomonas fluorescens* (0.5%). Tissue-cultured banana plants showed more incidence of banana streak virus (BSV) than plants raised by suckers.

**Citrus**

In precision-oriented fertilizer management in Nagpur mandarin, lack of soil test-crop response is considered to be the major drawback for inconsistent production response of Nagpur mandarin due to horizontal and vertical heterogeneity in soil properties. Two soil sites in the same orchard were identified through grid samplings, which represented Typic Ustorthent (Ap-A12-A13-C) and Typic Haplustert (AP-A2-A3 ss-A4ss-Ack-Ck) soil types. To rationalize fertilizer-use efficiency through site-specific nutrient management, fertilizer requirement varied from 1200 g N, 600g $P_2O_5$, 600 g $K_2O$, 300 g each of $ZnSO_4$, $FeSO_4$ and $MnSO_4$, 100 g borax, 400 g $MgSO_4$ and 100 g elemental S/tree on Typic Ustorthent to as much as 600 g N, 400 g $P_2O_5$, 300 g $K_2O$, 300 g each of $ZnSO_4$, $FeSO_4$ and $MnSO_4$, and 100 g borax, 400 g $MgSO_4$ and 100 g elemental S/tree on Typic Haplustert with fruit yield of 61–68

- Disease-free planting material was distributed at the NRC for Citrus, Nagpur
- About 9,862 healthy budgrafts of Nagpur mandarin were distributed

**SUCCESS STORY**

**Multi-K Brings Cheer to Kinnow Farmers**

The B and C grade fruits of kinnow do not bring remunerative returns to farmers, whereas 'A' grade fruits get premium returns. Non-availability of sufficient potassium during critical phase of fruit growth is the main reason of low quality fruits. Multi-K was, therefore, sprayed thrice along with other chemicals. First spray was done when the leaves attained two-thirdd of their normal size in March, second when fruitlets attained about 2 cm diameter and third after one month of second spray. Multi-K (2%) and Multi-K (1%) increased the proportion of 'A' grade fruits by 20% over the control.

kg/tree against fruit yield of 34–53 kg/tree with farmers' practices. The cost:benefit ratio of 1 : 2.1 in combined treatment further confirmed its superiority in yield response over farmers' practices.

At NRC for Citrus, Nagpur, 38,341 disease-free planting material of Nagpur mandarin, acid lime and sweet orange were distributed. About 9,862 certified healthy budgrafts of Nagpur mandarins through shoot tip grafting were also distributed to citrus growers. The inclusion of VAM (500g/plant) + PSB (100g/plant) + *Azospirillum* (100g/plant) + *T. harzianum* (100g/plant) with 100% RDF gave highest yield of Kinnow mandarin at Ludhiana, and sweet orange and acid lime at Rahuri and Nagpur mandarin at Akola. The requirement of inorganic fertilizer was reduced by 25% with the inclusion of biofertilizers at Tirupati. Leaf miner in citrus was effectively controlled with spraying of imidacloprid (0.005%) followed by NSKE (5%)/*Bacillus thuringiensis* at 0.1%. Spraying of imidacloprid (0.005%) was effective for blackfly. Lemon butterfly was effectively controlled by spraying of endosulfan (0.07%) or *Bacillus thuringiensis* (0.05–0.1%)/carbaryl (0.15%)/ thiodicarb (0.075%). Treatment with Bordeaux paste to trunk followed by soil application of *Trichoderma viride* follwed by Alphosetyl (0.2%) spray was effective for the management of *Phytophthora*. At Chethalli, indexing and confirmation of citrus tristiza virus (CTV) isolates was done by ELISA, dsRNA and RT-PCR methods. For the management of nymphal population of citrus blackfly, releases of 4-6 eggs of *Mallada boninensis*/shoot was found effective during *Hasta bahar* in Maharashtra.

**Sapota**

A collection of 92 accessions was maintained and evaluated. Application of 5 kg vermicompost with annual application of 150 g N, 40 g $P_2O_5$ and 150 g $K_2O$/plant for 9-year-old sapota and 25 kg FYM/5 kg vermicompost with 300 g N, 50 g $P_2O_5$ and 200 g $K_2O$/plant/year for 15-year-old sapota recorded significantly higher growth and yield. Application of 75% recommended dose of fertilizer through drip recorded higher yield (22.96 tonnes/ha) for Kalipatti sapota. Application of DDVP (0.03%) in second fortnight of March followed by polytrin-C (0.044%) in first fortnight of April, monocrotophos (0.05%), DDVP (0.03%) and chlorpyriphos (0.05%) applied in first and second fortnights of April suppressed bud-borer in sapota.

**Jackfruit**

Evaluation of improved clones revealed two good clones for table, chip and culinary purposes, nine for table purpose, 4 for making chips and two for culinary purpose. Inarching recorded maximum graft take during September and softwood grafting in October under 50% shade condition. Incidence of leaf-feeding caterpillar (*Margaronia bivitralis*), fruit-borer (*M. caesalis*), spittle bug (*Cosmoscarta releta*), bark caterpillar (*Indarbela tetraonis*) and fruit rot (*Rhizopus artocarpi* and *Aspergillus niger*) and leaf spot were reported from different regions.

**Mahua**

Vegetative propagation of mahua (*Madhuca latifolia*) by veneer grafting gave more success (80%) followed by cleft grafting (40%) on seedling rootstock.

**Arid Zone Fruits**

A total of six elite genotypes of ber and 10 of aonla were identified. Ber Chhuhara, Tikadi, Kathaphal, Kharki No. 1, Badami, Manukhi, Gloria and Safeda Rohtak scaped frost injuries. A large collection of bael, phalsa, lasoda, pilu, woodapple and khirni were collected and evaluated. The advanced lines of ber, viz. CIAH-Sel 1 and CIAH Hy.1 continued to show promise for yield, earliness, organoleptic taste and quality parameters. Spraying of calcium carbonate and borax aqueous solution 0.4% Ca + B (mixed) gave promising results by increasing fruit setting and reduction in fruit drop in aonla. The allelopathic influence of aonla leaf extract revealed that mustard crop was sensitive to water-soluble allelo-chemicals of aonla leaf extract, while wheat and mothbean were tolerant to it. The combination of vermicompost and inorganic fertilizers in a 50 : 50 ratio gave maximum fruit yield (42.5 q/ha), plant height and tree volume. Inclusion of bulk organic sources of nutrients increased moisture availability in root zone of pomegranate. In Kinnow and pomegranate, microsprinkler and drip irrigation at 75% CPE gave 75–80% increase in fruit yield, saving 25–30% irrigation water over basin pipe irrigation system. The promising isolates of bioagents CIAH-196 of *P. fluorescens* and CIAH-240 of *Trichoderma* were mass multiplied in both culture and subsequently formulated in talc powder with 1%

- A collection of 92 accessions of sapota was evaluated
- Improved clones of jackfruit were evaluated for edible purposes
- Ber CIAH Sel 1 and CIAH Hy 1 were promising for yield
- Six elite genotypes of ber and 10 of aonla were identified
- The promising isolates of bioagents were mass multiplied

cellulose. This formulated product was tested under field conditions for management of ber powdery mildew. CIAH-196 and isolate CIAH-240 showed high germination(80.1 and 78.5%) as compared to the control (60.5%).

**Temperate fruits**

Apple Oregon Spur, Golden Spur and Prima gave good yield under rainfed conditions at Mukteshwar in Uttranchal. Apple mosaic effected the yield adversely. Firdous, Shreen, Starkrimson, Green Sleeves, Silver Spur, Mollies Delicious, Cooper 4, American Apirouse, Winter Commercial and Starking Delicious apple were found precocious under Kashmir valley conditions. Walnut landraces, viz. LG-5, LG-10, LG-9, LG-7, LG-11, HN-1, SPS-3, LG-18, PPM-4 and YKB-4 were found promising for nut characteristics. Nut weight ranged from 13.73 to 27.16 g, kernel 7.15 to 12.75 g and kernels recovery from 46.96 to 59.39%. Late-blooming almond landraces, viz. BP-7 and GP-10, identified from Kashmir valley possessed 0.35–1.42 g kernel. The percentage of kernel in these land races ranged from 20.89 to 62.06. Walnut Landrace, LG-5, has a potential for commercial exploitation.

- Apple Oregon Spur, Golden Spur and Prima gave good yield
- Walnut landrace, LG-5, was promising
- Saffron CITH-$S_3$ clone was most promising

**Saffron**

The CITH-$S_3$ clone was found most promising in yield followed by CITH-$S_{43}$ and CITH-$B_{76}$.

**Post-Harvest Technology**

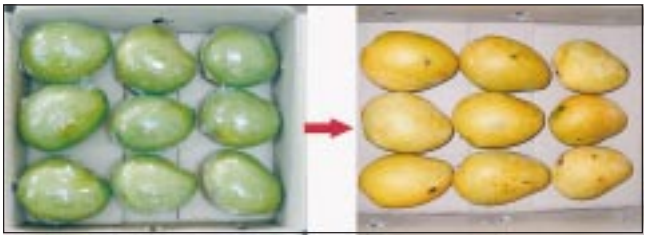
Packaging line for Dashehari mango (1 tonne/hour capacity) was standardized for de-sapping, hot water treatment, washing, drying and grading operations. Protocol for export of Dashehari mango has also been developed. The CFB boxes with 0.5% ventilation were found very effective for prolonging the shelf-life of different stages of mango, i.e. mature green, semi-ripe and fully ripe fruits under cold storage conditions for 24, 10 and 7 days, respectively. Stone jelly formation, a disorder in Dashehari, has been successfully controlled by three pre-harvest spraying of 2% $CaCl_2$ (dihydrate) at 10 days intervals using 0.1% Tween-20 as surfactant. In addition, this treatment also retained more matured fruits and delayed the ripening on tree, by advancement of maturity of fruits.

- The CFB boxes with 0.5% ventilation were found effective
- Individual shrink wrapping prolongs storage life of mango and pomegranate fruits
- The recipe for preparation of guava-aonla blended RTS drink was standardized
- A new protocol was standardized at NRC for Banana
- Several banana-based value-added products were developed

Promising landraces of walnut

Saffron CITH-$S_3$ clone

Shrink wrapping in pomegranate (*above*) and mango (*below*)



Individual shrink wrapping prolongs storage life of mango and pomegranate fruits. Matured green mangoes of Banganapalli could be stored in fresh, firm and green condition for one month at 8°C by individual shrink wrapping. The fruits ripe normally within a week after unpacking at ambient conditions with good surface yellow

colour, firmness, good taste and without any chilling injury. The storage life of freshly harvested pomegranate fruits of Bhagwa (Kesar), Mridula and Ganesh could be extended to one month at ambient temperature with retention of freshness and quality. At 8°C fruits of Bhagwa and Mridula could be stored for 3 and 2 months respectively without any chilling injury.

The fresh fruits of aonla possessed a high level of antioxidant activity and high content of total phenols (3,189.3 mg/100g), flavonoids (238.4 mg/100 g) and vitamin C (340 mg/100 g). Aonla could be stored for 30 days at 6–7°C with a very little loss to total phenols and flavonoids.The respective radical scavenging activity was 7,349.3, 6,040.6 and 7,293 mg/100 g in fresh fruits 15 and 30 days after storage. Aonla thus appeared to be a very prominent fruit as an antioxidant supplement and also an important constituent of neutraceuticals. Oil-less pickle of aonla could be stored up to 3 months.

The recipe for preparation of guava-aonla blended RTS drink was standardized. It was found that aonla pulp up to a level of 20% could be added to guava pulp for an acceptable quality of drink containing 10% pulp, 12–14 °Brix TSS and 0.28% acidity. The best quality of oilless aonla pickle was prepared with 2.5% added sugar apart from 10% salt, 1% red chilli powder and 1% asafoetida. The pickle could be stored up to 3 months in good condition. After this period, acceptability decreased fast due to high rate of browning and loosening of texture. Aonla juice heated to 80°C, pasteurized and added with 100 ppm KMS, was found to have minimum microbial load as compared to unheated and pasteurized samples. Value-added product like candies and pickles were made from unused rind portion of watermelon by a simple osmosis process and by addition of edible food colours. The candy has good texture, attractive colour, pleasant taste and storability. The product can be used as desserts and fruit salads as well as in chocolates. Candy preparation does not require sophisticated machineries and is an ideal means for generating income from small-scale production by farmwomen.

A new protocol was standardized at NRC for Banana by integrating several post-harvest treatments like, de-handing, heat shock, modified

Fruits of banana Robusta after 90 days of storage

atmosphere packaging and temperature management whereby the storage life of Robusta banana could be extended up to 3 months and Rasthali up to 4 months at 13.5°C and 90–92% relative humidity. At the end of storage period, all fruits could ripe well using ethrel with good eating quality. Several banana-based value-added products like banana fig, banana flower and fruit pickles, ready-to-serve juice, fruit bar, biscuits, flour (powder) and fibres were developed. Most of them have been commercialized and are now being manufactured. Use of banana stem juice as a remedy for renal calculi (kidney stone) is common in Tamil Nadu. A process was developed at NRC for Banana to convert banana stem juice, extracted from whole plant after harvesting of fruits, into a beverage having a storability up to 5 months under ambient conditions. The product is under commercialization by a private entrepreneur.

Tweenty-six varieties developed at IIVR, Varanasi, have been identified for release and notification by Central Varietal Release Committee. They are: Kashi Vishesh, Kashi Amrit, Kashi Anupam, Kashi Hemant and Kashi Sharad (tomato), Kashi Taru (brinjal), Kashi Anmol (chilli), Kashi Param (french bean), Kashi Shyamal

Kashi Vishesh

Kashi Agati

Kashi Pragati

and Kashi Gauri (cowpea), Kashi Mahima, Kashi Mangali, Kashi Vibhuti, Kashi Pragati and Kashi Satdhari (okra), Kashi 2, Kashi 3, Kashi Nandini, Kashi Udai, Kashi Shakti (pea), Kashi Sweta and Kashi Hans (radish), Kashi Kunwari (cauliflower), Kashi Madhu (muskmelon), Kashi Dhawal (ash gourd) and Kashi Harit (pumpkin). A cultivar of *lobia* is becoming popular at farmers fields due to resistance against golden mosaic virus.

At IIHR, Bangalore, tomato hybrid Arka Ananya with resistance to Tomato Leaf Curl Virus (ToLCV) and Bacterial Wilt (BW) was identified for release at national level. Its fruits are round, firm (5.0 kg/cm$^2$), medium-sized (50–65g) with light green shoulder, the yield being 76 tonnes/ha in 140 days. Suitable for summer and rainy seasons, Arka Anand, a new brinjal hybrid, has resistance to bacterial wilt and identified for release at national level. The fruits are green, medium long (20–22 cm) borne in clusters. The calyx is fleshy and green. Fruits tender with good cooking qualities, it yields 60–65 tonnes/ha in 140–150 days. Two CMS based chilli hybrids, Arka Meghana and Arka Sweta, were identified for release at national level. Arka Meghana is a high-yielding hybrid. Its fruits are long (10–11 cm) with 1.2 cm width, fresh yield 35 tonnes/ha and dry yield of 5.5 tonnes/ha in 140–150 days. Fruits are dark green and turn deep red. Arka Sweta is a high-yielding chilli $F_1$ hybrid. Its fruits are long (10–12 cm) with 1.1 cm width. Fresh yield is 38 tonnes/ha while dry yield 6 tonnes/ha in 140–150 days. Fruits are light green and turn red after ripening.

- Twenty-six new vegetables were identified
- Tomato hybrid Ark a Ananya and Arka Anand was identified
- Arka Meghana and Arka Sweta chilli were identified
- Chilli local strains were evaluated for Kashmir valley
- Of the 394 primers, 375 produced amplicons
- Primer OPB 16 was useful in determining purity of hybrid NTH 1
- Blanching and drying conditions of okra fruits were standardized

Chilli local strains were identified and evaluated under Kashmir valley conditions. The highest yield of dry chilli was recorded in CC 84 (262g/plant), followed by CC-167 (227g/plant) and CC-39 (202g/plant). The longest fruit was recorded in CC-151 (15.3 cm), followed by CC-132 (15.2 cm) and CC-126 (15.1 cm).

Seedling dipping at the time of transplanting followed by foliar application of bioagents (*Pseudomonas fluorescens*, *Bacillus subtilis* and *Trichoderma harzianum*) at 10 and 15 day intervals, result in lower incidence of disease and enhanced yield in tomato Mruthyunjaya 2. Breakdown of host resistance to tomato leaf curl virus in Mruthunjaya-2 and Avinash-2 was due to occurrence of new strains of virus at different places. The breakdown of resistance in tomato S24 in northern parts was mainly due to occurrence of a new strain of virus which was recombinant of mono and bipartite viruses. Resistance to tomato leaf curl virus has been introduced into four genetic backgrounds, Arka Saurabh, Arka Vikas, Arka Meghali and Pusa Ruby, through pathogen-derived resistance in a transgenic approach. Transgenic tomato Arka Saurabh, Arka Vikas, Arka Meghali and Pusa Ruby have developed resistance to tomato tospo virus (PBNV) through pathogen-derived resistance.

A blend ratio of 100 : 1 of two pheromone components (E)11 : 16-OAc and (E)11 : 16-OH was found most effective in trapping brinjal shoot- and fruit-borer. Pheromone lure set up on water trap was nearly twice more effective as compared to delta traps. Onion Arka Kalyan and SM11 × PBR showed better assimilation rates under water stress conditions, indicating their suitability under water stress. Application of FYM at the rate of 50% of recommended dose of chemical fertilizer equivalent as a combination of organic package for rose onion Arka Bindu yielded 23.12 tonnes/ha, which was at par with yield obtained with the recommended NPK fertilizer applied (23.36 tonnes/ha). Watermelon triploid (seedless) has been developed and evaluated under protected conditions. Its fruits are round, light green with dark green stripes, TSS (12–13%), rind thickness 2.5 cm, pink flesh and very good taste. Average fruit weight is 5–6 kg. Thirteen amaranth lines were evaluated for antioxidants, of which, IIHR-74 recorded maximum total antioxidant capacity (TAOC) of 355 mg/100g AEAC. Flea beetle, *Nisotra* sp. was identified as a major pest in mucuna, which caused severe damage to young plants by feeding and limiting growth of plants, resulting in 60% yield loss.

**Molecular markers for hybrid purity testing**

Out of 394 primers used for screening of NTH-1 hybrid and its parents (DVRT-1 Flora Dade), 375 primers produced amplicons, of which only six primers showed polymorphism (1.6%) among parental lines. Data of these primers were analyzed to distinguish primer that produced bands specific to male parent. One primer (OPB 16) was found to be useful in determining purity of hybrid NTH-1. This primer generated five amplicons, out of which one fragment of 1193 bp size was male-specific. For hybrid NTH-7, 253 primers were screened, out of which 51 produced amplicons and six of them detected polymorphism (11.8%). Of these six primers, OPB-19 produced an amplicon of size 2,186 bp which was effective in detecting selfed seeds in hybrid seeds as it was male parent specific.

**Regeneration and transformation studies**

The genotypes, Punjab Sadabahar, Pant Rituraj, DVRT-2, H-24, H-86, Sel-7 and DT-10 were used for regeneration and transformation studies. Seedling explants such as epicotyl, hypocotyl, cotyledon and shoot tip were used. As a standard procedure to obtain explants, seeds were germinated on MS basal medium and

5–7 days old seedlings were utilized. With hypocotyl explant, MS medium in combination with BA and Kinetin and leaf discs MS medium with BA and kinetin were tested. The genotype, H-24 and H-86, gave best regeneration frequency in both explants. H-86 had best regeneration potential, when cultured on MS medium containing BA. This regeneration procedure was used to facilitate gene transfer through *Agrobacterium tumefaciens* in H-86 using *Cry 1Ac* gene from the T-DNA of binary vector plasmid pBinAR, which also contains gene that encodes neomycin phospho transferase II (*nptII*). More than 45 putative transgenic plants were regenerated and are being maintained under laboratory conditions. These plants will be analyzed for integration of gene and its expression. The transformed progenies are being multiplied for further evaluation and bioassay. The number of shoot buds was recorded in genotypes VR Baigan-9 (IVBL-9) and VR Baigan-1 (IVBR-1) (MS + 2 BA + 1.0 Kin). The elongated explants were transferred on MS basal medium and root induction was achieved. This regeneration procedure was used to facilitate gene transfer through *Agrobacterium tumefaciens* in VR Baigan-9 (IVBL-9) using *Cry 1Ac* gene from T-DNA of binary vector plasmid pBinAR, which also contains gene that encodes neomycin phospho transferase II (*nptII*). More than 20 putative transgenic plants were regenerated and are being maintained under laboratory conditions. These plants will be analyzed for the presence of gene and its expression. The transformed progenies are being multiplied for further evaluation and bioassay.

**Drying of vegetables**

The blanching and drying conditions of okra fruits were standardized. Hot-water blanching treatment at 80 and 90°C for 2, 4 and 6 minutes resulted in no effect on inactivation of catalase and peroxidase enzymes. However, peroxidase enzyme was inactivated after hot water blanching treatment at 90°C for 4 and 6 minutes along with 0.1% magnesium oxide followed by dipping into 0.1% sodium sulfite solution. The catalase and peroxidase enzymes were inactivated after blanching in boiling water for half and one minute followed by dipping into 0.2% potassium metabisulphite solution. The drying condition in okra was standardized with initial drying of blanched okra at 70°C for 2 hours followed by drying at 60°C for 4 hours. Dried okra fruits upon rehydration showed complete discoluration and texture was adversely affected. However, blanched okra dried at 65°C for 4 hours resulted in retention of green colour and better texture.

**Precision nutrient management**

The pressmud @ 10 tonnes/ha was applied 15 days prior to field preparation and full dose of chemical fertilizers P @ 60 kg/ha and K @ 60 kg/ha coupled with N@ 60 kg/ha and S @ 25 kg/ha were applied at the time of final field preparation. The micronutrients Zn, B, Fe, Cu, Mn @ 100 ppm and Mo @ 50 ppm were applied thrice at 10 days intervals as foliar spray starting from 30 days after transplanting. The Azotobactor were applied as seedling root dip treatment. Full dose of chemical fertilizers except N was applied as basal dressing. The remaining 60 kg N/ha was topdressed in two equal splits.

**Management of bitter gourd fruitfly**

The efficacy of bait spray on fruit fly (*Bactrocera cucurbitae*) management in bitter gourd was evaluated under field condition during *kharif* season. Bait spray was initiated from 11 September 2004 at 7 days interval. During the post-bait spray period, the impact of bait application was reflected through relative variation in level of fruit infestation caused by fruit fly. Initially, the effect was not much significant. Later on infestation was very low in plots treated with bait spray of molasses. The average post-treatment fruit infestation was significantly less (35.65%) in molasses bait spray, followed by banana pulp (41.96%) and protein hydrolysate (43.24%). However, infestation level between protein hydrolysate and banana pulp was non-significant. Maximum yield (56.39 kg/plot) of bitter gourd was obtained from the plots sprayed with molasses based bait. There was no significant difference in yield between plots sprayed with protein hydrolysate (49.07 kg) and banana pulp (48.43 kg) based bait.

**Biocontrol of shoot- and fruit-borer**

The egg parasitoid, *Trichogramma chilonis*, was inundatively released @ 2.5 lakh parasitoids/ha with botanical and insecticide for management of brinjal shoot- and fruit-borer (BSFB). The foliar spraying of insecticide/botanicals was applied 10 days after previous release of parasitoid and parasitoids were released 7 days after foliar spray. Initially, relative level of fruit damage between treated and untreated plots was not prominent. However, effect of both the treatments in reducing fruit damage was prominent 90 DAT. On the basis of t-statistics, cumulative fruit damage over all harvesting indicated marginal superiority of both the treatments over the control. There was no significant difference between two *Trichogramma* releases either with botanical or with insecticide.

**IPM Strategy for BSFB**

Sex pheromone based IPM strategy for the management of brinjal shoot-and fruit-borer was demonstrated at farmers' fields

- Blanched okra retained green colour with better texture.
- A number of organic farming protocols for vegetables were developed
- Organically-grown cabbage Quisto gave yield at par with inorganically-grown one
- Sex pheromone-based IPM strategy for brinjal shoot-and fruit-borer was demonstrated

Kashi Komal

Kashi Shyamal

**Development of Organic Farming Protocols**

- The nutrient profile (both major and minor nutrients) of FYM, vermicompost, NADEP compost, press mud, biodynamic compost and activated sludge was estimated
- Application of organic nutrients at different doses, i.e. 5, 10, 15 and 20 tonnes/ha and soil nutrient balance sheet for tomato and cabbage was estimated, and found zero balancing for N and K and negative balance for P and S in a Typic Ustochrept soil
- The nutrients present in labile pool after addition of organic nutrients in time scale was determined. It was found that both P and S limiting except in press mud treated plots, while N, K, Fe, Mn, Zn, Cu are adequate.
- A linear rise in tomato yield with the level of organic nutrient supplementation was recorded
- In tomato open-pollinated variety, H-86, under press mud @ 20 tonnes/ha treated crop recorded an average yield of 454 q/ha, at par to its peer inorganically-grown crop.
- Organically-grown cabbage Quisto was at par in yield with its peer inorganically grown crop
- In qualitative traits for tomato, organically-grown crop showed higher percentage of titrable acidity, vitamin C and lycopene content as compared to tomato grown inorganically
- Soil solarization, seed treatment with *Trichoderma*, addition of neem cake and vermicompost in nursery of tomato and cabbage were found effective
- In tomato, incidence of TLCV infection, severity of leaf spot diseases and incidences of fruit rot in FYM, press mud, vermicompost and sewage sludge treated organic block were tested in H 86, DVRT 1, DVRT 2 and Sel 7 varieties. H 86 outperformed others in terms of resistance or escape to diseases

at 3 pilot project sites constituting 5 ha area each at Sultanpur, Salarpur and Basawn villages of Varanasi and Mirzapur districts. The technology was disseminated among brinjal farmers in Uttar Pradesh, Jharkhand, Orissa, West Bengal and Tripura through pilot demonstration, field days, distribution of technical bulletins, CD shows, newspapers, radio and TV documentaries.

The National Mushroom Repository has been enriched by adding 139 new mushroom cultures. Some of which are new records for India. *Tremella* species, a medicinal mushroom was collected from Western Ghats and reported for the first time. Advanced molecular techniques including sequencing of conserved genes were employed for molecular identification and characterization of mushroom germplasm up to species level. The RAPD markers were used as molecular tools for genetic characterization and selection of genetically diverse parents for breeding. A high-yielding single spore selection, SSI-4035, of *Agaricus bisporus* has been recommended for commercial release.

The composting period of *A.bisporus* was significantly reduced from 18 to 12 days and inoculation of selected strains of thermophilic fungi could further hasten the composting process. Coir pith alone and in combination was found as the best casing material. Preliminary trials on organic farming under environmentally-controlled conditions gave appreciable yields at par with other methods. The physico-chemical requirements for *Lentinula edodes* and *Flammulina velutipes* have been worked out. *Agaricus bisporus* and *Pleurotus sajor-caju* were raised in low-cost bamboo and cloth huts with good yield and demonstrated to farmers. Major pests and diseases of cultivated mushrooms were identified. The putative chemical sterilization technique developed for *Pleurotus* cultivation was found unfit for other speciality mushrooms, *Calocybe*, *Agrocybe*, *Lentinula* and *Auricularia* spp. Although, use of biopesticides in mushroom cultivation is advocated, most of biopesticides tested failed to inhibit spore germination of major mycoparasites. The molecular characterization of green mould

- The National Mushroom Repository has been enriched by its 139 new cultures
- A new mushroom *Tremella* species was collected
- A number of off-campus training programmes were organized
- About 400 farmers including NGOs were benefited by mushroom *mela*

Mushroom selection

disorders validated existence of intra-specific diversity in *Trichoderma harzianum* and *T.virens*. The *Ganoderma lucidum* showed that it is capable of producing lignin, cellulose, hemicellulose, protines, pectins and starch degradative enzymes. The cultivation technology of *G.lucidum* was further refined to enhance B.E. up to 22%. Techniques for Modified Atmosphere Packaging (MAP) to improve shelf-life of *A.bisporus* were standardized.

Questionnaires were sent to KVK, research organizations and mushroom growers to validate indigenous technical knowledge about mushroom cultivation. A number of off-campus trainings were organized in north-eastern states. The Mushroom *mela* was attended by 400 farmers, farmwomen, mushroom growers, researchers, extension workers, businessmen and NGOs from all over the country. Databases on different aspects of mushroom cultivation, growers and research personnel have been developed both in the form of CDs and directory. In addition, information on 1,200 mushroom-based postal stamps from 80 countries of the world have been compiled.

**Potato**

Germplasm collection was augmented by adding 9 parental lines from Sturgeon Bay, Wisconsin, USA, and 27 advanced hybrids from AICPIP, raising the total collection to 2,700 accessions. Three parental lines, QB/A 9-120, QB/B 92-4 and MP/99-322, developed at CPRI, Shimla, have been registered an as elite germplasm by ICAR/NBPGR Germplasm Registration Committee. Excellent tuber keeping quality was observed in 30 accessions, while good chipping quality was found in four accessions after six months of storage at 4°C. A hybrid, MP/98-31, with high dry matter (>22%), early maturity (80 days) and extra dwarfness (height 15–25 cm) was identified. Hybrids, MP/97-583 and MP/97-644, performed well in plains and hills, respectively. Hybrid, MP/97-583, was recommended for release as Kufri Chipsona 3. Advanced hybrids, SM/92-338, SM/93-237 and SM/91-1515, were found promising both in hills and plains. Hybrid, SM/97-1515, was recommended for release in hills as Kufri Himalini.

About 137 hybrids were evaluated and 56 were selected. Hybrids, J 96-278 and J 97-124, produced good quantity of baby potatoes 53 days after planting. Four TPS families, viz. HPS-26/54, HPS-32/54, HPS-44/13 and HPS-47/54, were found promising. A full-length ADPGlc pyrophosphorylase (glgC) gene was cloned from *E. coli* K12 strain and mutated by site-directed mutagenesis. Post Transcriptional Gene Silencing (PTGS) transgenic lines of Kufri Badshah were developed using *Agrobacterium* - mediated genetic transformation to identify transgenic lines of Kufri Badshah having resistance to bacterial wilt and late blight. Likewise, 14 transgenic lines tolerant to cold induced sweetening were identified.

- A database were developed
- Kufri Chipsona 3, a new chipping potato, was released
- Four TPS families were found promising
- Fourteen potato transgenic lines tolerant to cold were identified
- A hybrid was released as Kufri Himalini

Precision fertilization based on soil test increased fertilizer-use efficiency and benefit : cost ratio by 109 and 3.3%, respectively, over the recommended fertilization without affecting tuber yield. Winter potato acreage and production in India were assessed using Advanced Wide Field Sensor (AWFS) data from Indian Remote Sensing Satellite (IRSS) in collaboration with Space Applications Centre, ISRO, Ahmedabad. In northern plains, green manuring saved 61–139 kg N/ha under different potato cultivars. Kufri Badshah was poor user of N, whereas Kufri Sutlej has highest capacity to use N from green manure. Integrated use of 100% N (inorganic) and 50% P and K from inorganic fertilizers and balance from FYM was best for tuber yield, macro and micronutrients uptake and improved proteins and vitamin C under rainfed conditions in midhills of Shimla. In north-western plains, combination of 25 and 75% of NPK through vermincompost and inorganic fertilizer gave highest tuber yield in Kufri Anand and Kufri Chipsona 1, respectively.

**Potato Kufri Chipsona 3: Ideal for Processing**

Potato Kufri Chipsona 3, a superior chipping hybrid, is an improvement over hitherto very popular processing cultivars, Kufri Chipsona 1 and Kufri Chipsona 2. Its tubers having high dry-matter content of 22% or more, results in crispy low oil chips. The hybrid produces superior quality chips as evident by industrial frying. The chips are free from all internal and external defects with negligible browning. The hybrid is robust during storage at intermediate temperatures, as shown by superior quality chips made even after six months of storage.

In furrow irrigation, 38% saving in irrigation water was achieved by applying water to alternate furrows at the expense of 10.8% decrease in yield, which was further minimized to 6.2% with paddy straw mulch application. Sprinkler fertigation with N economized 25% of N dose along with water economy in irrigation water. Fertigation with N and K saved 40 kg N and 50 kg $K_2O$/ha beside 40% saving in irrigation water. In Indo-Gangetic plains (Modipuram), production of organic potato varied from 273–363 q/ha in Kufri Sutlej and 316–399 q/ha in Kufri Anand, when 180, 80 and 100 kg N, $P_2O_5$ and $K_2O$/ha were supplied through vermincompost. Adoption of biodynamic approach of nutrients application also reduced underground water pollution due to $NO_3$ leaching.

Two potyviruses isolated from *Solanum nigrum* and *Physalis floridana* were identified as Chilli vein banding mottle virus and $PVY^N$, respectively, based on sequence of coat protein genes. Print capture and immuno-capture based RT-PCR for detection of PVY and PLRV were standardized. Accessions, CP1444 and 1492, showed resistance to PVX, while 1492, 1342, 1574, 2012 and 2037 to PVY for second year. One *Fusarium* sp. from russetted tubers causing disease was isolated from potato sprouts, whereas eight isolates of *Actinomycetes* spp. isolated at Shimla did cause scab-like lesions on tubers but pathogen could not be re-isolated from diseased tubers. Adverse effect of water stress on russet disease was confirmed. Though *Trichoderma viride*, *B. subtilis* and *B. cereus* were effective in reducing incidence and severity of black scurf, their combination with 1 or 2% boric acid did not provide any additional advantage over only 3% boric acid. Accessions, NJ-12 and NJ-75, were found promising against PTM whereas hybrid, E/79-42, showed high resistance to potato cyst nematode under greenhouse at Ooty. Spraying potato crop with imidacloprid + summer oil or Thiomethoxam + summer oil was best in controlling white flies and leaf-hopper in early crop and aphids in main crop at Modipuram.

Single applications of CIPC fog in heaps significantly reduced sprouting and sprout growth in tubers up to 100 days of storage. Double application, in addition, reduced total storage losses also. Single spray application of CIPC also remained equally effective up to 70 days. Acceptable chip colour of 3 or below was observed in two advanced hybrids, viz. MP/97-583 and MP/97-644 after six months of storage at 10–12ºC with two CIPC fog treatments. Weight loss was within the acceptable limit of 10% after 120 days of storage at 8, 12 and 16ºC with CIPC, but the chip colour deteriorated in all cultivars. Two doses of irradiation (0.1 and 0.5 kGy) were as effective as CIPC in checking sprout growth. Reducing sugar content decreased with 0.5 kGy as compared to CIPC at 8 and 12ºC.

## Tropical Tuber Crops

Six new varieties of tuber crops were recommended for release by State Sub-Committee on Variety Release and Crop Standards, Orissa, for cultivation in Orissa. They are: Goutam (20–30 tonnes/ha, 105–110 days), Sourin (16–32 tonnes/ha, 105–110 days) and Kishan (17–26 tonnes/ha, 110–120 days) (sweet potato); Panisaru 1 (16 tonnes/ha, 180–210 days) and Panisaru 2 (13 tonnes/ha, 180–210 days) (Colocasia) and Orissa Elite (yield 22–25 tonnes/ha; 180 days) (greater yam). Two triploid hybrids of cassava, 4-2 and 5-3, were identified for higher and stable starch yield (29–32%) and tuber yield (36 tonnes/ha) from on-farm trials conducted at six locations in three districts in Tamil Nadu under irrigated conditions.

Protocol for regeneration of popular cassava, H 226 and H 165, through somatic embryogenesis was standardized. High frequency somatic embryogenesis was induced in MS medium supplemented with picloram (50 µM). Regeneration of normal plants was obtained by transferring embryogenesis callus to MS medium supplemented with BAP (2 µM) + NAA (1 µM) followed by culture in hormone-free medium. Cloning of ICMV coat protein gene in bacterial expression vector was done. Serological and nucleic acid based techniques for detecting viruses infecting cassava, sweet potato, yams and elephant-foot yam were standardized. Yam and elephant-foot yam-growing areas in Andhra Pradesh and Orissa were surveyed for disease incidence. During *kharif* season, anthracnose caused by *Colletotrichum gloeosporioides* was found to be severe which caused die-back in a local variety in sandy soil in Orissa. In Andhra Pradesh, severe mosaic symptoms were found in *D. alata* variety Bombay Yam. In elephant-foot yam, leaf rot caused by *Selerotium rolfsii* was observed. Deep ploughing with chisel plough, ridge planting, application of neem cake and *Trichoderma* and proper drainage were found to be effective in reducing the incidence of cassava tuber rot. Leaf curl virus infection in sweet potato was diagnosed and detected through PCR and NASH.

- Six new tuber varieties were recommended for Orissa
- Protocol for regeneration of popular cassava varieties was standardized
- Leaf curl virus in sweet potato was diagnosed and detected through PCR and NASH
- Growing of elephant-foot yam organically was on a par to conventional practices
- Over 4,000 collections of 16 species of tubers were maintained
- IGSP-11, an accession of sweet potato, gave highest carotene content

Green manuring *in situ* with cowpea C 152, application of indigenous rockphosphate (Mussoorie phosphate) and use of biofertilizers (*Azospirillum* and *Phosphobacterium*) could save about Rs 3,000/ha in the cost of production of cassava. Cassava genotypes, CE-33, CE-54 and CI-308, could yield more than 30 tonnes/ha under drought conditions of Tamil Nadu. For continuous cultivation of cassava, a fertilizer dose of NPK @ 75 : 37.5 : 75 kg/ha was found to be sufficient under rainfed situation of Kerala. *Pseudomonas fluorescence* was found to be efficient in elaboration of hydroximate type of siderophore. Organic farming of elephant-foot yam resulted in an yield of 66 tonnes/ha on a par with the conventional practice, but significantly high over traditional practice (50 tonnes/ha). Chinese potato responded up to 100 kg N/ha producing a tuber yield of 12.5 tonnes/ha.

Texture profile analysis was done on germplasm accessions of cassava. They were grouped based on textural properties. Also texture profile studies were done on food products from different cassava flour-based formulations. Cold water miscible starch technology from cassava was perfected and the product was released under the name 'Texcool'. An instant gulab jamun mix was made from sweet potato and product was released under the name' 'Nutrigulab jamun mix'. Mucilages were characterized from taro, tannia and yams. These were found to have pharmaceutical effects like serum lipid and triglyceride lowering action. New proteins synthesized in taro plants, as a consequence of water stress were characterized through gel documentation studies.

Farmers participatory evaluation of cassava in tribal settlements of Pachamalai and Siddheri hills of Tamil Nadu indicated that cassava entries, 9-1, 14-4, CI 800, CI 138, U-1 and KM-94, gave relatively high starch (27–29%) and tuber yield (30–32 tonnes/ha) compared to popular cassava H 165 (starch 25%; yield 28–30 tonnes/ha). Techno-economic feasibility reports on cassava starch as well as sago was completed and is being sold. Total Factor Productivity of cassava in Kerala was estimated to show a declining trend.

Over 4,000 collections of 16 species of tuber crops were maintained at 12 centres. Twenty-two sweet potato, three colocasia, two elephant-foot yam, four each of swamp taro, taro, and giant taro and one each of Xanthomonas and yam were newly added to germplasm at different centres. Accession IGSP-11 (sweet potato) registered highest carotene content of 13.31 mg/100 g. In cassava, application of half P + full N and K + FYM + phosphate-solubilizing bacteria (10 kg/ha) recorded significantly superior tuber yield (26.6 tonnes/ha) followed by application of half P + full N and K + FYM + AM fungi (10 kg/ha) which was superior to treatment with recommended dose of NPK. In elephant-foot yam, growing cowpea as green manure crop and incorporation *in situ* recorded highest yield of 47 tonnes/ha followed by polythene mulch treatment (35.77 tonnes/ha).

Pusa Gaurav and Arunima (rose); Hyb. 84-7-11, 86-3-4, 84-4-8, Arka Kesar, 87-22-1, Swarnima and Shagun (gladiolus); Baggi (Chrysanthemum); and Prajwal and Vaibhav (tuberose) performed well at many locations. Eco-friendly management strategy for control of two-spotted spider mite, *Tetranychus urticae* on rose in polyhouse, bioagents and botanicals were developed. Predatory mite, *Amblyseius tetranychivorus* @ 20/plant significantly reduced population (94.73%). Entomopathogenic fungus, *Verticillium lecanii* at 3g/litre was effective resulting in 61.13% reduction in population. Among various plant extracts tested, prickly poppy and pongamia oils at 1% caused 80–85% mortality, while pongamia oil in combination with garlic at 1% (1 : 1) caused 88% mortality. About 400-200-200 ppm NPK/plant/week in rose gave more number of flowers with better stalk length.

- Rose Pusa Gaurav and Arunima performed well
- The CS 1, a carnation hybrid, was developed
- Four pruning treatments in jasmine were satisfactory in overcoming season barrier

**Carnation**

Carnation CS-1, an interspecific hybrid of *Dianthus caryophyllus* and *D. chinensis*, has been developed which was found promising as a mini carnation. This can be cultivated in open field without any support. Planting carnation under cover with 200 ppm N in April was good for quality flower production.

**Jasmine**

To overcome season barrier in jasmine, four pruning treatments (August, September, October and November) prolonged flowering, while staggered pruning at monthly intervals resulted in continuous flowering during the lean season.

The $Al_2 (SO_4)_3$ (300 ppm) was useful for pulsing and $Al_2 (SO4)_3$ + kinetin (25 ppm) + sucrose (5%) as holding solution for anthurium; $Al_2 (SO_4)_3$ (1,000 ppm) for gerbera; $Al_2 (SO_4)_3$ (300 ppm) + sucrose (4%) + NaOCL (bleach, 25 ppm) for gladiolus; and $Al_2 (SO_4)_3$ (300 ppm) + sucrose (10%) for 8 hour pulsing of carnation or STS (50 ppm) + 8-HQC (50 ppm) + sucrose (2%) as holding solution for carnation had good promise. Good spike length can be obtained by employing BA 100 ppm and $GA_3$ 50 ppm in Dendrobium Sonia 17. For gladiolus *Fusarium* wilt, Benomyl (0.2%), Carbendazim (0.2%), Thiram (0.3%) and Captan (0.3%) were found best. Kavach (0.2%) against *Botrytis* grey mould of rose and gladiolus, and Dithane M45 against gladiolus were reported best. Benomy (0.2%) was found best for controlling *Sclerotium* wilt of tuberose. *Trichoderma harzianum* (20 g/$m^2$) followed by Benomyl (0.1%) + Captaf (0.2%) was effective against gerbera rust rot. Monocrotophos (0.2%) against *Aphelenchoids* foliar nematode of tuberose and Chlorpyriphos (0.2%) against *Helicoverpa* infestation of carnation are quite effective.

**Coconut**

Coconut germplasm was strengthened by adding 12 distinct coconut types. These included tender nut varieties, Uddha Gangapani and Chitta Gangapani, and another rare type from Bassakal, Bassakal Orange Dwarf, bearing elongated orange fruits. A mutant

coconut palm was identified at farmers' plots in Kasaragod district. In coconut, plantlets regenerated from plumular tissues of Tall (WCT) and Dwarf (CGD, MYD) cultivars were field planted at Kasaragod. A total of 125 plantlets retrieved from exotic embryos collected from Sri Lanka and 91 plantlets from Bangladesh were field planted at Kidu. Cryopreservation of WCT embryos gave maximum retrieval after 18 hours desiccation in silica gel or 24 hours desiccation in Laminar Air Flow. The young inflorescences (10–12 cm in length) extracted from mature trees and rachilla explants of about 10–15 mm length cultured on media containing Picloram, TDZ and high level of sucrose in dark resulted in transformation of floral primordia into shoots. Ten farmers' varieties and five germplasm accessions were characterized by microsatellite primer analysis, which resulted in molecular marker data. Nei's gene diversity varied from 0.010 in Pathitennampattai Vayalar Green Dwarf (VGD) to 0.582 in Pallikere Kuttiyadi Tall. Proportion of heterozygotes varied from 0.000 in Chowghat Green Dwarf (CGD) to 0.448 in Kappadam Tall.

Higher nut yield in coconut was obtained when 50% of the recommended dose of fertilizer was applied through drip irrigation (102 nuts/palm/year) though it was on a par with 75% (99 nuts/palm/year) and 100% (97 nuts/palm/year) of fertilizer applied through drip irrigation and 100% (101 nuts/palm/year) of fertilizer applied through conventional soil application in coconut gardens raised in sandy loam soil. In coconut-based high-density multispecies cropping systems, coconut yield ranged from 165 nuts/palm/year under one-fifth of the recommended fertilizer dose to 184 nuts/palm/year at one-fourth of the dose. The net return was highest when two-thirds of the recommended fertilizer dose (Rs 152,465) with a benefit : cost ratio of 3.83. Bajra napier fodder grass ($CO_3$) (96.83 tonnes/ha) and pumpkin can be successfully grown as intercrops in coconut gardens raised in coastal littoral sandy soils. One layer of dried coconut husk buried in trenches and planting of grass, resulted in higher green fodder yield, whereas pumpkin yield was higher with coir pith application.

Chowghat Green Dwarf (CGD) and Malayan Green Dwarf (MGD) were identified as resistant to root wilt disease. Both of them showed lowest disease incidence. However, MGD is better than CGD because of its higher yield and large size of nuts. MGD recorded maximum nut yield of 57 nuts/palm/year with copra content of 185 g/nut, oil content of 65.5% and oil yield of 1.2 tonnes/ha. MGD has good quality, sweet and tasty and more quantity of tender nut water (200 ml/nut). Large-scale cultivation of MGD will substantially increase coconut production and its productivity in the root (wilt)-prone tracts of Kerala.

Enzyme Linked Immunosorbent Assay (ELISA) was refined to a more rapid and highly sensitive diagnostic test. In the modified procedure, results could be obtained within 24 hours. The test is very economical, requiring only 1 ml primary antibody for testing 1,200 samples with replications. The test is widely used for selecting root (wilt) disease-free coconut mother palms for developing root (wilt) disease resistant/tolerant varieties. RAPD characterization of isolates of *Ganoderma* causing stem bleeding in coconut was done using OPA 01, OPA 02, OPA 03, OPA 04, OPD 03, OPD 04, OPA 11, OPA 18, OPF1 and OPG 15. Variation was observed in almost all the primers except OPD 03 and OPF1.

Vermicomposting trials with a 3 : 1 ratio of coconut leaves and banana pseudostem/pineapple/sugarcane bagasse/glyricida leaves showed that the earthworm *Eudrilus* sp. is able to compost these substrates efficiently. During vermicomposting of coconut leaves in cement tanks placed in the field, vermicompost turnover, *Eudrilus* number and worm biomass harvested were found to be negatively correlated to atmospheric temperature (–0.87, –0.74, –0.74 respectively) and positively correlated to relative humidity (0.89, 0.79, 0.79 respectively). Vermiwash prepared from coconut leaf vermicompost increased fresh biomass weight (36%), nodule number (30%) and nodule fresh weight (43%) in cowpea, when applied to soil. In maize, increase in cob yield (5–10%), and fresh cob weight increase (29–64%) was recorded in vermiwash-

- Coconut germplasm was strengthened by adding 12 distinct types of coconut
- A number of germplasm accessions were characterized by microsatellite primer analysis
- Bajra napier fodder grass and pumpkin were ideal intercrops in coconut gardens
- Chowghat Green Dwarf and Malyan Green Dwarf coconut were resistant to root wilt
- The ELISA was refined as a more rapid and highly sensitive diagnostic tool
- A prototype electronic water salinity detector was developed.
- A coconut chip slicer was fabricated
- Training programmes on drying of copra were conducted

**Income-generating Programmes**

The CPCRI, Kasaragod, successfully implemented a poverty-reduction programme sponsored by IPGRI/COGENT entitled "Developing Sustainable Coconut-based Income-Generating Technologies in Poor Rural Communities" in two coconut communities, viz. Ariyankuppam (East Coast) and Pallikkara (West Coast) during 2002–04. The communities realized additional net return of Rs 4,000–30,000/ha by means of intercropping of cereals and vegetables in coconut gardens. The community could also earn a profit of Rs 1,000 through the sale of Snow Ball Tender Nuts and Rs 6,700 through the sale of coconut chips. The farmers also produced 1,800 coconut seedlings and realized a profit of Rs 9,000.

applied plants. Okra yield could also be enhanced from 21.6 to 33%.

Root feeding of neem formulation containing Azadirachtin 5% @ 7.5 ml mixed with equal quantity of water caused 76% reduction in eriophyid mite incidence in coconut. Maximum mite population were recorded in sample nuts collected from the field during March–May.

A prototype electronic water salinity detector was developed to measure salinity of water with graphite electrodes as conductivity sensors. A coconut chip slicer has been fabricated and trials are being conducted. The know-how of 'coconut chips making' has been transferred to five entrepreneurs, and technology of snowball tender nut to two entrepreneurs. One training programme was conducted for farmers on product diversification of coconut at Calicut. Training programme on drying of copra using copra dryers was also conducted to five Kudumbasree units (women empowerment programme). Fresh coconut kernel and paste prepared from fresh kernel gratings were canned in canning industry for testing its shelf-life. Gas formation was observed in the control cans, whereas treated cans were free from fermentation.

**Arecanut**

A total of 126 germplasm accessions were characterized using different molecular markers, RAPD, ISSR and SSR. Repeatable protocol for somatic embryogenesis of arecanut Mangala, Sumangala, Mohitnagar and South Kanara Local from various tissues has been standardized.

The application of fertilizer at the rate of two-thirds of recommended fertilizer through drip irrigation once in 20 days gave maximum yield (7,112 kg chali/ha) as compared to soil application of full recommended dose (6,549 kg chali/ha). In cultural-cum-manurial long-term experiments, higher nut yield (102 nuts/palm/year) was recorded when organic manures + inorganic fertilizers were applied with two tillages, under rainfed conditions in red sandy loam soils, which was 155% more compared to the control. The substitution of chemical fertilizer with vermicomposted areca wastes on nutrition and productivity of arecanut showed that 100% vermicompost alone could supply full nitrogen requirement of the crop.

In arecanut plantation, lemon grass, palmarosa, vetiver, basil, davana, patchouli, long pepper, shatavari, brahmi, periwinkle, aloe and *Nilagirianthus ciliatus* performed better as intercrops. Eleven turmeric cultivars were evaluated in areca-based cropping system in Sub-Himalayan Terai Region of West Bengal. Turmeric Suguna gave highest yield (29.04 tonnes/ha) followed by CLS-2A (27.41 tonnes/ha) and Kasturi (26.22 tonnes/ha) under areca shade. The variety Suguna was also found to be tolerant to *Cercospora* leaf spot under partial shade of areca canopy.

**SUCCESS STORY**

**Quality Copra Making**

The farmers in Kasaragod district generally follow either sun-drying or use local copra choola for making copra. In these methods, copra is contaminated with dust as well as smoke causing discolouration of copra, which in turn leads to poor quality of coconut oil due to rancidity. This could be overcome by the use of copra dryers of different capacities. The KVK is popularizing copra drying technology developed by CPCRI, Kasaragod. Copra drying technology helps farmers to utilize dry agricultural waste as fuel; controlled combustion ensures economic use of fuel, drying can be done during monsoon season, smoke-free copra can be obtained; good quality oil can be extracted fetching premium price. This was mainly taken up by Self Help Group (SHG) of women organized under the local self-help group government programmes. The KVK Kasaragod, organized a total of 106 training programmes with the participation of 2,236 trainees including practicing farmers, farmwomen, rural youth, and extension functionaries. Of these training courses, 50 were on-campus and 56 off-campus, wherein 873 (313 men and 560 women) and 6,363 (632 men and 5,731 women) trainees participated, respectively.

**Cocoa**

Five high-yielding and drought tolerant lines of cocoa were identified. Hybrids I-56 × II-67, ICS 6 × SCA 6 and clone NC 45/53 recorded high dry bean yields of 1.48, 1.12 and 2.5 kg/tree/year respectively. Hybrids II-67 × NC 29/66 and II-67 × NC 42/94 with 1.45 and 1.25 kg dry bean yield/tree/year respectively were drought tolerant. These varieties are suitable for cultivation in Karnataka, Andhra Pradesh, Tamil Nadu and Kerala. Softwood grafting technique for cocoa was standardized and a total of 280,850 grafts of high-yielding clones were supplied to farmers, demonstration farms, regional nurseries and developmental agencies. In seedling progenies, the height of main stem may be maintained at 1.0–1.5m, before allowing the first jorquette. When budded-clonal planting material is used, it is advisable to keep 2–3 strong upright stems for good pod yields. Bean yield was positively correlated with plant canopy area and leaf area.

**Oil Palm**

Ganoderma disease incidence was observed in oil palm gardens raised in the vicinity of coconut gardens, palmyrah plants and

- The RAPD, ISSR and SSR (molecular markers) were used for arecanut
- A number of suitable intercrops for arecanut cultivation were identified
- Five high-yielding and drought tolerant cocoa lines were identified
- Softwood grafting technique has been standardized

cashewnut gardens. The fungal growth was more on malt extract agar compared to potato dextrose agar and Czapek dox agar media and in acidic pH than in alkaline pH. *Trichoderma harzianum* was found more effective than *T. viride* and *T. hamatum* against *Ganoderma*. The insecticides were more dangerous to oil palm pollinating weevil population as compared to bioagents. At high temperature and low relative humidity during summer no weevil population was observed in oil palm plantations. This leads to heavy bunch failure or bunch abortion.

Photosynthesis and related parameters were measured using portable photosynthesis system in ninth leaf from 7.00 AM to 5.00 PM. The photosynthetic rate ranged from 10.07 to 0.64 mmols/$m^2$/second The highest photosynthetic rate was observed during 9.00–10.00 AM and decreased thereafter with increase in leaf temperature. The lowest photosynthetic rate was observed at 5.00 PM. Maximum transpiration rate and stomatal conductance were observed at 7.00 AM and decreased with increase in leaf temperature. The photosynthetic rate, transpiration and PAR decreased from 3.00 to 5.00 PM. Photosynthetic water-use efficiency was highest at 9.00 AM and decreased as the day proceeded. A settling and sedimentation tank of 75 cm depth was designed and fabricated for conducting studies on settling characteristics of POME in the laboratory. The total solid sludge and residual oil were estimated and per cent oil and sludge removal/accumulation at different depths were derived and plotted against time.

**Cashew**

A total of 320 cashew accessions were evaluated. Cashew accessions collected from North-Eastern Hilly region (13) and Puttur (3) were planted in National Cashew Field Gene Bank bringing the total number of accessions conserved to 494. A total of 1,274 diverse germplasm accessions have been conserved in Regional Cashew Field Gene Banks. Cashew hybrids, H-1250, H-2438 and H-2453, were found promising at Puttur with a cumulative yield of 37.22 kg/tree (10 harvestings), 18.40 and 17.28 kg/tree (6 harvestings). About 47 $F_1$ hybrids were obtained from nine cross combinations at Bapatla centre. At Bhubaneswar centre, 813 hybrid seedlings were planted. A total of 666 hybrid nuts were obtained at Chintamani from 57 crosses. At Vengurle and Vridhachalam, 175 hybrid seedlings and 193 hybrid nuts were obtained from 22 and 9 cross combinations, respectively.

Rootstocks of Taliparamba-1, Brazilian dwarf, Koddippady-2 and H-4-7 were established in greenhouse and *in vitro* cultures (nodal cuttings) were initiated in Brazilian dwarf and Taliparamba-1. A total of 10 accessions including four species of cashew, cultivars of *Anacardium occidentale* and interspecific hybrids were screened for isozyme pattern of 14 enzymes. Pectin extracted from cashew apple pomace (2.59%) contained Ca, Mg, K, Na and Fe.

Eight training programmes were organized for farmers which included demonstration and farmers' meet (2), thematic campaigns on soil and water conservation measures, high- density planting and pruning in cashew (2), thematic campaigns on plant protection in cashew (2), skill training on vegetative propagation of cashew (1) and a cashew day (1). A total of 700 farmers were trained. Seven trainers' training programmes were organized which included cashew production technology (5), vegetative propagation of cashew (1) and pruning and top working in cashew and composting of cashew biomass (1). A total of 70 officials of development departments were trained. Socio-economic impact of cashew cultivation in Kannur district of Kerala was assessed apart from collecting training needs and constraints in cashew cultivation by cashew growers.

The spices germplasm was enriched by addition of 97 accessions of *Piper* spp., 9 of ginger, 11 of *Curcuma* spp; 25 of *Garcinia* sp; 6 of *Cinnamomum* sp; 2 of *Myristica beddomeii;* 11 of indigenous and 5 of exotic germplasm of paprika-alike chilli and paprika. *Piper nigrum* with bold berries, *P. argyrophyllum*, with long spikes and *Piper hymenophyllum* with profuse hairiness were important accessions of *Piper* spp. added to the gene bank.

Fifty cultivar accessions of black pepper were characterized and evaluated based on IPGRI descriptors. One accession of *Piper nigrum* collected from natural forests of Nelliampathy (Palaghat district) has been registered as a unique germplasm for its high oleoresin content (28.15%) and bold berries (INGR. 04111 and IC-370011). Seven elite black pepper lines, IISR Girimunda, HP-728, HP-780, IISR Malabar Excel, HP-1411, OPKm and IISR Thevam, were discriminated using RAPD markers and morphological characters. Inter Short Sequence Repeat (ISSR) Markers were found to discriminate *Piper* species, *Piper* hybrids HP 780 × *P. nigrum* (wild), IISR4176 × IISR 430, Panniyur 1 × Karimunda and their parents. Yield evaluation of 10 black pepper lines, OPKm. HP-780, HP-1411, Coll.1041, HP-1, HP-2, Coll. 4133 Coll. 1365 and Coll. 889 along with Sreekara (control) revealed superiority of OPKm, HP-1411 and Coll. 1041, yielding 4.05, 3.87 and 4.14 kg (fresh berries)/vine respectively as compared to Sreekara which yielded 2.94 kg/vine.

- The germplasm of spices was enriched by adding new accessions of many spices
- Fifty accessions of black pepper were documented based on IPGRI descriptors
- Various accessions of black pepper were found promising for essential oil, while others for oleoresin

Black pepper accessions, Acc. 1637, Acc. 1566 and Acc. 1493,

contained 4% oil, while Acc. 1602 contained 19% oleoresin, followed by KS-127, 4073 and KS 147 with over 16%. W-3001 contained 5.6% piperine, followed by HP-1523 with 4.3% and Acc. 836, 1261 and KS-139 with more than 3.6% piperine. In drought susceptible black pepper accessions, chlorophyll fluorescence started declining on increasing the stress intensity, while tolerant accessions showed relatively stable values. Correlation between black pepper yield and weather parameters (weekly rainfall, maximum temperature and maximum relative humidity) was established with multiple regression models. Weekly rainfall during crop period (June–January) had a positive association with yield ($R^2$=0.834), whereas weekly maximum temperature during crop period had negative relationship with yield ($R^2$=0.6113). Maximum relative humidity showed negative relationship during initial 18 weeks with subsequent positive association ($R^2$=0.9997).

- Molecular profiling was done in cardamom
- Ginger accession, Acc 578, from Nepal gave highest yield
- Ginger and turmeric were cultivated organically by applying FYM, vermicompost, ash and rockphosphate
- The $C_5$, a line of cassia, was found superior in yield, bark oil, leaf oil and bark oleoresin
- A new disease on vanilla was identified first time from the country
- Planting material of different spices was distributed among farmers

Raising of rooted black pepper cuttings in potting mixture applied with *Trichoderma* and application of *Pseudomonas fluorescens* strain IISR 6 at the time of planting and one and two months after planting in polythene bags is recommended for the production of healthy black pepper rooted cuttings.

Phytoplasma with phyllody symptoms was detected in black pepper using PCR. A 1.20 kb DNA fragment encoding portion of phytoplasma 16S rDNA consistently amplified by nested PCR was cloned and sequenced. The sequenced region contained 1,230 nucleotides. Sequence analyses showed that the gene was most closely related to members of aster yellows group (16Sr I) of phytoplasma. Citrus mealybug commonly found associated with black pepper was shown to transmit the Badnavirus associated with stunted disease. The transmission of virus was confirmed by symptoms and PCR using Badnavirus specific primers. Wild accessions Acc. 3283 and Acc. 3290 and one hybrid (HP 125) of black pepper were found to be resistant to *R. similis*. Field evaluation of promising accessions confirmed the resistance of Acc. 820 (IC No. 316481), Acc. 1090 (IC No. 316635) and HP 39 to *R. similis* infestation.

Larvae of *Spalgis epius* were observed to predate on root mealybug colonies of black pepper in field in Calicut and Wyanad districts. Squash (*Cucurbita moschata*) indicated its suitability for mass culturing of *Planococcus* sp.

In cardamom, molecular profiling using RAPD, ISSR and PCR-RFLP revealed two major divergent clusters, Kerala collections and Karnataka Collections. *Amomum subulatum* and *A. microstephanum* were found clustered with *Elettaria cardamomum*, indicating that *Amomum* is closest to cultivated cardamom. Field reaction of 42 cardamom entries against leaf blight (*Colletotrichum gloeosporioides*) showed that while glabrous selections of Malabar type MA-15, MA-18 and MA-20 were moderately resistant, compound panicle types, CP-9 and CP-2 were resistant to the disease. The most popular land race Green Gold (Neljiani Gold) also showed resistance to disease. Three cardamom accessions (CP, HY-2 and NHY-2) had high levels of essential oil (7.8, 6.8 and 6.4% respectively). Four collections (CP1, NKE 19, RR1 and NHY-15) with bold capsule size recorded high biomass and low relative water content. Drip irrigation @ 8 litres/clump/day recorded higher yield (575 kg/ha), followed by sprinkler irrigation once in 12 days (395 kg/ha) and once in 15 days (378.8 kg/ha). Thus, irrigating cardamom with drip (8 litres/clump), daily or sprinkler irrigation once in 12 days leads to higher yield in cardamom. Cardamom plots with contour staggered trenches (2 m × 0.45 m × 0.30 m) in alternate rows recorded less run-off (43.8 mm) and soil loss (148.09 kg/ha) compared to unplanted treatment (fallow), wherein maximum run-off (216.0 mm) and soil loss (944.12 kg/ha) were recorded. In trials with trench system of planting less run-off (10.8 mm) and soil loss (66.34 kg/ha) were recorded.

Ginger accession, Acc. 578, from Nepal gave highest yield (15.25 kg/3 $m^2$) with a dry recovery of 23.5% and fibre content of 1.5%. Acc. 162 was found to be superior to others in oil content (2.3%). The critical levels of Zn were found to be 2.1 mg/kg for soil and 27 mg/kg for foliar concentrations. Ginger and turmeric were cultivated organically by applying FYM, vermicompost, ash and rockphosphate, and *Pseudomonas* sp. as biocontrol agent for rhizome rot disease control. The mean yield recorded in ginger Varada was 7.5 kg/3 $m^2$ with a reduction of 26 and 22.8% rhizome yield as compared to chemical and integrated farming, respectively. In turmeric Alleppey, a mean yield of 15.5 kg/3 $m^2$ was recorded under organic cultivation with a reduction of 15.3% rhizome yield as compared to conventional system.

Three different curcuminoids (curcumin, demethoxy curcumin and bis demethoxy curcumin) could be separated from oleoresin of turmeric rhizomes by employing chromatographic techniques. Purity was confirmed based on UV absorption maxima, which were identical to authentic values. Cytological analysis of true turmeric seedlings of mother lines (Acc. 126) revealed a somatic chromosome no. of 84 or 78. Turmeric accessions, 773, 715, 772, 781, 727 and 445, had higher levels of oleoresin and curcumin

Promising *Gucinia morella*

(<5%). Turmeric was identified as one of the hosts of *Ralstonia solanacearum*. When *Pythium*, *Ralstonia* and *Fusarium* were inoculated simultaneously, symptoms of bacterial wilt incited by *Ralstonia* were found to be dominating in ginger. Among 93 putative endophytic bacteria isolated from ginger and turmeric rhizomes, 19 were found to inhibit rhizome rot pathogens (*Fusarium oxysporum*, *Pythium myriotylum*, *P. ultimum*, *Rhizoctonia solani* and *Ralstonia solanacearum*). For large-scale disinfection, rhizome solarization methodology was modified wherein the bulk of the ginger rhizome material was spread on a polythene sheet (100–200 kg) directly under sunlight. The rhizomes were covered with another sheet of polythene and borders were sealed with wet soil. The lethal temperature for *Ralstonia solanacearum* was achieved within 60 minutes when the rhizomes were exposed from 12.00 noon onwards. This methodology is easy and can accommodate large volume of rhizome material for heat treatment at a time.

Storage of ginger rhizomes in dried leaves of *S. nux-vomica* alone, *G. pentaphylla* alone, *S. nux-vomica* + sawdust (1:1) and *G. pentaphylla* + sawdust (1:1) were as promising as storage in sawdust alone. *In vitro* screening of endophytic bacteria for nematicidal activity indicated that mortality of nematodes ranged from 0 to 31.03%. Among root-knot resistant turmeric and ginger accessions, Acc. 43, Acc. 56 and Acc.57 in turmeric and Acc. 36 in ginger were superior in yield and other characters. The rDNA of *R. similis* was amplified using 18S primers P1 and P2. Species-specific primers were designed using bioinformatics tools for detection of *R. similis* and *Pratylenchus* species. The *Trichoderma* mass production venture with 10 years life period resulted in a net value of Rs 2,42,618 with less than 2 years of payback period, 121% internal rate of return and 1.84 B : C ratio.

Of the elite lines of cassia, $C_5$ was found to be superior in yield (475 g), bark oil (5.0%), leaf oil (3.09%) and bark oleoresin (10.70%). Highest oil (8%) and oleoresin (14%) were present in Acc. 57 and Acc. 60. Of the 106 nutmeg accessions evaluated, A9/18 (933 fruits/tree) was found to be superior. Approach grafts of dwarf clove (Acc. 197-IC 438344) using normal clove as rootstock was produced. Softwood grafting in *Garcinia xanthochymus* was standardized on nine months old *G. xanthochymus* rootstocks with 90% success. Grafts had a compact plant type and born fruits at an early age. The grafted plants flowered within two to three years after grafting, while seedling trees did not flower even seven years after planting.

White and pink flowered varieties of *Vanilla andamanica* were self and cross-compatible besides showing compatibility with *V. planifolia*. Cytological analysis of *Vanilla andamanica* revealed 2n = 40 as most frequent chromosome number. A new disease of vanilla caused by a fungal pathogen (*Cylindrocladium quinqueseptatum*) was identified and reported for the first time from India. Cucumber mosaic virus (CMV) on vanilla (*Vanilla planifolia*) was characterized on the basis of biological and coat protein nucleotide sequence properties. DAS ELISA method was standardized for detection of CMV infection in vanilla plants.

About 23,000 rooted black pepper cuttings, 8,047 cardamom seedlings, 1,000 cardamom suckers, 20 kg cardamom capsules, 4 tonnes of ginger seed rhizomes, 11 tonnes of turmeric seed rhizomes and 6,498 nutmeg grafts were distributed to farmers.

The All India Coordinated Research Project on Spices recommended six varieties namely, DH-246 (coriander); RZ-223 (cumin), HF-33 (Hisar), GF-11 (Jagudan) and RF-143 (Jobner) and Rmt-305 (fenugreek) Jobner, six varieties namely, IISR-Thevam, IISR-Malabar Excel, IISR-Girimunda and P-24 (black pepper) and IISR-Kedaram and IISR-Alleppey Supreme (turmeric) at IISR, Calicut; five entries namely, AN-01-1 (nigella), AD-01-43 and AD-01-6 (dill), and AA-01-61 and AA-01-19 (ajowan) at NRC Seed Spices, Ajmer, for state release. Five varieties of ajowan, dill and nigella were also released

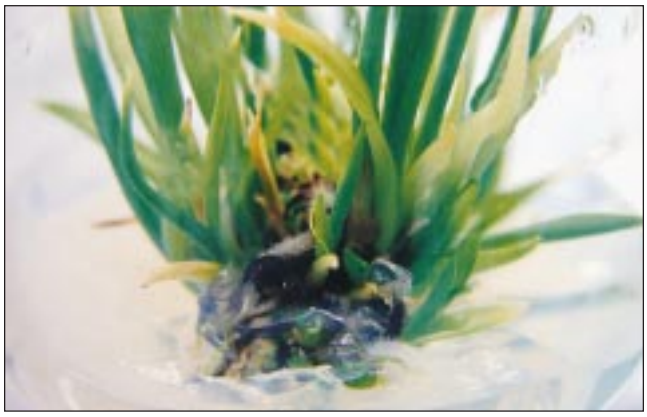
**Empowering Farmwomen**

In thematic campaigns and cashew day more than 200 farmwomen beneficiaries participated and got benefited. About 60% of the prize winners were farmwomen. All prize winners were presented with a certificate and a radio set so as to encourage the participation of women beneficiaries in cashew developmental activities

**Aloe**

Aloe accession, NMRM2, was found to contain high alin A, among all the existing accessions. Clonal propagation with a single shoot bud as explant, it was possible to obtain 28 shoot

buds after 2 weeks of cultures on half MS basal medium supplemented with different concentrations of BA, IAA and sucrose.



Mass multiplication in Aloe

**Ashwagandha**

In ashwagandha, total biomass yield/plant varied from 63.4 to 308.4 g at Hisar. In genotype GP-27-Local, highest root yield (38.5 g/plant) was recorded followed by WS-218 (26. 5 g/plant) and WS-90-125 (25.0 g/plant), whereas check (JA-20) yielded 15.0 g/plant. Maximum fresh and dry root yields were 3,542 and 828 kg/ha, respectively with a seed rate of 12 kg/ha. At Mandsaur, MWS-308, MWS-324 and JA-134 were superior in dry root yield. Similarly, seed yield ranged from 222 (MWS-333) to 694-kg/ha (MWS-308 and JA-134). Highest alkaloids content (0.68%) was in JA-134 followed by MWS-223 (0.6%). Highest root yield (642 kg/ha) was obtained with the application of vemicompost (5 tonnes/ha). At Udaipur, JA-20 was found to be superior over JA-134 in root yield. The seed rate of 8 kg/ha produced significantly highest fresh (1,290 kg/ha) and dry (465 kg/ha) root yields. Sowing on 1 September and harvesting on 1 April recorded significantly highest root yield (1,625 kg/ha). At Akola, highest root yield was recorded with harvesting at 100% flowering stage (563 kg/ha). The yield of total alkaloids was significantly highest at 100% flowering stage (350 kg/ha).

**Asalio**

In asalio, highest seed yield was obtained in MLS-7 (2066 kg/ha), followed by MLS-1 (1,823 kg/ha) and MLS-3 (1,703 kg/ha). The highest seed yield of 658 kg/ha was recorded with 0.6 IW : CPE, which was at par with 0.8 and 1.0 IW : CPE (609 and 602 kg/ha, respectively at NRCMAP.

**Asparagus**

In asparagus, dry weight of fasciculated roots/plant ranged from 0.57 to 1.39 kg/plant and saponin content from 4.50 to 5.34% at Hisar. Highest dry fasciculated root yield/plant was in HAR-7 (1.39 kg), followed by HAR-3 (1.23 kg), HAR-2 (0.998 kg) and HAR-6 (0.91 kg). At Akola, maximum saponin was observed in oven-dried samples in air-tight container (4.76%).

**Chirayata**

Extraction and estimation method of bitter compounds in chirayata, was standardized at Solan.

**Isabgol**

In Isabgol, highest seed yield/plant was recorded in genotype EC-41181-37 (7.2 g), followed by P-96 (6.9 g), PB-10-4 (6.5 g), PB-31 (6.4 g), DM-7 (6.3 g), PS-19 (6.2 g) and P-79 (6.1 g), whereas in the best check GI-1 seed yield of 4.7 g/plant was recorded at Hisar. At Mandsaur, swelling factor (ml/g) varied from 6.0 (SPS-19) to 9.6 (SLS-16) and days to 50% flowering from 56 (SLS-01) to 69 days (SLS-63). Seed yield ranged from 297 kg/ha (SLS-65) to 1,450 kg/ha (SLS-59). Sowing on 21 November produced significantly higher seed yield (834 kg/ha). Maximum seed yield was produced with three (689 kg/ha) and two (687 kg/ha) irrigations. At Akola, sowing on 20 November produced significantly highest seed yield (3,660 kg/ha). At Udaipur, application of three irrigations (at tiller initiation, full tiller and 75% flowering) produced highest seed (1,468 kg/ha) and straw (3,031 kg/ha) yield compared to others. Spraying of brassinosteroid (0.4 ppm) yielded significantly highest seed (1,189 kg/ha) and straw (2,461 kg/ha) compared to 0.2 ppm (1,023 kg/ha seed and 2,323 kg/ha straw) and control (864 kg/ha seed and 2,135 kg/ha straw).

**Kalmegh**

In kalmegh, significantly higher yield was obtained in Acc. No. 3 (2844 kg/ha) at Anand. In 43 accessions evaluation, fresh and dry herbage yields were highest in IC 342136 (290.6 g/plant and 99.16 g/plant) and lowest in IC111286 (120.8 g/plant and 32.12 g/plant). Andrographoloide content (%) in stems was highest in IC 260035 and IC 210635 (0.365) and lowest in IC-342141 (0.09). However, andrographoloide content in leaf was highest in IC 342141 (4.67%) and lowest in accession from Bhubaneshwar (1.281%).

**Lemongrass**

In lemongrass, genotype H-10 gave highest herb yield/plant

- A total of 43 accessions of kalmegh were evaluated
- The H-10, a lemongrass genotype, gave highest herb yield
- The NOP 03-1 genotype of opium poppy gave maximum seed yield
- Geraniol in palmarosa ranged from 70.33 to 92.94%
- The NMRM 2, an accession of aloe, contained high alin A

(1,174.31 g), followed by HL-9 (1,136.09 g) and HL-5 (1,085.28 g) against best check OD-58 (1,084.23 g). In genotype CKP-25, highest oil content of 0.81% and oil yield of 6.54 ml/plant were recorded. Application of nitrogen significantly increased yield and yield-attributing characters. Herbage yield was significantly high (4,223 kg/ha) with application of 200 kg/ha of N. Herbage (44.81 tonnes/ha) and oil (205 kg/ha) yield were found to be highest in LS-1.

**Liquorice**

At Hisar, fresh liquorice, stolon yields were higher (161.11 q/ha) in genotype HMK-6-2 followed by HMK-1-3 (136.11 q/ha), HMK-7-1 (125.00 q/ha), HMK-7-4 (111.11 q/ha), HMK-1-2 (108.33 q/ha) and HMK-7-5 (105.55 q/ha) against check HM-1 (94.44 q/ha).

**Opium Poppy**

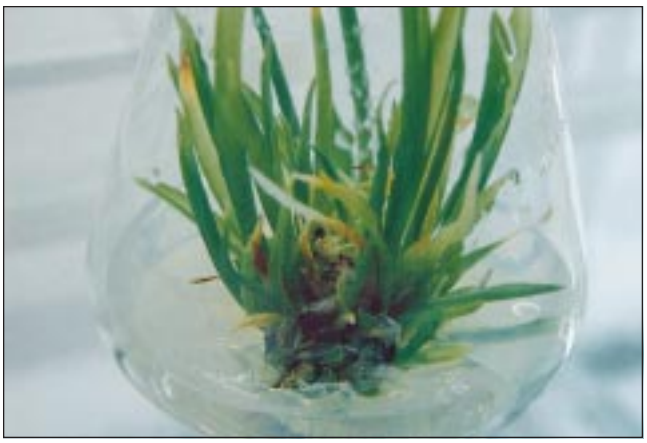
In opium poppy at Faizabad, maximum latex yield (42.70 kg/ha) was recorded in the genotype 1385. Maximum seed yield was recorded in genotype NOP 03-1 (958 kg/ha) and maximum husk yield (833 kg/ha) was recorded in N.D-20. At Mandsaur, latex yield ranged from 11.91 kg/ha (IC-19) to 77.45 kg/ha (MOP-1069) and seed yield from 208 kg/ha (IC-95) to 1,249 kg/ha (NBRI-5). Morphine content ranged from 12.4 to 17.3%, while thebain content was recorded low in MOP-1074, medium in MOP-575 and high in MOP-513. Highest latex yield was obtained with 75% of N supplementation through FYM and among the treatments receiving vermicompost, highest latex yield of 21.42 kg/ha was recorded with 75% N supplementation. Among vermicompost applications, highest seed (659 kg/ha) and husk (517 kg/ha) yields were obtained from 100% organic source. IC-114 and MOP-541 were found to have higher concentrations of morphine, thebine and codeine.

**Palmarosa**

In palmarosa, maximum herbage (4,769 kg/ha) and oil yield (241.39 kg/ha) were recorded with 150 kg N/ha. Geraniol content in oil ranged from 70.33 to 72.94%, while geraniol acetate varied from 15.73 to 19.00. At Hisar, fresh herb yield was highest in RH-03-67 (2.488 kg/plant) and lowest in RH-03-47 (0.156 kg). Oil content on fresh-weight basis ranged from 0.25 (RH-03-38) to 0.60% (RH-03-29). Computed oil yield ranged from 1.5 (RH-03-47) to 10.7 ml/plant (RH-03-67). Geraniol content ranged from 9.90 to 82.50%. Geranyl acetate content ranged from 1.10 to 10.76%.

**Safed Musli**

In safed musli, fresh fasciculated root yield ranged from 5.77 g/plant in GUJ 1 to 23.77 g/plant in RAJ 11. Number of fleshy roots/plant was highest in GUJ 2 (20.43) and it was lowest in GUJ 1 (4.30). Length of fleshy root ranged from 1.97 cm (GUJ 1) to 9.26 cm (MP 4). Two safed musli lines (NRCCB 1 and NRCCB 2) registered by National Germplasm Registration Committee as INGR No. 04113 and INGR No. 04114. At Anand, fleshy root yield was 6,764.56 kg/ha after detopping compared to 5,136.19 kg/ha. Highest fleshy root yield (11,855 kg/ha) was obtained from 10 cm × 10 cm spacing. Increase in fleshy root yield increased total income, highest being Rs 2,265,400 recorded from closest spacing and minimum (Rs 1,343,800) from 10 cm × 10 cm spacing. However, cost: benefit ratio was highest (1 : 6 : 16) with lowest plant population. At Udaipur, significantly higher fresh root yield (6,657 kg/ha) was obtained from the variety MCB-405 compared to MCB-412 (6,064 kg/ha). Closest spacing produced significantly highest fleshy root yield (7,743 kg/ha). Maximum fresh root yield (7,952 kg/ha) was obtained by MCB-405 planted at a plant-to-plant distance of 10 cm. Similarly, significant highest dry root yield of 1,590 kg/ha was recorded in variety MCB-405 with closest spacing. The yield attributes and fresh fleshy root yield were recorded maximum in ridge planting. At Akola, quality of fleshy root powder, in saponin content decreased with storage. Significantly lowest content was recorded after 12 months of storage (5.79%). Highest saponin was found in oven-dried material kept in air-tight container (6.13%). At Mandsaur, to develop proper management of fleshy root rot disease, soil application of potash @ 60 kg/ha and *Trichoderma viride* @ 5 kg/ha and or seed treatment with Bavistin @ 0.15% were used either singly or in different combinations. Combined treatment of potash, *Trichoderma* and Bavistin produced significantly lowest fleshy root rot disease incidence (14.15%).



Tissue culture in safed musli

**Sankhpushpi**

In sankhpushpi, polymorphism in terms of flower colour was recorded. Three distinct colour types were recorded. Eight different types of corolla shape were observed in the population namely

mucrunate, acute between, acute, retuse, obtuse and serrated, semi-gamopetalous. Chemical fingerprinting results showed 11 bands in HPTLC plates of different plant types collected from four subplots.

**Giloe**

In giloe (*Tinospora*), polymorphism in leaf shape was very much pronounced. Leaf base varied from cordate, subcordate or deeply cordate or truncate, while leaf apex varied from obtuse, mucronulate or apiculate. Males were in full bloom in December, however, females were not in flowering during this month. Maximum anthesis was in the afternoon, i.e. 12.00 to 4.00 PM. Pollen transfer in species is through wind. Floral visitors identified were aphids and black ant (*Dolichoderus* spp). Flowers opened at 6.00 PM gave maximum germination (69.09%). Chemical fingerprinting showed the presence of seven bands in leaf and nine bands in stems.

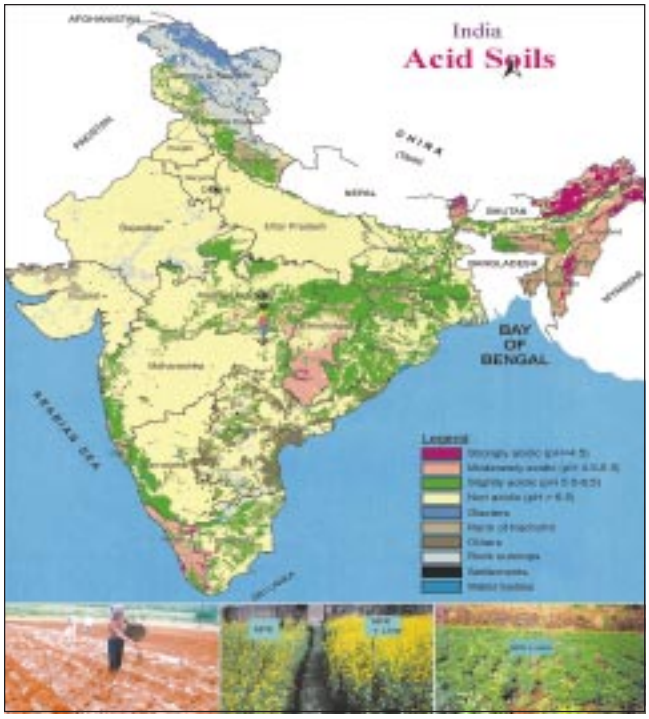
# Natural Resource Management

### Soil-resource survey

Soil-resource survey and mapping on 1:50,000 scale of 12 districts belonging to Jharkhand, West Bengal, Madhya Pradesh, Arunachal Pradesh, Bihar, Kerala, Uttaranchal, Punjab and Uttar Pradesh covering 3.3 million hectares has been done for their land-use planning. Atlases 126 at the division level for 11 districts of Andhra Pradesh covering 130.48 lakh hectares have also been prepared. And for land-use planning detailed soil surveys of 15 watersheds/farms on 1 : 10,000/1 : 5,000 scale have also been completed, covering 93,460 hectares.

### Acid soil mapping

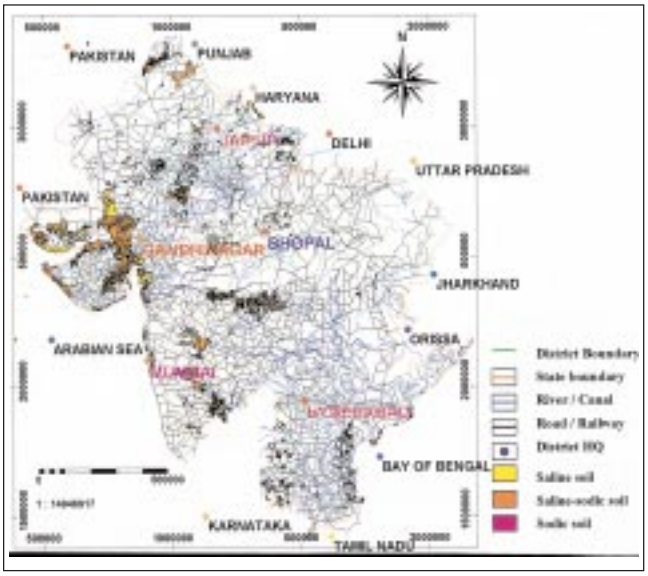
An acid-soil map has been prepared depicting extent and distribution of soil acidity in the country. The map will be useful to planners, researchers and farmers in formulation of appropriate amelioration strategies for the soils for enhancing their productivity.




*Acid soil map of India.* Twenty-five million hectares of cultivated lands with pH < 5.5 are critically degraded acid lands with low productivity

### Salt-affected soils digitized

Computerized databases in digital format for salt-affected soils of Rajasthan, Madhya Pradesh, Gujarat and Andhra Pradesh on 1 : 250,000 scale have been prepared using Integrated Land and




Digitized map of salt-affected soils of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh

Water Information System (ILWIS) software. The analogue maps were geo-referenced, and polygons of the salt-affected soils have been digitized and rasterized. The Survey of India maps with 1 : 1 million scale were geo-referenced and their different features such as state and district boundaries, road, railway, canal, river, state and district capitals were digitized to prepare thematic layers

- For land-use planning, soil-resource survey and mapping done for 12 districts belonging to Jharkhand, West Bengal, Madhya Pradesh, Arunachal Pradesh, Bihar, Kerala, Uttaranchal, Punjab and Uttar Pradesh
- Direct-seeded rice (DSR) technology standardized and demonstrated in farmers' participatory approach
- For preparing broad-bed-and-furrows evolved an indigenous cost-effective technique, replacing costly BBF-maker
- Continuous contour trenches performed better due to more moisture availability in trenches


The National Bureau of Soil Survey and Land-Use Planning, Regional Centre, Bangalore, has demarcated the state into following 6 Agroecological zones (I-VI in figure). These zones have been further divided into 17 agroecological subzones for efficient planning of crops.

**I. Northern Karnataka Plateau**

This receives a mean annual rainfall of 430 to 992 mm and is divided into 4 zones with LGP ranging from < 90 days, 90–120 days, 120–150 days and 150–180 days.

**II. Southern Karnataka Plateau**

This receives a mean annual rainfall of 450 to 925 mm and is divided into 4 zones with LGP ranging from < 90 days, 90–120 days, 120–150 days and 150–180 days.

**III. Southern transitional region**

This receives a mean annual rainfall of 750 to 1,030 mm and is divided into 2 zones with LGP from 150 to 180 days and 180–210 days.

**IV. Northern transitional region**

This receives a mean annual rainfall of 585 to 830 mm and is divided into 2 zones with LGP from 120 to 150 days and 150 to 180 days.

**V. Hilly region**

This receives a mean rainfall of 1,070 to 3,812 mm and is divided into 3 zones with LGP from 180 to 210, 210 to 240 days and > 270 days.

**VI. Coastal plain**

This receives a mean annual rainfall of 3,220 to 4,850 mm and is divided into 2 zones with LGP from 180 to 210 days and 210–240 days.

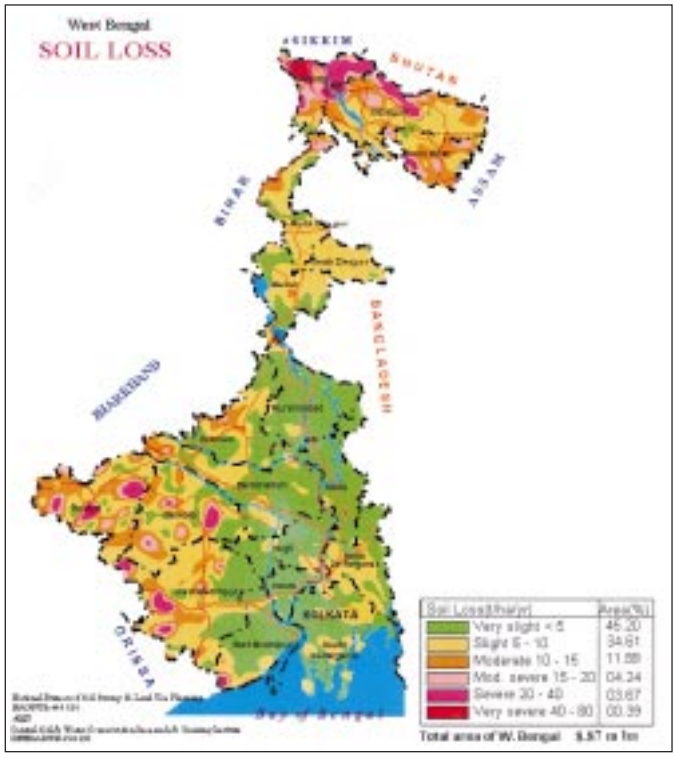
**Zero tillage in rice and wheat**

In Bihar, 25 hectares in 21 villages (covering 74 farmers) was brought under zero-tilled rice. Similarly, 9.5 hectares was brought under puddled direct-sown rice with 22 farmers. Even under erratic rainfall and late canal-water supply, establishment of rice during June 29–July 17 was possible with zero tillage. Under puddled broadcast, it was possible between July 11 and 20, and under puddled condition, transplanting was possible between July 15 and August 25. The average yield of rice under zero-tillage direct-seeded condition was 5.036 tonnes/ha. And under puddled direct-seeded condition was 3.7 tonnes/ha, which was found lower than conventional also (3.940 tonnes/ha). Similarly, under zero-tillage wheat, 22 districts were covered. There was a gain of Rs 2,260/ha with zero tillage in wheat. Savings were in land preparation/sowing (Rs 1,700), first irrigation (Rs 360) and seed (Rs 200). More than 80% farmers reported increase in wheat yield under ZT compared to conventional-sown wheat; 22% farmers reported 0.2–0.4 tonnes/ha increase in yield. The Govt of Bihar has announced 25% (maximum limit of Rs 5,000) subsidy for purchase of ZT machine.

for base map. These were then overlaid with a layer of salt-affected soils for preparing state maps of the salt-affected soils.

**Soil-erosion maps**

Soil-erosion map of West Bengal has been generated based on the soil-loss data at 10 km × 10 km grid. In major coastal belt

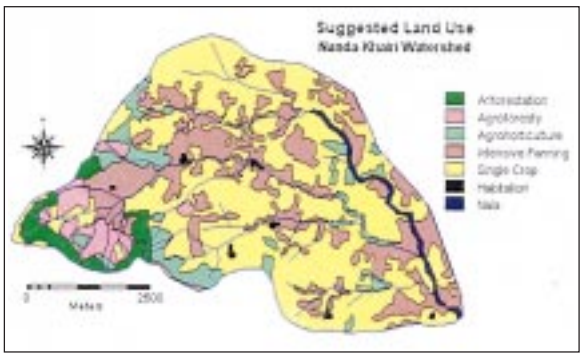


**Land-use-planning in rainfed ecosystem**

The climate was variable in all the 16 watersheds, covering 5,258 hectares from dry semi-arid to sub-humid. And the soils belonged to 5 orders with rainfed rice, oilseeds, cotton and coarse cereals-based production systems. Following eco-friendly and sustainable land-use models were identified for these watersheds.

**Suggested land-use planning of Nanda Khairi watershed**

Nanda Khairi watershed suggested land use map has been generated by integrating physiography, soil and slope. The present land use/land cover includes afforestation, agroforestry, agro-horticulture, single crop and intensive cultivation areas.


| Region | Sustainable land-use models |
|---|---|
| Akola | Sesame + castor in Vertisols |
| Anantapur | Groundnut in Alfisols with reduction in P usage |
| Arija | Maize + blackgram (2 : 2) |
| Bellary | Groundnut – *vamu* in Vertisols |
| Indore | Citrus + soybean–wheat in Vertisols |
| Kovilpatti | Coriander and chickpea + senna/ inter-relay crops for Vertisols |
| Rajkot | Groundnut + blackgram; cotton + sesame in Vertisols |
| Rewa | Soybean + pigeonpea (1 : 1) |
| Sardar Krushinagar | Pearl millet + greengram (3 : 1) |
| Sholapur | Safflower with compartmental bunding for deep Vertisols |
| Varanasi | Rainfed rice–pigeonpea in Inceptisols |

(75%), potential soil loss through water has been estimated at less than 5 tonnes/ha/yr. In many pockets of the west coast, particularly, in Maharashtra, Karnataka, Goa and Kerala, annual soil loss was found to be more than 4 tonnes/ha/yr.

### Sustaining rice-wheat system through direct-seeded rice (DSR) and conservation technology

Direct seeding of rice can overcome the problem of dependence on labour for nursery raising and transplanting operations. The DSR technology has been standardized and demonstrated in farmers' participatory research. It has showed potential of improving water productivity by 15–18% (as puddling requires lots of water), and of system profitability by 10–15%. Further, a significant improvement in the soil health has been recorded under the aerobic rice-based production systems. The DSR and *Sesbania* co-culture (brown manuring), followed by zero-till wheat and other upland crops (chickpea/lentil/mustard) have exhibited tremendous scope for their acceptability in the rice-wheat production system.

### Amelioration of acid soils

Apply lime at 0.2–0.4 tonne/ha in furrows at the time of sowing along with the recommended fertilizers. This enhanced yields of

Application of lime in furrows at Bhubaneshwar, Orissa


*Liming acid soils*. Liming enhances their nutrient-use efficiency by saving 50% of chemical fertilizers, particularly in oilseeds and pulses (Pigeonpea, Bhubaneshwar, Orissa)

various crops by 49–189% over farmers' practices, and also saved chemical fertilizers by about 50%, particularly in oilseeds and pulses. Mean benefit : cost ratio of the practice was 2.5. The adoption of this cost-effective technology on 25 million hectares of critically degraded acid soils can contribute an additional 25 million tonnes of foodgrains to the national food basket per annum.

**Integrated tillage, land and residue management in rainfed situation**

Reduced tillage (one harrowing and one intercultural operation with pre-emergence herbicide), followed by broad-bed-and-furrow (BBF) planting of rainfed cotton applied with recommended dose of fertilizers, incorporation of green manure and location-specific deficient nutrients gave 32.6% higher cotton-seed yields compared to farmer's practice of rainfed-cotton cultivation on flat-beds with conventional tillage involving one summer ploughing, followed by 2–3 harrowings and with numerous intercultural operations and application of about 70% of the recommended fertilizer dose. The net returns/benefits to farmers from this improved practice were in the range of Rs 4,955 in Kovilpatti (Tamil Nadu) to Rs 18,536 in Khargone (Madhya Pradesh) per hectare. The practice also improved soil physical and chemical properties. An indigenous cost-effective technique replacing costly BBF maker has also been evolved for preparing BBFs. Furrows of 40–50 cm top width could be opened with country plough by fixing a wooden attachment to plough to widen furrows and for rounding top edges.

**Soil- and-water conservation technologies**

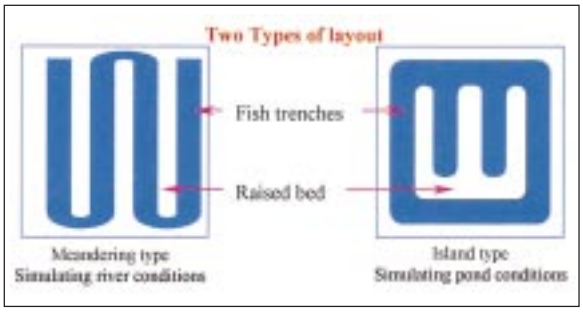
In semi-arid black soils, *Dichanthium* showed superiority to vetiver in soil- and-water conservation. Runoff and soil losses were 52.3 mm (71% reduction) and 0.5 tonne/ha with *Dichanthium annulatum* and were 83.7 mm and 1.6 tonnes/ha with vetiver. And these losses were 181.8 mm and 6.6 tonnes/ha from the bare plot.

Continuous contour trenches (CCT) with *Stylosanthes scabra* + *Gliricidia maculata* as vegetative barriers were most effective in minimizing runoff (3.95%) and soil losses (0.7 tonne/ha/yr). Cashew growth was also better with CCT and vegetative barrier. The better performance in the CCT was due to more soil-moisture availability in the trenches.

- In Patna, 37% farmers preferred fish-cum-horticulture system in waterlogged areas
- OPTALL model use facilitated optimal releases of canal-water
- Kinnow-plants mulched with *sal* leaves produced better quality fruits than *lantana* mulch
- Crop yields with sewage irrigation could be sustained with only 50% of the recommended nitrogen and phosphorus

**Land- and-water productivity enhancement through multiple water uses**

Productive utilization of seasonally waterlogged areas through multiple uses of water was investigated at the experimental farm of the ICAR-RCER, Patna. The preliminary results of the first year were quite encouraging. Two secondary reservoirs (40 m × 20 m at bottom) were constructed, and fish culture along with the horticulture/vegetables on the bunds was carried out. Economic analysis indicated a net profit of about Rs 44,000/ha from the system. The benefits are expected to increase further with production of banana/guava/lemon and duck eggs. In waterlogged areas




In waterlogged areas (water stagnation 0.3–1.0 m), fish trenches-cum-raised-beds with meandering-type trenches simulating river and continuous trenches surrounding island of raised-bed simulating pond are found profitable

(water stagnation 0.3–1.0 m), fish trenches-cum-raised bed with meandering-type trenches simulating river and continuous trenches surrounding island of raised-bed simulating pond were evaluated. The area under fish trenches was around 770 $m^2$ and was 444 $m^2$ under the raised-beds. Economic analysis indicated a profit of Rs 65,000 per hectare during the 1st year. For rice-fish culture in nylon-pens under waterlogged areas, field level was raised to enhance rice production, using soil excavated to construct fish-refuge (Central refuge) in 10% of the rice-area. It produced 6 tonnes/ha of paddy along with 153 kg of fish/ha. The profitability increased by 10% with the introduction of fish in the rice field. Fish-cum-horticulture in waterlogged area was preferred by 37% farmers. Nineteen per cent respondents liked fish-pond-cum-secondary reservoir and rice-cum-fish cultivation; only 15% farmers were reluctant to adopt any fish-production technologies.

**Model for canal-water management developed**

A water allocation plan was prepared by employing OPTALL model for Patna canal.

In some weeks canal-water supply was excessively higher than requirement, and in other weeks it was excessively lower than demand. The use of the OPTALL model, however, has facilitated

optimal releases of water. This model could help in regulating gate opening and corresponding water releases from canal system for optimal and equitable distribution of water in canal commands.

**Fertigation in banana**

Drip irrigation coupled with fertilizers advanced flowering of banana-plant and improved its quality and yield. Fruit size was bigger under drip irrigation (35–45-mm diameter for Harichal variety) in comparison to non-drip irrigated crop (28–37 mm). Yield increase was 273% in drip-irrigated crop over surface-irrigated one. The drip has improved overall profitability of the system.

**Supplemental irrigation and mulching**

Kinnow irrigated at 80-mm net cumulative pan-evaporation produced highest fruit yield (0.13 tonne/plant). The long-run plants raised with *sal* or *lantana* mulch also produced almost similar yields. Fruit quality improved with increased frequency of irrigation. Kinnow-plants mulched with *sal* leaves produced better quality fruits than *lantana* mulch.

**Urban and industrial effluents use in agriculture**

The build-up of organic matter and nutrients in soils with sewage irrigation improved yields by 12–24% of vegetables (cabbage–ridge-gourd), fodders (berseem–sorghum), grains (rice-wheat) and agroforestry (rice–wheat with poplar)-based systems. And the yields with sewage irrigation could be sustained with only 50% of the recommended nitrogen and phosphorus.

**Quality of produce of *Lepidium* with saline irrigation**

Chemical analysis of *Lepidium* oil revealed no effect of saline irrigation on its fatty-acid composition. Erucic acid, which is harmful to health, and present in most of the crucifers, has not been detected in *Lepidium* oil; hence, this oil could be compared with canola oil. In this, monounsaturated fatty acids (MUFA) and poly-unsaturated fatty acids (PUFA), which are good for health are found in high amounts. This oil possesses antioxidant properties, and can be used as the natural preservative.

*Lepidium* being raised in degraded calcareous soils with saline water

**SUCCESS STORY**

**Participatory water management in foot-hills of western Himalayan Region**

In a village in Raipur block of Dehra Dun district with the harvesting subsurface water-flow into a dug-out pond (260 cum) in a participatory mode (farmer's share 35%), and its utilization through lifting and underground pipeline system, 42 hectares could be irrigated for the first time; benefiting 125 families. And the cost of the system could be recovered within two years. Another tank of 350 $m^3$ capacity was constructed at village Bhopalpani. Water conveyance from pond was through gravity using underground PVC pipeline system. The farmers' contribution was over 51%.

Excellent crop and horticulture interventions in IVLP villages (Dehra Dun)

Harvesting and storage of subsurface flow through underground pipeline under the IVLP (Dehra Dun)

In Uttaranchal, the concept of participatory water-resource development is catching up even in villages not covered under the TAR-IVLP. The economic analysis of TAR-IVLP Project was worked out by considering 30 years project life at 10% discount rate with taking productive benefits from crop and horticulture sectors only. This revealed that project would yield net present value to the tune of Rs 127.69 lakh with a benefit : cost ratio of 1.55 : 1. The whole cost of the project can be recovered within 4 years due to the high internal rate of returns (105%).

### Regional-scale watershed plans and methodologies – case studies

- An action plan was generated for Nagarinala watershed (1,312 ha) in Kusumi-Dahuka in Nayagarh district of Orissa with GIS and remote sensing. The engineering measures included construction of percolation tanks, water-harvesting structures (WHSs), check-dams, contour-bunds/ contour-trenches, land modification, open dug-wells, diversion-weir, loose boulder structure, and renovation of WHS. Percolation tanks and WHSs enhanced groundwater level in micro-watershed, and also an increase in command area to 25 hectares in *kharif* and 27 hectares in *rabi*. Contour-bund cum-trench of 100-m length helped in storing water and sediments in degraded land, making it suitable for plantation. Construction of stone masonry spillway prevented soil erosion and crop damage in 7 hectares of upland. With open dug-wells, farmers grew different vegetables during *rabi* and rice in *kharif*. The profits obtained by farmers were enough to bear construction cost of wells. Construction of diversion-weir with three gates saved around 25 hectares of *kharif* rice.

  The cropping programme included high-yielding upland rice variety Vandana, medium-land rice variety Surendra and lowland rice variety Gayatri. Sex pheromone traps were used under integrated pest management. Green manuring with *dhaincha* was practised to partially substitute chemical-N fertilizer. The anti-termite treatments were beneficial to farmers in controlling crop damage. Pigeonpea and urdbean on bunds of rice gave extra income to farmers, besides increasing soil fertility.
- A short-term study in participatory mode for SS Pally micro-watershed of Nalagonda District, Andhra Pradesh was conceptualized. Based on the geo-hydrological parameters, runoff diversion channels, waterways, gully plugging by gabion structures, recharging of pits, percolation ponds and sand-bag checks were constructed/installed at appropriate places for preserving rainwater and reducing soil losses. Groundwater monitoring exercise showed 1 m increase in groundwater level of this watershed and there was 50% reduction in runoff. About 4 tonnes of soil was conserved by gabion structures and check-dams and 15 hectares were saved from soil and gully erosion. Green capping of bunds/ waterways by *Urochloa*, *Panicum*, *Cenchrus* and *Stylosanthes* and introduction of sweet-orange, sapota, mango and curry-leaf and avenue plantation of *jamun*, tulip-tree, cassia and sissoo resulted in making watershed greener; that was otherwise a scrub jungle.

## Balanced fertilization

Balanced application of N, P, K, S and Zn at the recommended rates (120 kg N, 60 kg $P_2O_5$, 20 kg $K_2O$, 20 kg S and 5 kg Zn/ha) increased wheat-grain yield by 15–24% over farmers' practices in Geelakhedi (Rajgarh district), Mugaliahat (Bhopal district) and Rangai (Vidisha district) villages (two experiments in each village) of Madhya Pradesh. Skipping application of P (NKSZn treatment) and S (NPKZn treatment) had resulted in reduction in wheat

### Site-specific nutrient management (SSNM) in rice–wheat system

A field experiment at the PDCSR, Modipuram, with hybrid rice (*cv*. PHB 71) and wheat (*cv*. PBW 343) in sandy-loam, mild alkaline soil was conducted for SSNM. The soil contained 0.7% organic matter and was deficient in available N, K, S, Mn, B and Zn. The SSNM recommendations for a yield target of 10 tonnes of rice/ha and 6.5 tonnes of wheat/ha were 170 kg N, 30 kg $P_2O_5$, 80 kg $K_2O$, 20 kg S, 17 kg Mn, 7 kg Zn and 0.6 kg B per hectare in rice and 150 kg N, 30 kg $P_2O_5$ and 80 kg $K_2O$ per hectare in wheat. In rice, SSNM schedule gave grain yield of 10.5 tonnes/ha, against 6.7 tonnes/ha under farmer's practice. The application of K at 80 kg $K_2O$/ ha gave 1.38 tonnes/ha of additional rice compared to no K. Skipping S and micronutrients brought yield reduction by 1.24 to 2.75 tonnes/ha. Similar trend was recorded in wheat also.

- Highest wheat yields in Madhya Pradesh could be sustained by adopting integrated nutrient management
- In Gujarat, application of Zn+S+B increased pod yield of groundnut by 32%.
- Mixed biofertilizers inoculation in pearl millet with 75% of recommended dose of N at farmers' fields at Hisar, Bhiwani, Jajjhar, Mahendergarh and Rewari increased its grain yield by 5% and fodder yield by 6%

### Leaf colour chart (LCC) for nitrogen management

Leaf colour chart measuring leaf colour intensity is recommended for efficient fertilizer-N management in rice;

Leaf colour chart (LCC) is a simple, rapid and cheap tool for managing N fertilizers efficiently

avoiding under or over fertilization. Its use, effecting saving of 15 kg N/ha in rice has successfully been demonstrated in three villages of Patna (Bihar).

yield. Similarly, wheat-grain yields were reduced significantly at 3 sites when Zn was not applied. The results clearly indicate that higher wheat yields could be sustained by encouraging farmers to correct N, P, S and Zn deficiencies by adopting appropriate nutrient-management practices.

**Crop response to micro and secondary nutrients**

In Gujarat, with 5 kg Zn/ha higher pod yield of groundnut was obtained. Seed treatment with 3% ZnO increased pod yield of groundnut by 3.3% and application of Zn + S + B increased pod yield by 32%. On blackgram, in Zn, and S-deficient swell-shrink soils of village Karkbel, district Narsinghpur, at one of the sites, net increase in yield of 0.17 and 0.37 tonne/ha was observed with 5 kg Zn/ha and 5 kg Zn + 40 kg S/ha, respectively. At another site, net increase was 0.15 and 0.31 tonne/ha with 5 kg Zn and 5 kg Zn + 40 kg S/ha, respectively. Higher B/C ratios of 3.53 and 4.28 were obtained with 5 kg Zn + 40 kg S/ha at the two sites respectively.

**Formulation and testing of mixed biofertilizers**

*Azospirillum* + phosphate-solubilizing bacteria (PSB) + plant-growth promoting rhizobia consortium developed for rice in Tamil Nadu, gave 10–15% higher yield at the recommended dose of NP (100%). And when these were used along with 75% NP, it saved 25% NP and produced yields at a par with 100% NP. This was effective for blackgram also. Mixed biofertilizers inoculation to pearl millet on farmers' fields at Hisar, Bhiwani, Jajjhar, Mahendergarh and Rewari at the 75% of the recommended dose of N resulted in increase in grain yield by 5% and fodder yield by 6%; giving additional net monetary returns of Rs 780/ha. In drylands, at Bawal in Haryana, inoculation of pearl millet, wheat and mustard with *Azotobacter*, *Azospirillum* and *Pseudomonas* at 75% of the recommended dose of nitrogen gave 10–22% higher yield. In three farmers' fields, experiments were conducted on vegetables. Inoculation of *Azotobacter*, *Azospirillum* and PSB strains on okra, brinjal and tomato in strongly acidic (pH 5.2–5.6) sandy-loams in Orissa, increased yields of these vegetables by 9–14% over and above the recommended nutrient management. Apparent nutrient-use efficiency increase for N was 12–36%, for P was 18–28%, for K was 9–15% and for S was 16–18%.

**New biofertilizer strain isolated for apple**

A PGPR strain *Bacillus megaterium* has been isolated from rhizosphere of apple seedlings from Solan, Himachal Pradesh, that can fix atmospheric nitrogen, solubilize phosphorus and inhibit pathogen, *Dematophora necatrix*, the causative organism of white-rot of apples.

- Pearl millet–potato–groundnut found promising in North-West Zone of Gujarat with highest pearl millet equivalent yield of 17,606 kg/ha/yr, productivity of 48.2 kg/day/ha and net returns of Rs 36,046/ha/yr
- Water-use efficiency of chickpea was greater in broad-bed furrow (BBF) than flat on grade (FOG)
- Growing carnations in low-cost greenhouses is a good option for landless and marginal farmers of Nilgiris
- *Karonda*, *bael* and *aonla* successfully established with saline water and high saline water at Bir Forest, Hisar

**Improving cropping intensity through varietal improvement**

Fingermillet genotype VR 708 and barnyard genotypes PRB 9602, VL182 and VL 187 are found promising with short-maturity period of around 80-85 days, ensuring double cropping and higher production in the rainfed valley of the north-west hilly region.

Goa, being a tourist destination, has a large scope for confectionery groundnut with value-addition. Varieties ICGV 98412, ICGV 98402 and ICGV 97049 have showed promise, yielding nearly 23 tonnes/ha against check ICGS 76 (16 tonnes/ha), corresponding to an increase of about 160%. These types with

*Henna*. The Khedbrahm accession of henna has been found high-yielding with 1.87% lawsone content

Guggal (*Commiphora wightii*), a gum-resin-yielding shrub, once used to grow in abundance in rocky habitat around Jaisalmer, is now a threatened species. Studies are undertaken for its propagation

consistent performance can be recommendated as the suitable crop in hilly terrains or as an intercrop in the cashew plantations.

Twenty clones of henna (*Lawsonia inermis*) from different parts of Rajasthan and Gujarat were evaluated for morphological traits, dry-leaf yield and lawsone content. The Khedbrahm accession of henna has been found high-yielding with 1.87% lawsone content.

*Guggal* (*Commiphora wightii*), is a gum-resin-yielding shrub that once used to grow in abundance in the rocky habitats around Jaisalmer but is now becoming extinct due to overexploitation and difficulties associated with its propagation. Studies at Jodhpur have showed that dipping of guggal-plant cutting for a few seconds in 5,000 ppm IBA solution is enough to initiate good growth. Early March is the best period for raising plants through cuttings. More than 500 cuttings, raised through this technique, have been transplanted successfully in the field.

**Crop diversification**

***Pearl millet-based cropping systems in Gujarat:*** In North-West Zone of Gujarat, pearl millet–potato–groundnut system was found promising with highest pearl millet equivalent yield of 17,606 kg/ha/yr, productivity of 48.2 kg/day/ha, net returns of Rs 36,046/ha/yr, economic efficiency of Rs 98.8/ha/day and irrigation water-use productivity of 146.7 kg of grains/ha-cm of water. The next best choice was castor-pearl millet giving estimated total pearl millet equivalent yield of 9,924 kg/ha/yr, productivity of 27.2 kg/day/ha, net returns of Rs 20,188/ha/yr, economic efficiency of Rs 55.3/day/ha and irrigation water-use productivity of 141.8 kg of grains/ha-cm of water.

***Pearl millet-based cropping systems in Haryana:*** In Western Zone of Haryana, pearl millet–potato–greengram system was better in production and productivity. But, considering profitability and nutrient-use productivity, pearl millet–pea–maize fodder and cotton–wheat were equally good with net returns of Rs 24,625 and Rs 24,793/ha/yr, economic efficiency of Rs 67.5 and 67.9/day/ha, nutrient-use productivity of 36.9 and 38.4 kg of grains/kg of nutrients and irrigation water-use productivity of 165.4 and 148.0 kg of grains/ha-cm of water.

***Pearl millet-based systems in Rajasthan:*** In Semi-arid Eastern Plains Zone of Rajasthan, clusterbean–onion system was identified better with highest production of 18,098 kg/ha/yr, productivity of 49.6 kg/day/ha, net returns of Rs 50,767/ha/yr, economic efficiency of Rs 139.1/ha/day, nutrient-use productivity of 58.4 kg of grains/kg of nutrients applied and water-use productivity of 258.5 kg of grains/ha-cm of water.

***Pearl millet-based cropping systems in Uttar Pradesh:*** In South-Western Semi-arid Zone of Uttar Pradesh, mainly representing Agra region, the green manure–potato–sunflower system was found suitable and viable choice, to replace existing pearl millet–wheat system, with highest production of 12,711 kg/ha/yr, productivity of 34.8 kg/day/ha, net returns of Rs 21,114/ha/yr, economic efficiency of Rs 57.9/ha/day, nutrient-use productivity of 28.9 kg of grains/kg of nutrients used. Pearl millet–wheat system can be further diversified through greengram

**SUCCESS STORY**

**Drought mitigation by crop diversification in rainfed uplands of eastern India**

In deficit-rainfall years (2000, 2002) in Dhenkanal (Orissa), when productivity of upland rice was very low, much higher returns were obtained from diversified cropping systems. Highest net returns per annum were obtained from maize (Rs 19,500 to 26,000/ha), followed by groundnut+pigeonpea (Rs 20,124 to 21,592/ha), sole groundnut (Rs 15,420 to 18,960/ha), sole pigeonpea (Rs 13,325 to 16,200/ha), sole blackgram (Rs 9,648 to 11,650/ha); sole rice gave nil to Rs 5,400/ha. Rice substituted crops recorded much higher rainwater-use efficiency (6.3 to 13.4 kg/ha-mm) as compared to rice (1.61 kg/ha-mm). Rice-based intercropping with pigeonpea, blackgram and groundnut recorded much higher rainwater-use efficiency (3.3-3.9 kg/ha-mm).

Rice substituting crops also gave much faster returns in rainfed uplands. Data showed that maize-cob yielded net returns of Rs 23,391/ha in 70 days (Rs 314/ha/day), whereas sole crop gave only Rs 52.30/ha/day. And it boosted farm productivity and income of poor tribal farmers of Dhenkanal district of Orissa. This technology has potential to raise average productivity of 4.3 million hectares of upland rainfed rice-area of eastern India from 0.75 tonne/ha to about 7.5 tonnes/ha (rice equivalent yield) with average net returns of at least Rs 15,000/ha/annum. Besides increased water-use efficiency and profitability, this technology has a potential to provide regular employment, to supply balanced and quality food to farmers and to sustain soil health in drought-prone areas.

in summer after harvest of wheat; this requires limited additional irrigation facilities.

***Changing land configuration for increasing productivity of Vertisols:*** Broad-bed-and-furrow (BBF) registered 18% and 16.5% greater grain yield of soybean and maize than flat on grade (FOG) land configuration. Total seasonal runoff and soil losses from BBF were lesser than FOG. In winter, grain yield of chickpea was greater in BBF than FOG. Water-use efficiency of chickpea was also greater in BBF than FOG. The total system productivity in order was maize/pigeonpea intercropping ≃ maize–chickpea > soybean/maize intercropping–chickpea > soybean/pigeonpea intercropping > soybean–chickpea in BBF and FOG.

***For better livelihood:*** Following crop diversifications fared well for better livelihood.

- Growing cotton in deep alluvial soils of Agra with one-life saving irrigation at 21 DAS and spacing of 60 cm × 60 cm was more economical than pearl millet. Cotton-seed yield was 1.5 tonnes/ha and gave Rs 7,747/ha higher net returns over pearl millet. Cotton–wheat cropping system gave net returns of Rs 24,881/ha as against Rs 13,956/ha from pearl millet–wheat system.
- Carnation cultivation in low-cost greenhouse can be a good option for landless and marginal farmers of Nilgiris. Economic evaluation for carnation-flower cultivation was carried out by assuming project life as 20 years. Different discount rates of 10, 15 and 25% were used to calculate net present worth (NPW), benefit : cost ratio (BCR) and internal rate of returns (IRR). The BCR was higher at 10% discount rate (2.70), followed by 15 and 25% discount rates (2.48 and 2.05, respectively). The net present worth was higher at 10% discount rate (15.10 lakh), followed by 15 and 25% (9.92 and 4.93 lakh). The IRR was found 75.9%, indicating high managerial enterprise returns. The cost : benefit analysis has indicated that the project can be highly economical.
- Winter maize yield equivalence showed highest value for maize + *satawar* cropping system, followed by tobacco – maize – *dhaincha* (GM), maize + potato – blackgram + elephant-yam, maize + potato – greengram – sesame, maize + potato – green chilies, wheat – greengram – maize, maize – ladiesfinger – horsegram and Indian mustard – greengram – maize systems. The highest net returns were observed from maize + *satawar* (Rs 128,270), followed by tobacco – maize – *dhaincha* (GM) (Rs 77,890/ha), potato + maize – *dhaincha* (GM) (Rs 65,368/ha), potato + maize – greengram – sesame (Rs 65,368/ha), wheat – greengram – maize (Rs 51,548/ha), maize + potato – green chilies (Rs 48,803/ha) and maize – ladiesfinger – horsegram (fodder) (Rs 47,009/ha). The benefit : cost ratio was highest (8.21) under winter maize intercropped with aromatic and medicinal plants, maize + *satawar*, followed by maize + *musukdana* (4.68), maize + *sania* (3.36), maize + *ashwagandha* (2.63) and maize + lemongrass (1.69).

**Weed management**

**Zero-tillage for weed management in rice–wheat system**

Zero-till direct-seeded rice (DSR) reduced significantly population and drymatter of *Chenopodium album* in subsequent wheat-crop as compared to transplanted rice. And zero-till wheat reduced *C. album* and *Medicago hispida*, increased soil-moisture content and yielded more compared to conventional tillage. In transplanted rice-wheat system, zero-tillage increased *Avena ludoviciana* and reduced *Phalaris minor* in wheat.

**Integrated management of water-hyacinth**

Herbicide 2,4-D (1.5-2.0 kg/ha) or glyphosate (2.0–2.5 kg/ha) in strip covering about 15% area at 6 months interval with bioagent culture *Neochetina* sp controlled two waves of infested water-hyacinth in 22 months. Bioagent alone would have taken 24–36 months to control only one wave of water-hyacinth.

**Agri-horticulture system for biosaline agriculture**

For rehabilitation of calcareous degraded soils at Bir Forest, Hisar, survival rate of *karonda* (*Carissa carandus*) was 97–100%, *aonla* (*Emblica officinalis*) was 83–90% and *bael* (*Aegle marmelos*) was 90–98%. This is indicative of successful establishment of these plants with saline and high saline waters. The plant height ranged from 91 to 123 cm for *karonda*, 126 to 243 cm for *aonla* and 202 to 263 cm for *bael*, after 2 years of plantation. Barley and clusterbean could be raised successfully in interspaces during initial years of their establishment.

Barley intercropped in *karonda* plantation during its initial years of establishment with saline-water irrigation

**Farming system module developed for dryland agriculture**

A farming system module covering 0.53 hectare was initiated on a watershed basis at Hyderabad. Arable cropping systems comprising castor + clusterbean (1 : 1), pearl millet + pigeonpea (3 : 1), sorghum+pigeonpea (3 : 1) and sunflower–horsegram were tested on 0.3 hectare. As a part of the horticulture component, tomato, brinjal (525 $m^2$), and custard-apple, *amla* (0.08 and 0.1 ha) were also grown. Drumstick, perennial pigeonpea and henna were grown along the bunds. Preliminary results have indicated that the arable crops in different systems under limited irrigation realized a net income of Rs 4,188 and a BC ratio of 2.27 in spite of severe drought experienced during physiological growth stages of crops. Tomato and brinjal recorded a gross income of Rs 402 and 750 respectively.

**SUCCESS STORY**

**Off-season vegetables cultivation**

Nursery raising of off-season vegetables in villages of Ranchi comes up as a self-help-group-based micro-enterprise. Each community growing approx 2 lakh seedlings, generated an additional income of Rs 20,000 in three months. Adoption of wilt-resistant varieties of brinjal and tomato helped farmers in early transplanting of seedlings in fields during rains. This, in turn, helped in generating more income per unit area (approximately 167.8 and 228.8% increase in income over traditional varieties) due to higher yield and harvesting of a significant proportion of the total yield in off-season; fetching higher price in the market.

**Farming system development interventions**

***Backyard poultry production with improved breed:*** Poultry-rearing in backyard is popular among resource-poor farmers, especially backward and tribal communities.

Divyan breed of poultry has been evolved for rearing in the backyard with higher growth rate and egg production. Rearing of this is more economical than indigenous breed in respect of age at first laying and egg production. Egg production is expected to increase up to 325% and age at first laying of eggs may decrease up to 170.6%.

***Small-scale duck-farming with improved breed:*** Khaki Campbell breed of duck was procured from Krishi Vigyan Kendra, Rama Krishna Mission Ashram, Ranchi, Jharkhand, and distributed among farmers. This breed of duck is popular worldwide for higher egg production.

Khaki Campbell duck-rearing was found more beneficial than indigenous breed in age at first laying and egg production. Egg production is expected to increase up to 352.94% and age at first laying of eggs may decrease up to 170.58%.

For having the profit of early-season vegetables, vegetables nursery is raised under low-tunnel polyhouses

***Mushroom cultivation:*** Currently 100 farm-families are growing mushrooms for their own business and home consumption in Patna. Women SHGs in Beeranchak village raised 100 bags of oyster-mushroom. In three successive pickings, average yield of mushroom from one bag was 885 g. In Beeranchak, Dosiya Tola, Bhelura Rampur and Beerpur villages of Patna district more than 40% families are growing oyster-mushroom.

***Raising vegetables nursery under low-tunnel polyhouse:*** Early-season vegetables in summer are more remunerative; but raising of nursery due to low temperature in winter is difficult. A study was conducted to examine the possibility of raising nursery under low tunnel polyhouse and availability of early-season seedlings. Technique of raising vegetable nursery under low-tunnel, iron-formed polyhouse was assessed against usual farmer practice of raising vegetable nursery with the start of summer (March). About 25 farmers were benefited from one polyhouse by getting early-season seedlings (Early Feb.). And farmers got a profit of Rs 2,000 from selling of nursery, besides meeting their own requirements of transplanting. The youth and women can adopt summer vegetable nursery raising under polyhouse for commercial purpose.

**Sunflower threshing device**

Local method of sunflower threshing for seeds removal caused drudgery to women-workers. To overcome this, a portable threshing device has been developed. It consists of a 750 mm × 750 mm square-frame made of 25 mm × 25 mm × 3 mm angle iron. Small pins of 3 mm dia and 10 mm length are welded (10 mm

**Impact of mechanization on dryland crops**

| Crop | No. of farmers | Area covered (ha) | Machinery utilized | Approx. profit (Rs/ha) |
|---|---|---|---|---|
| Maize | 44 | 175 | CRIDA planter | 7,000 |
| Groundnut | 64 | 111 | Cultivator, CRIDA planter, sprayer, digger, thresher, decorticator | 2,105 |
| Soybean | 81 | 151 | CRIDA planter, NRCS weeder | 1,300 |
| *Rabi* sorghum | 40 | 195 | Rota till drill, V-blade, cycle hoe | 1,400 |
| Castor | 14 | 175 | CRIDA six-row planter, tractor-drawn blade hoe, CRIDA castor sheller | 4,530 |
| Cotton | 32 | 194 | Rotavator, six-row inclined plate planter, interculture with sweep | 2,560 |
| Fingermillet | 133 | 800 | Tractor-drawn fluted roller drill, tractor-drawn interculture, tractor-drawn reaper and power thresher | 6,100 |
| Pearl millet | 22 | 187 | Ridger seeder | 1,220 |
| Rainfed rice | 84 | 428 | Tractor-drawn disc harrow, seed-cum-fertilizer drill, self-propelled reaper, power thresher | 7,420 |

row-to-row and 15 mm pin-to-pin) on to 20 mm flats, which are fixed on the frame. The device is simple and can be locally fabricated. Two women can work at a time and give output of 12–15 kg of grains/hr. It saves 25% of time as compared to local method.

### Gas-fuelled automatic control dryer

It consists of a drying chamber coupled with external gas-fired furnace through which hot-air is blown inside using 0.5-hp electric blower. The set temperature inside is controlled through microprocessor-based relay control. The dryer is most suitable for horticulture products like *amla*, curry-leaf, drumstick leaves, and medicinal and dye-yielding plants like senna and henna. The machine dried product maintained its natural colour and quality. This dryer has been well accepted by the industry, and has been commercialized.

- A portable sunflower-threshing device developed to save women-workers from drudgery
- Gas-fuelled automatic control dryer while drying maintained natural colour and quality of products of *amla*, curry-leaf, drumstick leaves and medicinal and dye-yielding plants like senna and henna

# Livestock and Poultry Improvement and Management

- Flexible data processing system provides even raw data for further analysis
- Under phenotypic characterization programme several indigenous breeds of cattle, buffaloes, sheep, goat, poultry, camel and horses were studied in their home tract
- Twinning in Kutchi goats increased up to 50% by supplementary feeding
- Breed specific marker was identified for Surti buffaloes
- Twinning in Malpura, Marwari and Bharat Merino was not found linked with *FecB* gene
- Marwari equine population has high genetic variability that equine breeders may exploit
- Genetic bottleneck was not observed in Ankleshwar and Punjab Brown poultry in past populations
- Juvenile body weight of naked neck was superior to normal birds
- HSRBC and HCMI lines showed higher Newcastle disease vaccine response
- Under *ex-situ* conservation programme frozen semen samples of cattle, buffaloes, goats, sheep and camel were preserved in genebank
- Molecular genetic characterization of wildlife species was initiated

**Livestock information management**

A generalized and flexible data processing system was developed for management and analysis of field survey data on characterization of animal genetic resources. It works for all the livestock and poultry species and accepts any type of questionnaire format. Analysis of the data can be performed on the basis of districts, animal classes and the strata defined on the management practices. Herd data can be analysed for a species, a district and a village. The user can view and extract the raw data for further analysis using available commercial software.

**Phenotypic characterization and evaluation of indigenous breeds**

***Kenkatha:*** This cattle breed is distributed in Lalitpur, Hamirpur, Chitrkoot and Banda districts of Uttar Pradesh and Tikamgarh district of Madhya Pradesh. Animals of this breed are mainly used for draught purpose and milk, and are of small size having grey and white body. Head is short and broad, horns curved, face short and disc shaped, hump and dewlap moderate, ears horizontal, muzzle, eyelids and hump black, tail moderate in length, and udder and teats small but squarely placed. The average measurements (cm) for body length, height at wither and heart girth were 101.60, 103.33 and 136.86 respectively. The birth weight, daily milk yield and calving interval ranged from 12 to 15 kg, 0.5 to 2.0 kg and 15 to 20 months respectively. The load carrying capacity of a pair of bullock was 5 to 8 q with 4 to 6 km/hr speed.

***Hallikar:*** Hallikar animals are distributed in Mysore, Mandya, Bangalore, Kolar, Tumkur, Hassan and Chaitradurga districts of Karnataka. Milk yield of Hallikar cows is low but their bullocks are famous for draught capacity. The chest girth, body length and height at withers (cm) were 161.02, 134.44, 132.15, respectively, in adult males, and 148.14, 126.67 and 124.51, respectively, in adult females. The coat colour of animals is grey to dark grey. The head is prominent with typical horn pattern i.e. emerging from top of poll, goes back up to half of its length and thereafter bends slightly forward and slightly inward at tips. The average milk yield of cows varies from 0.5 to 3.0 kg/day. The load carrying capacity of a pair of bullock ranged from 0.5 to 5.0 tonnes for 5 to 15 km in a day.

***Banni:*** These buffaloes are prevalent in Nakhatrana, Khavda, Haji Peer, Bhrindiara, Hodka, Zarpara villages. Banni area has 35,000 to 40,000 buffaloes. They are usually black and few (about 5%) are brown, which are good milk yielder. Built medium to large, morphologically these buffaloes have distinct coiling of the horn, which is aligned vertically to the body and coils inwardly. The animals are wedge-shaped with heavy backs and are maintained under (almost) zero input system. Their age at first calving is 3 to 4 years; dry period, 1 to 1.5 months; lactation length, 10 to 10.5 months; calving interval, 14 months; average daily milk yield, 10 kg, and fat in milk, 7-8%.

***Sonadi:*** These sheep are medium to large in size. Average body weight, body length, height at wither and chest girth of rams and ewes were 42.2 and 29.7 kg, 72.6 and 64.3 cm, 74.1 and 66.3 cm, and 81.7 and 73.9 cm respectively. The face is white or light brown, and this colour may extend up to neck. Ears are small to medium in length. Both the sexes are polled. The tail is thin and

of medium length. Body is covered with white, open and coarse fleece.

***Nali:*** The Nali sheep is found in Ganganagar, Churu and Jhunjhunu districts of Rajasthan, and southern parts of Hisar district of Haryana. The animals are medium in size. The average body weight, length, height at wither, chest girth were 38.85 kg, 68.95cm, 69.16 cm and 80.03 cm, respectively, in males, and 31.38 kg, 64.17 cm, 64.39cm and 75.95 cm in females. The face is light brown and the skin is pink. Both sexes are polled, ears are medium and tubular, tail is short to medium and thin, fleece is white, coarse and dense, and wool is of reasonably good carpet quality. Age at first breeding in males ranged between 12–18 months with a breeding life of 5–6 years. In ewes, age at first lambing ranged between 18–24 months. The lambing rate was about 80% and lambing interval 12–18 months. An ewe produced 4–8 lambs in its lifetime. The Nali sheep are maintained for mutton and wool production. Average greasy wool production was about 1.5–2.0 kg per annum in 2–3 clips.

Sonadi sheep

Sirohi goats are reared for milk and meat purpose

Kutchi goats

***Sirohi:*** Sirohi goats are found in the Sirohi, Ajmer, Chitorgarh, Rajsmand and Udaipur districts of Rajasthan and the adjacent districts of Gujarat state. The animals are reared for milk and meat purpose. Three types of colour variants, viz. brown spots, brown spots but with white patch on the face and uniform light brown, were observed. The estimated average means of body height, body length, chest girth (cm) and body weights (kg) were 77.62, 77.14, 77.62 and 43.05, respectively, in adult males, and 75.52, 75.81, 76.37 and 38.35 in adult females. Polled animals are present in Devgarh area of Rajasmand district. The flock size varies from 10 to 100. Animals are kept on pasture grazing; stall fed animals are rarely seen. Females show maturity at about 12 to 18 months of age. The breeding seasons are March–April and September–October. Kidding is once in a year. Twining is only in well fed goats (10–20%). Milk yield varies from 0.5 to 2.0 kg.

***Kutchi:*** These goats are found in the villages of Banaskantha, Patan and Kutch districts of Gujarat state. Kutchi goats are of medium size and are uniformly black with shinny light grey skin. Nose is slightly Roman. Muzzle, eyelids and hoofs are black. Eye pupil is brown. Horns are small (2 cm) to long (30 cm), corkscrew type, greyish black and curved upward. Ears are pendulous, small (4 cm) to long (24 cm) and black. Ears with white spots or white base are also seen. Forehead is convex with curly tuft hair particularly in male. The average body weight of male and female goats were 44.57 and 35.58 kg, respectively. They mature at 12 months of age. Twinning is 20%, however, with supplementary feeding it increases up to 50%.

***Marwari:*** Marwari horses constitute an elite group of indigenous horses, which are known for their sturdiness, swiftness, elegance and beauty. The phenptypic characters of Marwari breed were established. True-to-breed Marwari horses (114) comprising 98 mares and 16 stallions from 7 different locations were evaluated.

***Ankamali:*** This pig derives its name from the Ankamali block in the Ernakulum district of Kerala. These pigs are also

Ankamali pigs are suitable for backyard pig farming

found in Karnataka, Tamil Nadu, parts of Maharashtra and Andhra Pradesh. They are raised in backyard on kitchen waste and other agricultural and industrial byproducts. They are black often with white patches. They possess a long face, tapering towards the nostrils and bulging can be clearly seen at the joints of the jaw. Their body is medium sized and compact with pot belly as compared to exotic pigs. The hair on the neck and part of the back are thick, long and bristle but those on the sides and the flank are thinner and shorter. Head and shoulder are heavier as compared to hindquarters, back is slightly arched and rump is dropping. Tail is thin and long. Females possess 6–12 teats. Males are generally heavier than the females. The average litter size at birth is 8.0 and litter size at weaning is 5.0. The average age of slaughter is 9 months. Normally pigs over 40 kg are sold for slaughter. The dressing percentage is 68.

**Molecular genetic characterization of indigenous breeds**

***Cattle and buffalo:*** At the IVRI Izatnagar, molecular characterization of cattle and buffalo breeds was undertaken.

- Polymerase chain reaction – restriction fragment length polymorphism (PCR-RFLP) studies in cattle breeds (Jersey, Sahiwal, Hariana and Tharparkar), crossbred cattle (Holstein Friesian × Hariana) and buffalo breeds (Murrah, Bhadawari and Mehsana) with *Hae* III and *Rsa* I, revealed that the MHC class I gene is highly polymorphic in studied cattle and buffalo populations.
- Alleles (17) selected on the basis of PCR-RFLP and single stranded conformational polymorphism (SSCP) were cloned and sequenced for the characterization of MHC class I gene in 3 buffalo breeds (Murrah, Mehsana and Bhadawari) and indigenous (Sahiwal) and crossbred (Holstein Friesian × Hariana) cattle.
- Crossbred cattle calves with certain genotypes showed better cell-mediated immune responses suggesting thereby that the calves of these genotypes might respond well to the natural infection with *Brucella* organisms.
- A fragment of insulin like growth factor binding protein 3 (IGFBP3) gene was of 654 bp size in Surti buffaloes, as compared to 655 bp in Murrah and Bhadawari breeds, which may be used as breed specific marker of Surti breed.
- A 280 bp amplified product of insulin like growth factor 1 (IGF1) gene was found to be polymorphic in goats and monomorphic in buffaloes by PCR-RFLP, SSCP and sequencing techniques.
- The cDNAs of integrin beta 2 (ITGB2) gene of buffalo were cloned and sequenced.
- RAPD-PCR analysis of buffalo DNA, based on 20 primer sequences revealed that 11 to 35% polymorphism obtained in buffalo

**Tho-Tho cattle**

This cattle breed is distributed in nearly all the districts of Nagaland state. The breed is also known as Ameshi, Sheapi, Chokru, Tseso etc. They are reared primarily for meat and dung production and occasionally for milk by all the major tribes of Nagaland. The animals have social importance to Naga tribes particularly for dowry and other tribal rituals. Free-range system without any supplementary feeding is followed. However, farmers offer common salt to their animals once in a week. During non-cultivating season (December to March), animals are left free for grazing and do not return to their homestead. During cultivating season (April to November), animals are grazed during day time and are brought back for night. Natural breeding is practised. The animals are very hardy and believed to be disease resistant. However, sporadic cases of FMD, tick infestation and gastro-intestinal nematodiasis are reported. In adult animals body length, height and heart girth ranged from 99 to 109 cm, 114 to 117 cm, and 139 to 147 cm, respectively. The milk production is 0.5 to 1.0 litre/day, lactation length 3 to 4 months, age at first calving 3 to 4 years, service period 60 days, calving interval around 1 year, life span 15–16 years, and lifetime production is 8–10 calves.

Major tribes of Nagaland rear Tho Tho cattle

genome was able to segregate the high and low service period animals with 39% dissimilarity by cluster analysis. However, sub-groups of animals with high and low age at first calving could not be segregated by RAPD-PCR analysis. Some SSR sequences were able to show 44% dissimilarity in DNA band patterns of high and low milk producing buffaloes.

***Yak:*** The molecular genetics work was initiated, and the random amplified polymorphic DNA (RAPD) assay, using 10 random decamer oligonucleotide primers, was conducted to study the genetic similarities and divergence among five types (Common, Bisonian, Bareback, White forehead and Hairy forehead) of Indian yaks.

***Sonadi***: Microsatellite analysis of Sonadi sheep with 15 FAO (USA) proposed ovine specific microsatellites exhibited wide range of genetic variability depicted by allele number varying from 3 to 9, observed heterozygosity from 0.181 to 0.956, expected heterozygosity from 0.275 to 0.851, and polymorphism information content (PIC) from 0.252 to 0.809. In addition various average genetic variability measures, viz. allele diversity (5.8), observed heterozygosity (0.567), and gene diversity (0.667) showed high genetic variability in Sonadi sheep.

***Marwari:*** The microsatellite based molecular genetic profile of Marwari sheep displayed a high level of genetic variation. The observed alleles, effective alleles, observed heterozygosity, expected heterozygosity and polymorphism information content (PIC) values were estimated.

**Kenguri, Bellary, Bandur and Hassan sheep:** Genetic characterization of these sheep breeds by using the microsatellite markers revealed that the effective number of alleles was lesser than the observed number of alleles. The mean observed heterozygosity was significantly lower compared to expected heterozygosity. The average PIC values were 0.70±0.03, 0.66±0.03, 0.63±0.04 and 0.66±0.04 in these populations.

***Biotecnological studies on* Fec*B gene:*** The *FecB* mutation was analyzed in Garole × Malpura (GM) cross (144), out of which 14 were homozygous (*Fec*$B^{BB}$), 89 heterozygous (*Fec*$B^{B+}$) and 41 non-carriers (*Fec*$B^{++}$). Malpura, Marwari and Bharat Merino were found non-carriers for *Fec*B mutation. Twinning in Malpura (42), Marwari (20) and Bharat Merino (20) was not found linked with *Fec*B gene.

***Barbari:*** The number of alleles observed varied from 2 to 10 with an overall mean of 5.542 ± 2.167. The average expected gene diversity within the population ranged from 0.171 to 0.814 with an overall mean of 0.584±0.191. Eleven loci showed significant heterozygote deficiency in the Barbari goat population.

***Jamunapari:*** Genetic analysis at 23 microsatellite loci revealed substantial genetic variation. Average polymorphism and expected gene diversity in the population were 1.066±0.510 and 0.528±0.237, respectively. Population showed fairly high level of inbreeding (f = 0.189±0.049) and global heterozygote deficit.

**Mewari camel**

The Mewari breed is one of the important indigenous breeds of camel, commonly found in South Rajasthan and adjoining Malwa area of Madhya Pradesh. This breed is not being maintained at any farm of the central/state government. A survey was, therefore, conducted and the breed was characterized in the breeding tract itself. The major breeding tract of the breed encompasses Udaipur, Chittorgarh, Rajsamand districts in Rajasthan and adjoining Neemuch and Mandsour districts of Madhya Pradesh. The breed can also be seen in Bhilwara, Banswara, Dungarpur districts and Hadoti region of Rajasthan, which can be considered as a minor breeding tract of the breed. The tract consists of hills of the Aravali in Mewar area. The population of Mewari breed is about 0.025 millions (based on 1997 livestock census, Government of Rajasthan) in the major breeding tract.

Mewari camels are stouter and slightly shorter than Bikaneri. They have strong hindquarters, heavy legs, hard and thick foot pads. They are well adapted to travel and carry loads across hills. The body hair are coarse, which protect them from the bites of wild honeybees and insects. The body colour varies from light brown to dark brown but some animals are almost white, such variation in body colour is generally not seen in other breeds of camel. The head is heavy, set on a thick neck. Unlike the Bikaneri camel, the Mewari camel has no 'stop', but its muzzle is loose. Ears are thick and short, set well apart, tail is long and thick. In females the milk vein is prominent and the udder is well developed.

***Attapady:*** Genotypic characterization of Attappady goats revealed high level of genetic variability depicted by wide range of Levene's and Nei's expected heterozygosity values, PIC estimates and mean number of alleles. Observed heterozygosity average (0.546), mean expected heterozygosity (Levene's 0.616, Nei's 0.609) implied a higher genetic variability within breed.

***Bhutia:*** These horses are bred and reared for riding as well as pack purposes all along the Tibetan border and the sub-Himalayan tract from Punjab to Darjeeling. The genetic characterization using 25 microsatellite markers showed that the mean observed and effective numbers of alleles at all loci were 5.64 and 4.62 respectively. The mean observed and expected heterozygosity at these loci was 0.56 ± 0.07 and 0.79 ± 0.05 respectively.

***Marwari:*** Molecular characterisation of these horses was attempted using 26 polymorphic microsatellite markers, known in exotic breeds of horses. Of these, 3 markers were monomorphic in Marwari horses. DNA polymorphism studies revealed high level of heterozygosity and low level of heterozygosity deficit in Marwari horse population, which reflect high genetic variability in Marwari equine population that can be exploited by horse breeders for planning breeding strategies for its conservation. The present

Marwari equine population did not reveal any recent bottleneck, which is very informative and important for equine breeders. To conserve the germplasm of Marwari, technique for cryopreservation of semen of Marwari stallions was standardized.

***Bikaneri, Jaisalmeri and Kachcchi camel:*** DNA samples from Bikaneri, Jaisalmeri and Kachchhi camel breeds were analysed for allelic status at 8 microsatellite licu. The annealing temperature and PCR amplification was optimized for 18 primer pairs. Microsatellite loci, viz. VOLP 32, LCA 37, LCA 23 LCA 77 and CVRL 08, were found monomorphic in indigenous camel breeds. The primer CVRL 07 amplified polymorphic band in 3 Indian breeds. The allele size ranged from 272 to 305 bp. The observed and expected heterozygosities in the Bikaneri, Jaisalmeri and Kachchhi breed were 0.792, 0.4, 0.727 and 0.545, 0.64, 0.731 respectively. The PIC ranged from 0.518 to 0.686. At CVRL 05 locus 4 alleles each were amplified in the size range of 174 to 155 bp in Bikaneri and Jaisalmeri camel and 3 in Kachchhi camels. The observed and expected heterozygosity in Bikaner, Jaisalmeri and Kachchhi breeds was 0.55, 0.57, 0.615 and 0.670, 0.536, 0.522 respectively. The PIC ranged from 0.404 to 0.611.

***Molecular cloning, characterization and promoter analysis of the camel milk protein gene(s):*** The a-lactalbumin gene promoter fragment was amplified using camel genomic DNA as template. Polymerase chain reaction gave a clean band of about 880 bp. The PCR product was characterized. Results of Hae III digestion differed from that of the Arabian alpha lactalbumin promoter sequence. The gel pattern of *Hae* III digestion showed 4 bands. The Arabian alpha lactalbumin promoter sequence contains only two restriction site for *Hae* III but our Indian camel population showed 3 restriction sites for the same promoter. Therefore, it can be said that the promoter sequence of Indian camel population has an additional *Hae* III restriction site at about 450 bp. Hence it can be said that the amplified sequence is of a-lactalbumin gene promoter but with polymorphism for *Hae* III.

***Ankleshwar:*** The number of alleles observed across the microsatellite loci studied, varied from 4 to 11 with an overall mean of 6.44 in Ankleshwar poultry. PIC indicated the high polymorphism across the loci with an overall mean of 0.623. The average expected gene diversity ranged from 0.304 to 0.843 with an overall mean of 0.670. Genetic bottleneck was absent in the past population of Ankleshwar poultry.

***Punjab Brown****:* Microsatellite loci, evenly distributed throughout the poultry genome, were used for generating the data for inferring population genetic parameters. The average number of alleles are 8.05 and average effective number of alleles 4.34. The average expected and observed heterozygosity are 0.74 and 0.61 respectively; and population is in Hardy-Weinberg Proportions in approximately 50% of the loci studied. The mode shift test revealed that the population has not experienced any genetic bottleneck in the last few generations.

**Genetic diversity in Indian goats**

Indian goats make up 20% of the world's goat population. Indian subcontinent contains 20 well-characterized goat breeds, which vary in their genetic potential for the production of milk, meat and fibre, disease resistance, heat tolerance, and fecundity. The molecular characterization of Indian goats from different geographic regions was done by using mtDNA sequence data from the HVRI region, and diversity and differentiation analysis by microsatellite marker. The first analysis of Indian goat mtDNA diversity in 10 breeds revealed significant genetic structure among them. Two novel additional lineages, D and E, were observed, showing that considerable additional diversity exists within Indian domestic goats. All the examined domestic goat lineages fall in single monophyletic group that was distinct from available wild goat sequences. The lineages contributing to domestic goats were, therefore, derived from unknown population that may now be rare or extinct. Further investigations of wild goats and archaeological specimens are therefore needed to investigate these ancestors. Genotypic data from 17 microsatellites were used to assess genetic diversity and relationship among 8 Indian goat breeds. The highest observed heterozygosities were observed in Jakhrana goats. The phylogenetic tree and the plot for principal component analysis grouped the Indian goats according to their geographic origin and distances between populations were significantly different from each other.

Considerable additional diversity exists within Indian domestic goats

***Genetic selection and breeding for better performance in specialized naked neck male and female broiler population:*** Two naked neck pure broiler strains having naked neck gene (NNWP and NNCP) have undergone specialized selection programmes over a period of 10 generations. The fertility percentage was 82.2% and hatchability on FES (fertile egg set) was 77.5 in

NNWP. Corresponding values in NNCP were 81.9 and 76.8. The selection criterion in NNWP and NNCP was primarily based on the high 5-week body weight in last 2 generations. The selection criterion in earlier generations was mainly high 6-week body weight. The superiority of juvenile body weights of naked neck over normal broilers at different ages was observed in this generation in both the populations. The combined naked neck birds (homozygous + heterozygous) showed superiority over normal progeny in both lines for dressing percentage and cut-up-parts. The naked neck birds of both the strains, further exhibited superiority for less feathers and abdominal fat at 6 weeks of age.

***Genetic characterization and improvement of colour broiler lines:*** At the PDP, Hyderabad, PB-1 and PB-2 synthetic pureline broiler populations have been maintained for production of a multi-colour commercial broiler for intensive farming. In the S-14 generation of male line, age at sexual maturity, egg weight at 32 and 40 weeks and egg production up to 40 weeks of age were 154.6 days, 54.8 g, 59.8 g and 63.3 eggs, respectively. The corresponding values for the same traits in the S-14 generation of female line were 151 days, 52.5 g, 58.0 g and 65.4 eggs, respectively. The next generation of both the lines were reproduced. Selection differential for 5-week body weight was 165.7 and 109.7 g with an intensity of selection of 1.16 and 1.31 σ, respectively, in the male and female lines. The fertility and hatchability on total and fertile eggs set were 72.7, 62.8 and 86.4%, respectively. The primary trait (5-week body weight) in S-15 generation was improved by 26.6 g over previous generation in male line while it remained unchanged in female line. For assessing the genetic gain in these lines, a control line was maintained.

***Naked neck (Na) and dwarf gene (dw) lines for use in tropical poultry production:*** Two distinct populations carrying naked neck and dwarf genes in broiler background were maintained for use as a resource population in tropical broiler breeding programmes. In NG-03 generation of naked neck line, the average fertility and hatchability on total and fertile eggs set were 83, 61 and 74%, respectively. The average 6-week body weight was 917 g with selection differential of 175.2 g and intensity of selection of 1.15 σ. The age at maturity, egg weight at 28, 32 and 40-week, and 40-week egg production were 171.8 days, 54.4 g, 57.5 g, 62.3 g and 51.8 eggs, respectively. In DG-03 generation of dwarf line, the corresponding values were 162.3 d, 49 g, 51.3 g, 55.8 g and 57.1 eggs, respectively. The average 6-week body weight was 601 g with a selection differential of 85.2 g, and intensity of selection was 0.78 σ.

***Genetic selection for immune response in naked neck population:*** In broiler pure lines, direct or indirect selection of resistant strains, general immunocompetance and marker assisted selection, are being considered as promising breeding strategies against a number of infectious diseases each with different initiations.

Initial results of the study on the antibody response to Newcastle disease (ND) vaccine at 14, 28 and 42 days of post vaccination, showed that among fixed effects, hatch and genotype were significant at 14, 28 and 42 days of age for vaccine response. No significant difference between sex was observed.

**Genetic characterization of wildlife**

Work on molecular genetic characterization of wildlife species was initiated at the IVRI, Izatnagar. Partial mitochondrial 12S rRNA genes of peacock (*Pavo cristatus*), Indian wolf (*Canis lupus lupus*), hog deer (*Axis porcinus*) and Himalayan musk deer (*Moschus chrysogaster*) have been cloned and sequenced. The wolf 12S rRNA sequence exhibited 100% homology with that of dog. The peacock and poultry (*Gallus domesticus*) sequences were not similar, indicating potential use of PCR – RFLP to differentiate these species.

**Transgenesis and reconstitution of poultry species**

***Using* ex-vivo *embryo culture system*:** The chick has been used as a model system since the beginning of development biology and the ability to make the transgenic modifications/ reconstitution of the endangered poultry species, would be a useful tool for these studies. Understanding basic development of the chick has relevance to both medical and poultry science research. Following hatching observations were recorded in embryo culture system of chicken:

(i) Orientation of embryo during 20–21 days of incubation – majority of embryos were positioned on left (49.48) followed by dorsal surface uppermost (23.71), right side (21.65), ventral surface upper most (3.09), and vertical (2.06).

(ii) Membrane penetration – almost 82.47% embryos penetrated the membrane, 12.37% embryos failed to penetrate the membrane and 5.15% were in dropped condition.

(iii) Out of total embryos hatched, 65.97% had regular breathing, 22.68% irregular/infrequent breathing, 7.21% had shallow breathing and 4.13% had rapid breathing. No breathing, vocalizing, deep, and gasping were absent during 20 to 21 days of incubation.

(iv) Chorioallantoic membrane was found becoming detached in 43.29%, followed by well-attached-to-shell (31.95%), poorly attached (20.61%), and slight hemorrhage at shell (4.12%); and high-up-shell and pulse visible conditions were not observed.

(v) Maximum number of embryos (70.10%) in EC-system showed none visible urates followed by a little (15.46%), some (10.30%) and a lot (4.12%).

(vi) Embryos exhibited no yolk sac in 41.23%, followed by

34.02% of about 1 $cm^2$ visible, about 2 $cm^2$ visible 12.37%, more than 2 $cm^2$ visible 10.30%, connecting yolk sac 2.06%, and zero percentage to either side of embryos.

(vii) Climax activity (45.36%), followed by some activity (40.20%), activity of legs (5.15%), head activity (3.09%), and 2.06% each of rapid burst, body and no activity.

(viii) Right feet or legs were visible in 49.48% followed by visibility of left feet or legs (21.64%), neither feet/legs visible (19.58%), feet/leg between head and shell (8.24%) and both feet/leg visible (1.03%).

(ix) Dry allantoic fluid was revealed in 49.48% followed by moist (28.86%), wet (10.30%), very wet (4.12%), milky (1.03%), clear (2.06%) and yellow allantoic fluid (4.12%).

(x) In embryo culture system maximum number of embryos showed horizontal position of beak (45.36%) followed by beak down and not visible (19.58%), beak up (15.45%), feet over beak (7.21%), beak under thigh (6.18%), beak towards shell (4.12%), beak under yolk (1.03%), and body head down (1.03%).

(xi) Comparative embryonic development at various stages of incubation in *ex-vivo* embryo culture and normally incubated eggs, revealed that only embryo culture system can provide the opportunity to see the development of same embryo continuously each and everyday, during complete incubation period.

In quails semi-quantitative RT-PCR method revealed that myostatin gene expression was at lower levels from E2 to E6 stage of broiler embryo. At E7 stage, highest expression was observed in breast muscles, whereas, liver and brain showed lower expression. Heart did not show myostatin mRNA expression at E7 stage. At day 9, all the organs showed myostatin expression but higher levels of expression were observed in leg and breast muscles and intestine. From E12 to E18 stage the expression of myostatin lowered in all the tissues. One of the siRNA synthesized by *in vitro* transcription was used for transfection in primary CEF. The negative control without siRNAs were also kept. The transfected cells showed marked morphological differences like rounding, aggregation and vacuoles formation from that of control cells from 18 hr onwards.

In G3 generation of immunodivergent lines of layer, HA titre differed between lines whereas the serum lysozyme and IgG levels did not. The genetic diversity between divergent lines was estimated as 0.04±0.02 by RAPD-PCR technique.

The overall mean for SRBC response ($log_2$ titre), CMI (% thickness), serum lysozyme (g/ml) and IgG (mg/ml) levels were studied in immunodivergent broiler lines. The heritability estimates of respective traits were 0.10±0.05, 0.44±0.17, 0.06±0.04 and 0.09±0.05. The candidate genes, viz. BL-ßII, IFN-γ, IL-2 promoters, IL-2 R γ chain genes and TGF-ß3 were analysed. PCR-RFLP of IFN-γ with *Tsp* I enzyme showed genotypes AB and BB. *MnlI* PCR-RFLP of IL-2 promoter showed genotypes AA, AB and BB. IFN-γ gene promoter (669 bp) was cloned in pGEMT vector. Amino acid sequences of IL-2 exons of SDL were also analysed. Kinetic and differential expression of iNOS, MIP-1ß, IL-2 and IFN-γ genes by RT-PCR and real time PCR were studied in HCMI and LCMI lines. Vaccine response to ND vaccine and MTT assay showed higher values for HCMI compared to LCMI lines. Among different divergent immune response lines, average Newcastle disease (ND) vaccine responses were higher in HSRBC and HCMI lines.

Random genomic differences between Red jungle fowl (RJF) and *desi* fowl were detected using RAPD, MASA and microsatellite markers. In general RJF showed less genetic similarity with other chicken breeds. A 448 bp fragment from 12S rRNA gene was amplified in RJF using universal primers and sequenced. It showed 99% homology with chicken sequences whereas 91% with other avian species including Green jungle fowl.

A resource population was developed for MHC characterization in guinea fowl. A 234 bp fragment and one 277 bp fragment was amplified using 2 separate sets of chicken specific primers. From AJ 2.1 clone, a 700 bp fragment having exon 2, intron 2 and exon 3 of BL ßII gene was eluted and biotin labeled is to be used as probe.

### *Ex-situ* conservation

Frozen semen doses of cattle (Kangayam, Punganur, Hariana, Amritmahal, Tharparkar, Dangi, Sahiwal, Gir), buffalo (Bhadawari, Tarai, Surti, Murrah), goat (Chegu, Black Bengal), sheep (Garole) and camel (Jaisalmeri) are being maintained in genebank for posterity.

### Network Project on Animal Genetic Resources

***Khillar:*** The Khillar cattle are distributed in Satara, Sangali and Solapur districts of Maharashtra, and 48.9% farmers reared Khillar cattle. Average number of cattle was 2.85 per household. Most of farmers fed unchaffed green (98%) and dry (96%) fodder. Farmers (42%) used groundnut-cake, cottonseed-cake, and ready-made feeds available in market.

***Gangatiri:*** The Gangatiri cattle are distributed in Varanasi, Chandauli, Ghazipur and Ballia districts of Uttar Pradesh and Bhabhua (Kaimoor), Buxar, Arrah and Chhapra districts of Bihar. Majority of the livestock owners (34.1%) have large land holding (>7.5 acres) followed by marginal (30.5%) and landless (19.5%). Only 16.4% of the cattle owners grow fodder. The general practice is to house the animals during night (86.81%) and allow them to graze during day.

***Surti:*** In Kheda, Vadodra and Bharuch districts Surti buffaloes

Gangatiri cattle

Bonpala sheep

were 20.6, 30 and 56.1% of total livestock population, respectively. Majority of the buffalo owners (82 to 97%) were landless or small land holders having up to 5 acres of land. The Bharuch district has more tribal population. More than 95% of females and 70 to 80% of males are engaged in dairy business. The animal sheds are generally *kutcha* and open-walled. Breeding through AI is more common in Kheda and Vadodra districts.

***Bonpala:*** Banpala sheep population estimate of nearly 1,671 was far less compared to the census figure of 5,530 sheep (Livestock census, Sikkim, 2004-05). The flocks remain healthy even without any vaccination or deworming, probably due to isolation and agro-climatic conditions. Common ailments include diarrhoea and minor wounds. The ewe can sustain only one lamb because of low milk production. They are sheared twice a year. The ban on

Chhotanagpuri sheep

Coimbatore sheep

forest grazing is forcing the sheep-owners to adopt the alternative sources of livelihood. It may cause a serious threat to Bonpala sheep and also to the yak and Siri cattle of Sikkim.

***Chhotanagpuri:*** These sheep are maintained primarily for mutton and the wool, which is coarse, open and hairy. They are maintained on extensive grazing without any supplementary feeding. Chhotanagpuri sheep are of small size. with black, brown or white coat colour. Males are horned and females are polled. The body is covered with coarse and open fleece. Head, belly and legs are devoid of wool. Lambing rate is about 120–140%. Wool production ranges from 400 to 600 g/adult/annum. Most animals suffered with coccidiosis, amphistomiasis, trichuris and bursate. The incidence of amphistoms was least in Ranchi district and highest in West-Singhbhum.

***Coimbtore:*** These sheep are reared mainly by Kurumba gounder, a shepherd community. Most flocks are migratory and some are stationary. The animals are maintained on grazing without any supplementation. Sheep are penned in harvested fields. They are medium size with black or brown head and white body. In many

Rampur Busbair sheep

animals the colour extends up to the shoulder. Some animals with black or brown spots in the head were also recorded. Ears are medium size and horizontally oriented. Rams are both horned and polled while ewes are hornless. The fleece is generally white, coarse and open. Most flocks practise selective breeding. The breed is primarily maintained for mutton and there is little income from wool.

***Mandya:*** These sheep have roman nose, hanging wattles, light brown head and neck, dwarf and stocky body, well projected shoulder and chest cavity with well sprung up thoracic ribs, and uniform top-line. Evenly placed short and stumpy legs and wide apart hipbones indicated a square type meaty conformation of the breed. Sheep are mainly kept on grazing, however, a few farmers keep the animals on stall-feeding. Some of the farmers practise sheep tethering in their cropland, shifting from place to place and bringing back to their homestead in the evening.

***Rampur Bushair:*** The breeding tract of Rampur Bushair sheep falls under varied climate from cold desert Himalaya to low lying Shivalik hills. These are primarily reared for wool and mutton purposes, and are also used as pack animals. Animals are predominantly brown followed by brown/white and white. The majority of animals are horned. The horns are curved. Average flock size ranged between 20–1,000 in migratory flocks and 2–20 in stationary flocks. Migration may take place from the permanent or temporary abode in the valley to the alpine pastures during summer only and to the foothills and plains in the winter. The flocks are primarily grazed on alpine pasture during summer, and on the harvested fields, forest areas, uncultivated fallow and barren lands during winter. Tree leaves and pods of fodder trees constitute an important feed resource during winter and early spring. The wool is coarse/carpet type. The lamb wool is fine and is used to manufacture tweeds of which, especially brown fetches higher price.

***Ganjam:*** The Gola community rears Ganjam goats. The goats are reared in range system and stay in jungles throughout

Ganjam goat

Mehsana goat

the year. They solely depend on natural vegetation and no supplementary feed is given. Flock size ranges between 700–1,000. The male kids (9–12 months-old) and aged females are sold at regular intervals. Kids up to 3 months are allowed to suckle the mother. Animals are black and brown however, admixture of white, brown and black are also seen. The major source of income is from sale of male kids (9–12 months), milk and ghee and the manuring of the farmers' fields.

***Mehsana:*** This goat breed is found in Banaskantha, Patan and Mehsana districts, its adjoining areas, and is mainly reared by *Rabaries* and *Vaghris* communities for milk and meat. Mehsana goats constituted 35.2% of total goat population in these districts. The male and female ratio is 1 : 17. Mehsana goats are mostly maintained on zero input under extensive production system. The farmers adopted both open (49.0%) and closed (11.7%) types of housing, and practise goat breeding in summer (May–July) only.


Nagori cattle


Rathi cattle


Kangayam cattle


Pandharpuri buffalo

### *Genetic characterization*

***Ponwar cattle:*** Analysis of DNA with a battery of microsatellite markers revealed polymorphism at all microsatellite loci. Observed and effective number of alleles varied from 3 to 10 and 1.8 to 6.2, respectively. Mean number of observed and effective alleles was 5.9±1.7 and 3.4±1.2, respectively. Observed and expected heterozygosity ranged from 0.194 to 0.8, and from 0.45 to 0.85 with the mean of 0.497±0.176 and 0.682±0.113, respectively. The results reflect substantial genetic variability in Ponwar cattle.

***Kherigarh cattle:*** All microsatellite loci were polymorphic. Observed and effective number of alleles varied. Mean number of observed and effective alleles was 6.2±1.7 and 3.7±1.2, respectively. Observed and expected heterozygosity ranged from 0.260 to 0.808, and from 0.49 to 0.86 with the mean of 0.574±0.131 and 0.717±0.090, respectively. The average observed hetrozygosity was lesser than the expected. The average expected gene diversity (Nei 1973) within the population ranged from 0.489 to 0.845 with an overall mean of 0.709±0.090. Bottleneck test indicated that the population had not undergone bottleneck at least in the recent past.

### In-situ *conservation*

***Tharparkar cattle:*** Elite Tharparkar cattle (73) were selected in Jaisalmer district. Bull calves (24) of more than 1 year of age were registered. The selection criteria were true-to-the breed characteristics, good health and dam's yield.


Tharparkar cattle

***Toda buffalo:*** Their calves (20) were purchased and maintained at the University farm. The young bulls were given training on semen collection.

***Magra:*** The selected ewes were reared under feeding and management practices. Elite ram-lambs (54) were selected on the basis of yearling body weight, dam's wool yield, wool yield of the individual, general health status and overall performance.

***Spiti horse:*** Elite female animals (58) were selected from different villages. Out of the total male progeny born, 6 were selected and registered.

### Ex-situ *conservation*

Male calves and bulls of Nagori, Rathi, Kangyam cattle and Pandharpuri buffaloes were purchased. They were vaccinated against common diseases and trained for semen donation.

- Farm and year of calving, affect age at first calving, highest milk yield 300 days, peak yield etc. in Frieswal cattle
- Under field progeny testing programme the decreasing trend in age of calving of Frieswal daughters born from first to fourth set of bulls was observed
- Wet average, herd average and 300 day milk yield in Nili Ravi buffalo showed improvement
- Higher twinning was observed in Marwari sheep
- Jamunapari goat had 39.9% multiple birth with 1.42% kidding rate
- Barbari goats showed marked increase in body weight at 12 months, milk yield at 90 days and kidding rate
- Pigs having lean meat with 60–70% less fat compared to Large White Yorkshire breed, were produced
- Egg production up to 40 weeks of age was highest in CARI-Sonali
- Age at sexual maturity declined in desirable direction in poultry
- Body weight of broiler at 5 weeks of age increased over previous generations
- Shank length and antibody titre showed improvement in Vanraja bird
- Improved varieties of fowls were evaluated in different localities

### Cattle

***Frieswal:*** The total population of Frieswal females at 43 Military Farms of the country was 17,099 (860 adult cows, 5,850 young stock and 1,389 calves).

The overall mean of milk yield 300 days was 3,038.7 kg. The effects of farm, parity, season and year of calving and age at first calving (AFC) were significant on milk yield in 300 days (MY300 days). Frieswal cows at Mhow produced (3,884.3 kg) the highest MY300. The average MY300 in first lactation was 2,622.1 kg. The cows attained the highest MY300 in sixth lactation (3,177.4 kg). Peak yield (PY) averaged 14.82 kg, and farm, parity, season and year of calving and AFC affected it significantly. Average lactation length (LL) was 319.1 days, and farm, parity and season and year of calving and AFC affected it significantly. The overall mean of AFC was 990.0 days, and farm, season and year of birth affected it significantly. The simple average of weight at first calving (WFC) was 375.7 kg, and farms, season and year of birth, and AFC affected it significantly.

### *Indigenous breeds*

***Hariana:*** The female herd strength was 1,176. The breeding population contained 808 female and 12 breeding bulls with the overall conception rate of 61%. The per cent cows in milk, wet average per day per cow and herd average per day were 39.10%, 4.24 kg and 1.73 kg, respectively. Young bulls put to training took on an average 35.88±1.78 days to be ready for draught purposes. The mean fatigue score for empty cart ranged between 2.20 and 2.90 after 2 hr work and 2.75 and 3.15 after 3 hr work. In cart with 8 q load, the corresponding values were 3.10 and 3.60 and 3.90 and 4.35, respectively. Average carting ability (as per C.K. Thomas method) was 18.34.

***Ongole:*** The female herd strength was 1,360. The breeding population comprised 914 females and 5 breeding bulls The conception rate was the highest (66.81%) at associated herd, Lam, followed by at GP Unit, Lam (56.90%), and was the lowest at associated herd, Chintaldevi (33.60%). The per cent cows in milk, wet average per day per cow and herd average per day were 35.66%, 3.18 kg and 1.13 kg, respectively. The age at first calving averaged 50.08 months. The average lactation milk yield and peak yield was 402.6 and 2.59 kg. The overall average of service period and lactation length were 254.4 and 181.5 days, respectively. Their superiority over the herd average ranged between 18.71 and 29.41 kg (3.47 to 5.45%). Draught studies were undertaken on 10 animals by using single harness plough with digital dynamometer. Draught power varied from 0.68 to 0.86 hp among the bulls.

### *Field progeny testing*

The genetic improvement through field progeny testing of Frieswal cattle is being carried out at three units.

***PAU unit:*** So far 81 bulls have been used in 4 different batches. During this year semen from fifth set of 22 crossbred bulls was used, and 5,530 inseminations were carried out. The conception rate was 40.5% and 2,063 pregnancies were confirmed. Daughters (624) from first 4 sets have completed their first lactation (305 days) with average yield of 2,697.8 (2,254 to 3,001 kg), 2,827 (2,397 to 3,265 kg), 2,829 (1,710 to 3,406 kg) and 2,905 (2,111 to 3,509 kg) kg, respectively, indicating considerable variation in the breeding values of the bulls used in these sets.

Frieswal cow—Milk yield of a cow at Mhow was recorded as 3.884.3 kg in 300 days

The average fat percentage of daughters of first, second, third and fourth set of bulls was 3.7, 3.8, 3.9 and 3.9 respectively. The average age at first calving of daughters born from four sets of bulls was 1,192, 1,145, 1,117 and 981 days respectively.

***KAU unit:*** The overall conception rate in 5 batchs was 32%, and 401 female calves have been born. Daughters (759) from first 4 sets of bulls have completed their first lactation (305 days) record and the average yield observed was 2,079, 2,903, 2,074 and 2,226 kg respectively, indicating the superiority of the progeny over the other animals in the field born from other sources. The average age at first calving of daughters born from first, second, third and fourth set of bulls was 1,110, 1,024, 1,280 and 1,031.3 days respectively. The average fat percentage in the second, fifth and eighth month of lactation was of 3.8, 3.9 and 4.0%.

***BAIF unit***: During the year 4,751 inseminations were performed, 3,806 inseminations were followed for pregnancy diagnosis and 1,631 pregnancies were confirmed. The average conception rate of this batch was 42.85%. Out of 20 sires under test, 4 sires recorded conception rate above 45%, and of 10 ranged from 41 to 45%. The average age at first calving was 32.29 months with average lactation yield of 2,748 kg.

### *Buffalo*

The Murrah is the most important milch buffalo breed with its home tract in central parts of Haryana. At the CIRB, Hisar, a herd of Murrah buffaloes is being maintained for progeny testing programme and to make available progeny tested superior bulls for buffalo farmers of the country. The wet average of Murrah herd at the institute was 6.30 kg while herd average was 4.65 kg.

### *Network Project on Buffalo Improvement*

Under this project, the ninth set of breeding bulls – originating from nominated matings with elite females – is being tested currently. In addition, field progeny testing has also been initiated to increase accuracy of selection. The top ranking bull in the institute herd in the second set showed sire index of 1,987.4 kg. Doses of frozen semen from progeny tested bulls are available at various centres under the project, and total stock of frozen semen from Murrah bulls at the institute is over 285,000.

Progeny testing programme for Nili Ravi breed is being undertaken at Sub Campus of the institute at Nabha. The wet average, herd average and 300 day milk yields were 6.86, 4.65 and 1,848 kg, respectively, with improvement of 17.1, 35.6 and 26.0% as compared to values in 1992–93. Similarly, age at first calving and calving interval also showed significant improvements – over 10% each.

Elite herds of Jaffarabadi, Surti, Bhadawari, Pandharpuri, Godavari and Swamp buffaloes have also been established at the respective centres under Network Project. Average 305 days or less lactation yield in Jaffarabadi buffaloes was recorded as 2,069, while in Pandharpuri 1,687 kg, Surti 1,633 kg, Godavari 2,540 kg, Bhadawari 1,029 kg and in swamp buffaloes 496 kg.

## Sheep

### *Sheep for fine wool*

***Carpet wool:*** The Magra breed is considered to be the best indigenous carpet wool producing sheep. Their body weight at birth, 3, 6, 9 and 12 month were 3.10, 16.95, 22.68, 26.32 and 28.37 kg, respectively. The tupping, lambing on available and

Hariana cow and bull

tupped basis were 97.6, 69.5 and 71.2%. Fibre diametre, hetro fibres, medullation percentage, staple length and crimp showed an increase.

At the Arid Region Campus Bikaner, Marwari sheep – a breed, which is preferred by migratory farmers for its hardiness – showed weight at birth, 3, 6, 9 and 12 month as 3.24, 16.30, 22.00, 26.46 and 28.19 kg, respectively.

***Dual purpose sheep:*** Genetic improvement in Bharat Merino were aimed to develop it as a dual purpose (mutton and wool) sheep. At Avikanagar, body weights at birth, 3, 6, and 12 months of age were 3.11, 14.79, 22.62 and 27.23 kg respectively. The overall survivability was 90.12%. Culling was 13.92%. The tupping and lambing percentage on the basis of ewes available were 91.18 and 80.64. Tupping% was 88. Overall mortality was 7.06%. The average fibre diameter was 23.24 µ, medullation was lesser than 1%, and the average staple length was 8.1 cm in the annual clip. At North temperate Research Station, Garsa, Himachal Pradesh, the body weighs at 3, 6, 9 and 12 months of age were 12.15,19.62, 21.53 and 25.09 kg respectively.

**Goat**

***Genetic improvement in goats in field and farm conditions:*** Genetic improvement of Jamunapari goat is being carried out through selective breeding in the nucleus flock. Use of bucks selected on the basis of index value (combining 9-month body weight and 90 day's milk yield of dam) indicated improvement in both milk yield and body weight. The mean body weights at birth, 3, 6, 9 and 12 months of age were 3.37±0.03, 11.59±0.10, 16.49±0.22, 22.42±0.29 and 28.44±0.33 kg, respectively. The improvement in body weight at 9 and 12 months of age were 38.22 and 39.96% more over the years. The kids under feedlot weighed 21.84±0.43, 32.67±0.53 and 38.88±0.44 kg at 6, 9 and 12 months of age, respectively. Improvement in 90 and 140 days milk yield was recorded as 88.85 and 82.0%, respectively, over the years. This breed is prolific as apparent from 39.9% multiple births with 1.42 kidding rate. The heritability estimates for body weight at birth, 3, 6, 9 and 12 months of age were 0.37±0.09, 0.24±0.08, 0.18±0.07, 0.23±0.08 and 0.26±0.08, respectively. Genetic and phenotypic correlations among adjacent body weights were high.

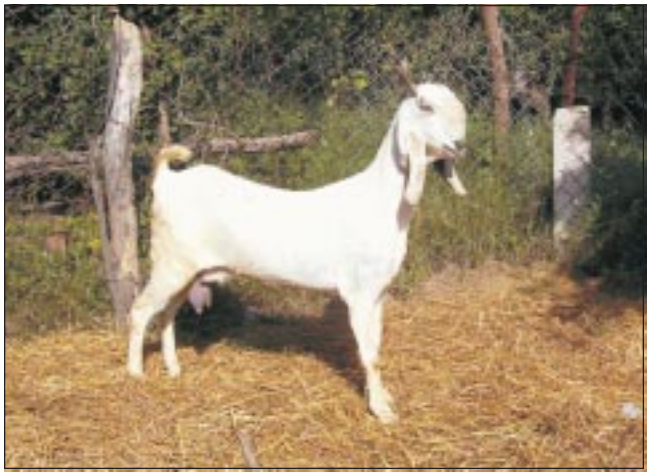
Similar approach for improvement of Barbari breed yielded encouraging results. Body weight at 12 months has recorded about 18.46% increase in growth rate over the years. The milk yield at 90 days showed about 63.96% increase over the years. The kidding rate was about 1.61 indicating highest population growths in Barbari goats. Study conducted on Jakhrana goats, a milch breed of Rajasthan revealed 37.21% multiple birth. Body weights of adult male and female were 43.84 and 68.72 kg, respectively. And 140 days milk production was recorded as 81.72 kg.

A field study, undertaken in the home tract of Zalawadi goats

**Jamunapari goats**

The home tract of Jamunapari goats, the Chakarnagar area (Chambal ravine) of Uttar Pradesh, is known for its natural biodiversity. Improvement programme is being carried out by the CIRG in 2 adopted villages. The observation regarding population dynamics, growth parameter, milk yield, kidding pattern, disease occurrence have been recorded. The socio-economic and parasitic characterization of field condition indicated that goat rearing was an integral part of the livelihood of locals. Body weight, milk yield, and reproductive performance were recorded. The milk production in 90 days of lactation was 105.05 kg and body weight at 9 month of age was 25.40±0.36 kg, which indicated increasing trend over the years.

Jamunapari goat at field conditions



Jamunapari goat

in Surendra Nagar district of Gujarat, indicated that goats were mostly reared by *Robanes* and *Bharwal* (nomadic tribes) communities locally called *Maldhary* under extensive system of management. Zalawadi is a large size, black colour goat with spiral horn. The average flock size ranged from 13 to 71. The peak milk yield was observed as 2.25 kg and lactation length ranged from 5 to 7 months. Ratio of buck to adult doe was 1:80. This breed is prolific. Farmers were suggested to select bucks considering breed phenotypes, height, weight and dam's milk yield, and does on the basis of breed phenotype, milk yield, udder size and teat length and height.

**Rabbit**

At the NTRS, Garsa, the German Angora rabbits were being improved. The average annual wool yield of general and breeding flocks was 817.27 and 928.92 g, respectively. The respective performance for GA progeny flock is 483.5 g. Females had shown a general tendency to yield higher wool as compared to their respective male counterparts. The average annual wool yield of adult general flocks of BA, RA and A1-cross are 495.83, 454.39 and 423.39 g, respectively. At the SRRC, Mannavanur, body weight at 12 weeks was 1.741 and 1.776 kg in WG and SC, respectively.

**Pig**

Besides developing infrastructural base for the NRC on Pigs, a base line survey was carried out to document the existing status of pig production in the 8 states of North East including Sikkim.

***All India Coordinated Research Project on Pigs:*** Crossbred pigs were produced at centres of the AICRP on Pigs, with increasing level of exotic inheritance up to 87.5%. At the Assam Agricultural University, Khanapara, and IVRI campus, Izatnagar, production of crossbreds (indigenous × landrace) was continued, and at Jabalpur, Tirupati, Katupakkam, Mannuthy and Goa centres crossbreds between indigenous and Large White Yorkshire were produced. At the Mannuthy centre, Kerala Duroc breed was used as the terminal sire over the crossbred between indigenous and Large White Yorkshire (75%) so as to produce lean meat with 60–70% less fat compared to LWY breed. All the centres resorted to *inter-se* mating either with 75% or with 87.5% genetic groups to study the stability level.

**Camel**

The overall calving was 92.86%, with Bikaneri 91.67%, Jaisalmeri 90% and Kachchhi 100%. The conception rate was 85.11% which is better than the previous five years performance. The continuous selection, change in mating system and procurement of good males in time from the breeding tract brought this improvement. The lowest age at first conception was observed in Kachchhi (1,728.88±151.07 days) followed by Bikaneri (1,764.57±70.25 days) and Jaisalmeri (1,897.07±110.33 days). A large SE in Jaisalmeri and Kachchhi suggests the scope for improvement. The age at first calving was 2,184.48±83.22 days. The average of first gestation period was 393.64 days and that of subsequent gestations 385.88 days.

**Poultry**

***Poultry for egg***

In layers, significant genetic responses for 40 weeks of egg production was observed as 0.99±0.18 and 0.75±0.19 eggs per generation in IWH and IWI strains, respectively. Among crossbreds, the egg production up to 40 weeks of age was highest (108.72 eggs) in CARI-Sonali followed by 104.5 eggs in CARI-Priya and 80.73 eggs in CARI-Debendra. The mean egg weight at 40th week of age ranged from 51.9 to 55.1 g in different lines. The fertility in RIR stocks ranged from 88.1 to 91.9%, and hatchability ranged from 64.8 to 73.5%. Genetic responses of 1.02±0.19 eggs and 63.9±10.8 g of egg mass per generation at 40th week were highly significant.

***Poultry for meat***

In broiler, overall average body weights at 3 and 5 weeks in colour synthetic male line (CSML) were 567.86±1.64 and 1,054.65±3.40 g, respectively. The estimates of heritability for 3- and 5-week body weight were 0.19±0.04 and 0.24±0.05, respectively, in CSML. The genetic and phenotypic response for 5-week body weight in CSML and synthetic male line (SML) were 24.64±4.66 and 36.81±6.56 g per generation, respectively. Fertility percentages were 78.3 and 81.0 in colour synthetic female line (CSFL) and synthetic dam line (SDL), respectively. The corresponding percentages of hatchability (FES) were 89.0 and 83.1. The overall average of body weight at 3 and 5 weeks in CSFL were 538.50±1.48 and

A pair of colour broiler line

1,040.48±3.05 g, respectively. The corresponding means in SDL were 482.57±3.89 and 1,072.39±5.07 g, respectively. The estimates of heritability for 3-and 5-week body weights were 0.16±0.03 and 0.21±0.03 for CSFL, and 0.18±0.04 and 0.26±0.05 for SDL. Genetic and phenotypic responses for 5-week body weight in CSFL line were 27.87±3.01 and 40.05±5.58 g/generation, respectively. Fertility percentage in IC3, IR3 and CARIBRO-Tropicana were 76.2, 89.1 and 68.7, respectively. The mean body weights at 3 and 5 weeks of age in CARIBRO-Tropicana, IC3 and IR3 were 449.10±3.44 and 873.46±6.39 g, 293.65±4.10 and 614.35±6.32 g, and 367.76±4.14 and 709.27±8.03 g, respectively.

### All India Coordinated Research Project on Poultry Breeding

#### *Poultry for eggs*

Under the AICRP on Poultry Breeding, 6 layer strains of White Leghorn were subjected to selective breeding through intra-population selection for egg production up to 64 weeks of age, superimposed with independent culling level for egg weight at 28 weeks of age and layer house viability. At the KAU, Mannuthy, the part period egg production of IWN and IWP strains ($S_{21}$ generation) up to 40 and 64 weeks of age increased over previous generation. The 40-week egg weight in both the strains improved marginally over preceding generation. The fertility and hatchability in IWN improved in the present generation. At the AAU, Anand, the egg production up to 64 and 72 weeks and egg mass production up to 72 weeks of age in IWN and IWP strains, showed improvement. The fertility and hatchability in IWH, IWI and control population ($S_{27}$ generation) at the CARI, Izatnagar, improved over the preceding generation. The egg production up to 40 weeks of age increased in IWH (by 4 eggs) and IWI (by 11 eggs) over previous generation.

**Management of costal agro–eco system affected by super cyclone in Orissa**

The Regional Centre of CARI has been allotted an NATP research project under the costal agro ecosystem for rehabilitatation of the super cyclone affected families by introducing poultry as a source of income generation. The high yielding birds developed at the CARI were distributed among 2,300 farm families and ducks among 400 families.

The dual-purpose bird CARI-Devendra developed by crossing between synthetic colour broiler as male and RIR as female line were distributed in the costal super cyclone affected families in 13 villages. Similarly Gram Priya and Vanaraja chicks were also distributed. The centre with full technical support monitors the performance of these crosses. Most of the affected families earned Rs 1,000–2,000 either by sale of eggs or as meat bird or chicks.

- The rapid growth of this bird helped the poor schedule cast families in the rehabilitation and regeneration of their lost livestock.
- The growth performance and production of these crosses are far better than the native birds available in these areas.
- The work and achievement of the NATP project is very encouraging as the adapted farmers are able to regenerate their own stock using these high yielding birds with the help of native hens for regular income generation.

Vanaraja male line parents

Vanaraja female line parents

**SUCCESS STORY**

**Household poultry farming in Manipur**

A newspaper hawker, Shri Shyam Kumar Singh of Shamushang village, Imphal West District maintained a small Vanaraja unit. Initially, he started with 20 birds (5 males and 15 females). The unit was improved to retain 90–100 adult hens with 20–25 cockerels. His annual income was Rs 18,000 from his primary profession of newspaper sales. His family has his mother, two children and wife. He made low cost shelter and feed for Vanaraja birds. In 2004, he disposed 15 cockerels and earned Rs 3,035. He regenerated 273 straight run chicks, and the males weighed 2.44 kg and the females 1.76 kg, at 17 weeks of age. The process of multiplication and disposal of birds continued and he earned Rs 9,427. He is being seen as an achiever of rural poultry farming in the region.

Vanaraja rearing in Manipur —a joy for whole family

The age at sexual maturity declined in desirable direction on genetic scale to the tune of 0.58 and 0.37 days in IWH and IWI strains, respectively. The egg production up to 40 weeks of age in HI strain cross (104.5 eggs) increased over the preceding generation at this centre. The fertility and hatchability in IWD ($S_{25}$) and IWF ($S_{24}$) lines at the ANGRAU, Hyderabad, improved over previous generation. The egg production up to 40 weeks of age in IWD (115 eggs) and in IWF (117 eggs) improved over the last generation. The phenotypic response (for 5 generations) for egg production up to 64 weeks of age (primary trait) in IWD was 5.83 and in IWF 4.91. The genetic response (for 5 generations) of this trait in IWD was 2.40, and in IWF 1.48.

**Random Sample Poultry Performance Test**

The IBL-80 of the PAU, performed best with 6-week-body weight of 1,540 g and of 7-week body weight 1,972 g; corresponding feed conversion efficiencies of 2.19 and 2.26, respectively, and dressing percentage 74.7%, at Random Sample Poultry Performance Test, Gurgaon.

Pureline White Leghorn populations, viz. IWH, IWI and IWK, are being maintained and selected at the PD on Poultry, Hyderabad, for part period egg production to 64 weeks of age following Osborne Index with independent culling level selection for egg weight at 28 weeks of age. The IWK and IWI lines produced 3.3 and 7.3 more eggs to 40 weeks of age over previous generation. The egg weight at 40 weeks of age for IWH and IWK lines increased by 0.7 and 1.0 g over the preceding generation, respectively. The HI (IWH × IWI) cross was superior to IH (IWI × IWH) cross and laid 270 eggs up to 72 weeks of age.

### *Poultry for meat*

This component of AICRP on Poultry Breeding included colour synthetic broiler lines (CSML) and CSFL and corresponding control at CARI, Izatnagar; SDL at OUAT, Bhubaneshwar; PB-2 at PAU, Ludhiana, and UAS, Bangalore. Mass selection for 5-week body weight with due weightage for conformation traits in the male line and 5-week body weight, egg production and hatchability in the female lines have been continued to achieve the set target in the meat stocks. The mean body weight at 5 weeks of age in PB-2 and control lines in $S_{10}$ generation at the UAS, Bangalore, was 1,003 g and 853 g, respectively. Feed conversion ratio up to 5 weeks of age was 2.01 in PB-2 and 2.04 in control line. The body weight at 5 weeks of age increased by 66 g over preceding generation. The average body weight at 5 weeks of age in PB-2 and control lines in the present generation was 824 and 703 g, respectively, at the PAU, Ludhiana centre. The corresponding feed

Gramapriya chicken scavanging in rural backyard

A pair of Dahlem-Red line

### Free-range household poultry farming in NEH region

The activity of free-range poultry farming with low input costs was initiated in Manipur, Mizoram, Nagaland and Arunachal Pradesh under NATP, and its impact over 5 years was evaluated. PD on Poultry supplied fertile eggs and day-old chicks of Vanaraja germplasm to the centres located in these states.

In Manipur, the adult females weighed 2,190 and 2,800 g at 20 and 40 weeks of age, respectively. They matured between 164 and 178 days of age, and on an average produced 2.8 eggs/week. A sample study conducted in Manipur over 64 beneficiaries in 18 locations showed that 440 surplus adults were sold for meat purposes and earned Rs 76,010 @ Rs173/bird. Also, the beneficiaries multiplied chicks on their own. Similarly, in Nagaland 337 families reared and multiplied Vanaraja birds for domestic purpose. A perceptible increase in egg and poultry meat consumption was noticed after the introduction of family poultry farming in the pockets of Nagaland. In Arunachal Pradesh, the adult females matured between 172 and 187 days of age and produced 3.3 eggs/week/bird. Surplus males and females were disposed to earn supplementary income of Rs 86,662 @ Rs 224/bird. Similar trend was also witnessed in Mizoram.

efficiency was 2.18 and 2.56 in PB-2 and control lines, respectively.

The genetic and phenotypic responses for 5-week body weight were positive and significant for SDL population at the OUAT centre. The feed conversion ratio up to 5 weeks of age was 1.94 in this population (SDL) in $S_{10}$ generation. The body weight at 5 weeks of age in CSML (1,054.65) and CSFL (1,040 g) in the present generation was improved by 16.7 g and 20.5 g, respectively. The genetic and phenotypic responses for 5-week body weight (for last 4 generations) were 24.6 and 36.8 g in CSML and 27.9 and 40.1 g in CSFL lines, respectively, in $C_4$ generation at the CARI, Izatnagar centre. The development of purebred dwarf dam line was undertaken at the JNKVV, Jabalpur. The dwarfing gene line

Krishibro—multicolour broiler chicks

was subjected to mass selection for 6-week body weight. Also, egg production and hatchability were considered for improvement in this population. A colour dwarf line was also maintained at this centre. An improvement of 22 g was observed in 6-week body weight in the white dwarf line during the $G_6$ generation. An improvement of 1.9 and 1.0 eggs in white and colour dwarf lines, respectively, was observed over previous generation.

**Rural poultry production**

***Development of lines for production of germplasm suitable for rural and tribal areas:*** A colour line was used at the PD on Poultry, to develop male line for production of Vanaraja, a dual-purpose germplasm for rural poultry production. Selection was practiced for shank length and antibody titre, the desired traits. In $S_6$ generation, age at sexual maturity, body weight at 20 and 40 weeks of age, egg weight at 28, 32 and 40 weeks and egg production up to 40 weeks of age were 172.5 days, 2,134 g, 2,734 g, 49.8 g, 52.6 g, 54.3 g and 43 eggs, respectively.

A multi-colour plumage population is being improved as female line of Vanaraja. In $S_4$ generation of female line, the age at sexual maturity, body weight at 20 and 40 weeks of age, egg weight at 32 and 40 weeks and egg production up to 40 weeks of age were 153.9 days, 2,306 g, 2,543 g, 52.3 g, 53 g and 61.1 eggs, respectively. During juvenile stage, due weightage was given for antibody titre, shank length and plumage colour. During $S_5$ generation, body weight at 4 and 6 weeks of age were 382 and 727 g, respectively. Shank length and antibody titre showed an improvement of 0.5 mm and 0.16 ($\log_2$ value), respectively, over the preceding generation, which was desirable to ensure better survivability in the harsh environment of rural areas. The average intensity of selection for shank length and antibody titre was 0.26 and 0.73 $\sigma$. The heritability was low to moderate for body weight at 4 and 6 weeks of age and low for shank length and antibody titre.

***Tinted egg layer for backyard poultry farming:*** Dahlem Red line was utilized as female line for production of Gramapriya, which is a layer variety developed by the PD on Poultry, for backyard poultry production. It has completed 3 generations of selection for part period egg mass. In $S_3$ generation, age at sexual maturity, body weight at 20 and 40 weeks of age, egg weight at 28, 32 and 40 weeks of age and egg number up to 40 weeks of age were 178 d, 1,176 g, 1,855 g, 51.3 g, 53.9 g, 56.1 g and 79.6 eggs, respectively.

***Rural poultry germplasm evaluated at Agartala:*** At the ICAR Research Complex for NEH Region, Agartala, testing of various germplasm developed for augmenting rural poultry production in the region under AICRP on Poultry Breeding, was continued. Krishna J, developed at the JNKVV, Jabalpur, and Gramapriya, developed at PD on Poultry, Hyderabad, were evaluated.

Fertile eggs of Gramapriya and Krishna J were hatched and reared at the Institute farm up to 12 weeks of age. The body weight of Krishna J at Institute's farm was higher than that at under farmers' field. Body weight of Gramapriya was higher compared to Krishna J under both the management systems.

***Backyard poultry:*** In indigenous fowl, the highest fertility (81.0%) was observed for Aseel Kagar but hatchability (FES) was highest for CARI-Red (82.4%) among the purebreds. McNally, logistic curvilinear and Adams-Bell model were the best fit to describe egg production of Frizzle (F), F × CR and CR × F, respectively. For egg production curves of Kadakanath (Kn), Kn × CR and CR × Kn, the curvilinear logistic, monomolecular minus linear term, and logistic minus linear term, respectively, were best fit models with $R^2$ values of 91.6, 98.4 and 97.4%. The improved varieties of indigenous fowls developed for backyard poultry production were evaluated in different localities.

In general, the mission to promote free-range poultry farming at low input costs and an awareness of its utility for the household purpose was realized in these 4 NEH States. The families had access to eggs and chicken meat for consumption and for earning supplementary income through disposal of poultry produce.

### *Guinea fowl*

In guinea fowl, average body weights at 12 weeks of age were 861.25±5.32 g, 839.65±6.72 g and 826.25±3.19 g in Lavender, Pearl and White guinea fowl varieties, respectively.

### *Quail*

A new white plumaged phenotype of quail was developed for commercial exploitation. Homozygous (wh/wh) has white plumage with dark eye while heterozygous bears two-colour pattern known as Tuxedo.

- Immune response was assessed in sheep for early diagnosis of haemonchosis
- Suitable drug delivery system has to be developed to protect the allelochemicals of herb *Lawsonia inermis*
- *Babesia equi*-specific ELISA was developed
- Abortus bang ring test was found reliable to test brucellosis in mithun
- Matrix gene of Indian isolate of avian influenza virus (H9N2) was sequenced
- Several herbal medicines were tested
- Sensitive diagnostic techniques and effective vaccines were developed for IBD, rabies, turkey-pox, Ranikhet disease etc.
- In FMD type A the field situation demands a change in vaccine strains
- Complete nucleotide sequence of several Asia 1 field isolates were determined
- Indigenous staining technique for leptospira was developed

**Foot-and-mouth disease**

Field specimens (683) from different outbreaks in the country were examined and subjected to serotype confirmation by sandwich-ELISA using the direct materials. No virus could be detected in 317 sample, and from rest type O, A, and Asia 1 were detected. Outbreaks due to type O virus were recorded in 14 states, and types A and Asia 1 in 5 states. All the three serotypes were prevalent in Madhya Pradesh, West Bengal and Gujarat. Samples were processed for revival in cell culture (BHK-21) system and in 21 samples virus could be recovered comprising type O, Asia 1 and type A. The field isolates of type O and Asia 1 are antigenically related to the in-use vaccine strains in serological tests indicating that the vaccine strains are good enough to cover the circulating field isolates. However, in type A the field situation demands change of vaccine strains. Work in this direction indicates that IND 81/00 (reference strain of genotype VII) could be a candidate.

Molecular epidemiological analysis of type O virus indicates the hide- and-seek nature of Pan-Asia strains in the disease outbreaks. The type A field isolates had a deletion at $VP3^{59}$ and formed a separate cluster in the genotype VII. This novel genetic cluster was observed as early as November 2002 from the state of Assam (IND 24/03) and within 1 year it spread into 5 other states including Gujarat at the western and Karnataka at the Southern parts of India. In type Asia 1, the newly emerged viruses that were responsible for disease outbreaks in different states last year were involved in all the outbreaks of this year also, indicating the dominance of divergent group of virus. The complete nucleotide sequence of several type Asia 1 field isolates was determined. The tree topology of the individual genes was similar to that of the complete coding region or primary polyprotein cleavage products in isolation when used for an equivalent analysis. The identification of residues, positive selection of some of which are antigenically critical, made a beginning in the understanding of antigenic features of this serotype. The virus repository of the Project Directorate on FMD has 1,193 (O, Asia 1, A, C) field isolates.A multiplex-PCR (mPCR) for serotyping of FMD clinical samples developed earlier was further evaluated on clinical samples, and now it can be used as a backup test for ELISA for FMDV serotyping. Work was initiated to evaluate the potentiality of the expressed proteins in comparison to the whole virus particle in sandwich-ELISA. The expressed VP1 protein of type O was specific.

**Animal disease monitoring and surveillance**

Computer interface based diagnostic kits were developed for diagnosis of brucellosis and IBR antibody as per the standards of IAEA.

### National Animal Disease Referral Expert System

National disease database for the past 15 years and meteorological and agro-ecological data from all the agro-climatic zones of the country were compiled, as a part of National weather based animal disease forecasting. And forecasting for 14 animal diseases was made with 75 to 98% accuracy.

The outputs from NADRES would provide the following:

- GIS based animal health information system
- The livestock disease forecasting system
- Demarcation of country into eco-pathozones based on specific livestock diseases
- Livestock disease economics

National sero-epidemiological surveys for brucellosis and infectious bovine rhinotracheitis, showed an overall incidence of 18 and 51% respectively. Sero-epidemiological surveys in bluetongue and PPR were conducted based on stratified sampling framework, and their incidence showed an increasing trend. The sero-prevalence of bluetongue is to the extent of 51% and that of PPR 15.3%, and a further screening is under progress.

Isolates (599) of different serovars of leptospira are being maintained. *Leptospira* from an apparently normal elephant was isolated and its typing is in progress. At the ADMAS an indigenous staining technique was developed for leptospires, which is very useful even at field level. The prototype kit is being validated at field laboratories.

Online official software was developed for animal disease monitoring and forecasting. The stratified random survey revealed prevalence of nationally important animal diseases like IBR (25%), brucellosis (16.31%), PPR (10.78%), bluetongue (37%), CCPP (34%), swine fever (33%) etc.

**Gastro-intestinal parasitism**

Epizootiological studies revealed prevalence of GI nematodes infection in sheep, goat, cattle and buffalo in various districts of Uttaranchal, Himachal Pradesh, Uttar Pradesh, Haryana and Delhi. The prevalent infections were of *Haemonchus* sp., *Trichostrongylus* spp., *Oesphajostomum* spp., *Bunostomum* spp., and *Strongyloides* spp. in all the livestock, whereas *Cooperia* spp. in cattle and *Ostertagia* in sheep and goats were also recorded. In Rajasthan bioclimatograph was prepared for prediction of *H.contortus* and *Trichostrongylus* spp. infection in relation to meteorological factors. Software named FROGIN was developed for forecasting of haemonchosis in sheep for arid and semi arid zones**.** The software gives result as predicted faecal egg count (FEC) on start of the month, intensity of FEC for next 60 day and pasture level burden for the month which will be helpful to improve worm control scheme. In Tamil Nadu overall prevalence of GI nematode infection was 42.6% in sheep, goat, cattle, buffalo. In Madhya Pradesh and also in Chhattisgarh, epizootiological studies were conducted. *Haemonchus* spp. was predominant infection in cattle. In pigs prevalent infections were *Ascaris suum*, *Strongyloides* and *Schistosoma incognitum*. In the northern hills and plains of Chhattisgarh the strongyle infections were

**SUCCESS STORY**

### Effect of vitamin E supplementation

Dairy animals generally develop mastitis immediately after parturition because of reduced immuno-competence. Supplementation of vitamin E reduceed the incidence of both clinical as well as sub clinical mastitis leading to significant improvement in milk yield during first month of lactation (20–30%). The oxidative stability of milk produced from vitamin E supplemented cows also improved as compared to their control counterparts. Milk vitamin E content of vitamin E-supplemented animals was also higher. Retention of foetal membrane and metritis were less in vitamin E supplemented cows and buffaloes. It is recommended that cows and buffaloes should be daily supplemented with vitamin E @ 1,000 IU/head and 1,500 IU/head, respectively, from 30 days prepartum to 30 days postpartum. Daily dose of vitamin E supplementation for 60 days amounts to Rs 60 and 90 in cows and buffaloes, respectively. The technology is simple, cheap and cost effective, seeing the heavy losses (Rs 6,000 crores/annum) incurred due to mastitis in dairy animals, and needs to be propagated among dairy farmers.

**SUCCESS STORY**

### Liquid phase blocking ELISA for detection of antibodies in vaccinated animals

The liquid phase blocking ELISA (LPB ELISA) test was developed at the Project Directorate on Foot-and-mouth Disease (PD FMD), Mukteswar. It is a sensitive and specific serological test for determining the protective antibody levels in animals following vaccination. The LPB ELISA helps in determining the protective antibody levels in animals following vaccination by comparing the pre- (0 day) and post-vaccinated (21st day) sera from animals. The results (expressed as $\log_{10}$ antibody titre) are obtained within 24 hr and have replaced the more cumbersome serum neutralization test for determining the protective antibody levels in animals. A titre of $\log_{10}$ 2.1 indicates protection against homologous challenge i.e., challenge with virus, which is used for making the vaccine. However, protection against heterologous strains (field strains) will depend on the antigenic similarity between the field and vaccine strains. The test is being used by the regional centers of the PD FMD for measuring post vaccinal immune response in animals for the FMD control program of Government of India.

**Patents**

- Development of a process of preparing a bio-organomineral formulation for the therapy of skin ailments in animals
- A process for preparing an indigenous drug formulation for the treatment of diarrhoea in animals
- Development of a technology for an area specific mineral mixture to increase productivity of bovines i.e. milk yield and body weight in Uttar Pradesh State

prevalent in cattle and buffaloes. In Meghalya the GI parasitism showed increasing trend in cattle and decreasing trend in pig. In ducks the infection recorded in Assam were *Ascaridia galli*, *Strongyloides* spp., *Capillaria* spp., *Echinostome* spp, *Hymenolepis* spp. and *Rallietina* spp. In Sikkim prevalence of GI helminths was significantly more in subtropical and high humid zones. During summer and autumn infection rate was higher in goats followed by cattle and lowest in yak. In West Bengal prevalence of GI parasitism was higher in small ruminants (71.98%) than that in large ruminants (46.13%).

For early diagnosis of haemonchosis in sheep immune response was assessed with different antigens using different tests. In Western blotting, third week experimental post infection (PI) sera recognized 26, 60 and 120 kDa polypeptides whereas with the naturally infected sera only 60 and 120 kDa polypeptides were recognized. In affinity purified fraction 60 and 120 kDa polypeptides were detected in SDS-PAGE. In immunoprecipitation 26, 32, 60 and 120 kDa polypeptides were detected in excretory-secretory antigen (ES) by antibodies as early as first week PI. In dot-ELISA solid dot was formed on the nitrocellulose membrane with B-1 fraction and the antibodies against *H.contortus* were detected as early as first week PI. In dip stick-ELISA antibodies were detected in the sera as early as first week PI. In western blotting 152 kDa in *Oesophagostomum* spp. and 31 kDa in *Bunostomum* spp. were immunodominant. Dot-ELISA was standardized for detecting infection in goats and cattle. Immunization trials were conducted by using con-A H11 antigen. In lamb reduction in worm count was 77.5%, whereas egg count reduction was 85.1%. In the immunized animals the abomasum did not show lesions. SDS-PAGE of the gut protein of *Ascaris suum* revealed polypeptides ranging between 26 to 118 kDa. With DID antibodies in

**Technologies commercialized and MoU signed**

1. Development of an indigenous methodology: IVRI crystoscope as a field tool for determining optimum time for fertile insemination in animals
2. MoU was signed between institute and 2 private firms

Equiherpes ß-ELISA kit

hyperimmune serum raised against *Ascaris suum* gut protein showed precipitin line, which was also observed in countercurrent immuno-elecrtrophoresis indicating antigenic nature of protein. Anthelmintic resistance with fenbendazole and levamisole was recorded at Government Sheep Farm, Dim Chandi, Uttaranchal. Nematophagous fungi such as *Arthrobotyrus oligospora* were having excellent predatory activity against *Haemonchus* spp. larvae and could survive in gut environment.

**Haemorrhagic septicaemia**

Specimens, comprising 5 morbid materials, 56 sera samples and 154 cultures were received for isolation and confirmation of *Pasteurella*. Only 74 out of 154 cultures, were identified as *Pasteurella* on the basis of biochemical tests and PM-PCR assay. No isolation could be made from morbid material. A successful trial of low volume saponified HS vaccine was carried out in dairy cows. The animals were 100% protective at 9 months and 80% at 12 months of post vaccination against challenge using HS virulent culture. Combined vaccine prepared against HS and FMD was tested in calves. The animals were protective against both the antigens at 28 days of post vaccination on challenge test.

Molecular studies were conducted for identification and characterization of *Pasteurella multocida* isolates from various animals and avian species, by PM-PCR, HSB-PCR, multiplex-PCR, RAPD-PCR and REP-PCR. Outer membrane protein from *Pasteurella multocida* B:2 serotype, isolated and characterized by SDS-PAGE and Western blotting, revealed 2 major proteins of 32 kDa and 38 kDa, which were immunogenic in nature.

**Bluetongue (BT)**

BTV vaccine using BEI inactivated bluetongue virus serotype 1 adjuvanted with saponin yielded promising results in experimental sheep. Inactivated vaccines against BTV type 1 and 23 were prepared. Field trial conducted with type 1 vaccine produced good

humoral immune response. BTV serotype 23 (Bhopal isolate) and BTV serotype 2 were passaged in cell culture for attenuation. BTV-23 got attenuated while some more passages of type 2 were required for attenuation of the virus. The 56.43% serum samples of sheep, goat and cattle from Punjab, Himachal Pradesh, Rajasthan, Uttar Pradesh, Uttaranchal, Maharashtra and Gujarat were found positive for BT antibodies by cELISA and AGPT. One of the 164 blood samples from Gujarat and AP was positive for BTV in RT-PCR. Type specific primer for typing of new isolates of BTV was designed. No appreciable variation was observed in nucleotide sequences of Indian isolates and Australian isolate of BTV 23. Per cent homology of nucleotide sequence of M5 gene of BTV Indian serotypes was from 38.6 to 39.1 with AHSV1 and AHSV 9 and 53.4 with EHD. Indian BTV types are closely related to each other forming monophyletic group. Full length S7 gene of the isolates is 1,154 bp along with a single ORF of 1,050 bp. Typing of virus isolates was done at the typing centre and the virus isolates of type 1, 2, 15, 18 and 23 were submitted to the repository. Samples of midges were identified as *Culicoides oxystoma*. A model trapper/attractor was developed to capture midges.

**Animal health research in various livestock and poultry**

***Equine:*** A neutralizing monoclonal antibodies-based diagnostic kit Equi-herpes B-ELISA kit was developed. This kit tests the serum sample using single dilution (1:250) thus making it very economical. DNA fingerprinting of different EHV-1 strains revealed that more than one genetically variant strains of EHV-1 are circulating in equine population of Northern India. A patent application entitled "Neutralizing monoclonal antibody-based blocking ELISA diagnostic kit for detection of equine herpes virus-1 specific antibodies" is being submitted for getting Indian patent for this diagnostic kit.

Extracts from medicinal herb *Lawsonia inermis* were evaluated to develop a dry treatment of *Trypanosome evansi* infection of equines. The results indicated that the constituents of *L. inermis* responsible for trypanocidal activity *in vitro* might have been degraded *in vivo* system when administered by oral or intraperitoneal route. For *in vivo* activity, a suitable drug delivery system needs to be evaluated to protect the allelochemicals.

A sandwich-ELISA was standardized for rapid diagnosis of rotavirus-associated diarhoea. This ELISA was 100% sensitive and highly specific as compared to virus isolation and RNA-PAGE.

Equine piroplasmosis caused by *Babesia equi* is a serious problem of equines in India. To develop improved diagnostics for this ailment, a truncated gene segment of one of the merozoite surface proteins, EMA-2 of *B. equi* was expressed in *E. coli* and the expressed soluble GST fusion protein was purified. An ELISA was standardized using this recombinant protein as antigen. The assay quantitatively differentiated the reference positive and negative serum samples. The assay was specific in detecting *B. equi* antibodies only.

Molecular diagnostics were developed for EHV-1 and EHV-4 viruses, *Streptococcus equi* subspecies *equi* and *S. equi* subspecies *zooepidemicus* and trypanosomosis. Sandwich-ELISA was developed for diagnosis of equine rotavirus infection.

Active sero-surveillance was conducted in Maharashtra, Rajasthan, Chandigarh, Delhi, Gujarat, Haryana, Himachal Pradesh, Punjab, Tamil Nadu, Chhattisgarh, Uttar Pradesh and West Bengal. EHV-1 antibodies were detected in 2.05% samples, while *Babesia equi* sero-prevalence was detected in 21.80% serum samples tested. Samples tested for equine infectious anaemia, African horse sickness, glanders, brucellosis and *Salmonella* Abortus equi were not found positive.

***Cattle:*** The animals of the institute were screened for brucellosis using Rose Bengal Plate Test (RBPT) antigen and found that all samples were negative for the infection. The test was also compared with the positive serum.

***Mithun:*** Abortus Bang Ring Test (ABRT) was used to detect the presence of antibodies against *Brucella abortus* in mithun milk. During the investigation, 30.8% of the total screened animals were found positive for *Brucella abortus*. These positive cases were confirmed further through A-B ELISA test. The result indicated that ABRT is a reliable test for detecting brucellosis in mithun. The immune response of mithun vaccinated with commonly available cattle FMD vaccine was evaluated. Approximately 80% of the vaccinated mithuns had protective antibody levels against serotypes 'O'.

***Yak:*** An overall prevalence of trematode, cestode, nematode and *Eimeria* species recorded in yaks were 6.74, 9.03, 76.22 and

**Quality control and production of veterinary biologicals**

- A total of 270,000 doses of RD 'F' strain, 31,650 doses of lapinized swine fever vaccine, 149,310 ml of BPL-inactivated anti-rabies vaccine, 100,000 doses of tuberculin PPD, 10,000 doses of mallein PPD, 37,000 ml of *Brucella* agglutination test antigen, 3,960 ml of *Brucella abortus* Bang Ring antigen, 760 ml of Rose Bengal Plate Test antigen, 110 ml of *Brucella* positive serum, 2,000 ml of *Salmonella* Abortus equi 'H' antigen, 50 ml of *Salmonella* poly 'O' sera, 100 ml of S. Pullorum positive sera and 6,100 ml of S. Pullorum coloured antigen were produced and quality tested; 84,300 doses of tissue culture sheep-pox vaccine were tested for infectivity titre.
- Using FMD vaccine production technology in BHK-21 cell culture, 6.40 million doses of monovalent FMD vaccine were produced and 3.90 million doses of trivalent FMD vaccine were supplied.

35.07%, respectively, at Nyukmadung Farm. Prevalence of Neoascariasis in newly born calves has been identified as an emerging problem. *Parafilaria bovicola* and *Babesia bovis* in yak and its crossbreds were recorded for the first time. The ailing animals responded to the treatment.

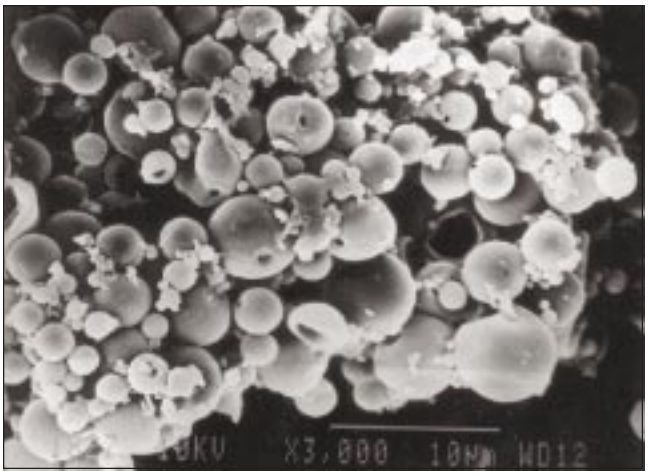
***Sheep:*** The data on health status of animals in breeding experiment showed that at Avikanagar, the breed-wise EADR was minimum in Malpura sheep (0.236) followed by Chokla (0.363), Bharat Merino (0.407), Garole × Malpura (0.532), Avikalin crosses (0.628), Avikalin (0.698) and Garole (1.722). The age-wise analysis revealed that EADR is inversely proportional to the age of animal. The major causes of mortality in adult flock were suppurative pneumonia, debility and JD. Among hogget and weaner major diseases encountered were toxaemia, suppurative pneumonia and urolothiasis. In sheep overall sero-prevalence of BT disease in farm flocks was 22.93%.

Period for higher prevalence of *Haemonchus contortus* and *Trichostrongylus* spp in population can be broadly predicted by the bio-climatograph. Studies on improvement of resistance to *Haemonchus contortus* showed that the susceptible progenies of Malpura breed had 3–5 times higher FEC (faecal egg count) compared to resistant progenies. Similarly in Avikalin breed the susceptible progenies had 2-4 times higher FEC values compared to resistant progenies.

At the ARC Bikaner, equivalent average morbidity rate (EAMR) was 0.1607 in Marwari and 0.20038 in Magra breed. The overall EAMR was 0.1559 (612 cases) per 1,000 animal days. The major clinical manifestations were pyrexia with haemorrhagic gastroenteritis (PPR) which occurred as an outbreak. The other manifestations were diarrhoea (16.3%), pneumonia (9.64%) and cases of general systemic state (8.49%). There were 12.90% cases of Johne's disease in Magra breed.

***Camel:*** *Trypanosoma evansi* isolated from camel were maintained in liquid nitrogen at –196°C under 12% (v/v) glycerol as cryoprotectant, for genetic homogeneity. On agarose gel (1.5%) electrophoresis a product range on first amplification revealed at 562 bp while on nested PCR using ITS-1 and intervening 5.8s, it comes around 500 bp. The sensitivity of all the reaction down to 1 to 10 parasites.

Faecal samples of farm herd camels were screened for different helminth parasites. The RAPD assay showed 6 distinct RAPD marker patterns ranging in size from 650 to 2000 base pairs with 2 different polymorphic patterns. Recovery of bacteria from more than 90% of the clinically infected quarters showed that in camel mastitis is mainly due to bacterial pathogens. Clots and flakes were found in the milk of the clinically infected quarters. Sodium concentration showed high increase in clinically infected camels but K concentration was almost same between milk of normal and clinically infected quarters.



Scanning electron micrograph showing PLG microspheres entrapped with combined RD&IBD virus (3000x)

***Rabbits:*** In rabbits at Avikanagar, the age-wise EADR ranged from 0.609 (adult) to 9.106 (weaner). Out of total necropsy, 73.6% belongs to weaners. Male rabbit had higher EADR (3.833) compared to female (2.966). Monthly EADR ranged from 0.148 (September) to 9.975 (March).

***Exotic diseases:*** The sequence encoding E2 gene of bovine viral diarrhoea virus has been expressed in *E. coli* as truncated recombinant protein using pTriEx expression system. The matrix gene of Indian isolate of avian influenza virus (H9N2) has been sequenced.

**Surgical and clinical interventions**

Polyglycolic acid proved to be a better suture material than silk. Cyanoacrylate adhesive produced stronger bonding between urethral incised surfaces than fibrin glue. The role of ultrasound therapy was established in the treatment of hindquarter weakness, abdominal wall defects, arthritis and delayed fracture healing in rabbits and canines as one of the substitutes to conventional therapy. Acupuncture therapy was useful in the treatment of hindquarter weakness and posterior paresis in canines and caprines. The modified technique of interlocking nailing was successful in fixation of fractures in dogs with osteopenic bones. Attachable magnetic field stimulator was designed, assembled and tested for electromagnetic characteristics. Modified DS formulation with additional 'K' constituent was effective in clinical cases of diarrhoea in adult sheep and goats. Parental fluid containing sodium acetate as the alkalizing agent was the most effective low cost treatment in severe acidosis associated with calf diarrhoea. Parental fluid with sodium L-lactate was equally effective albeit higher cost. Nimesulide was found to be a more potent uterine relaxant *in vitro* indicating its potential use in abortion in goats.

## Development and improvement of diagnostics and vaccines

### *Diagnostics*

Dot-ELISA was developed for quick diagnosis of PPR infection in small ruminants. A rapid, highly specific and antigen capture RT/PCR was standardized and developed for the detection of PPR using the cell culture adopted PPR virus. Nested RT-PCR technique was quite effective for diagnosis of classical swine fever in field/tissue samples. Nested RT-PCR primers targeted to highly conserved UTR were used efficiently for detection of infectious bronchitis virus isolates. ELISA was found quite sensitive for diagnosis of paratuberculosis in sheep and goats. Duplex PCR was found promising for confirmation of *Mycobacterium a. paratuberculosis* isolates in bovines. PCR assay was used to detect and differentiate the *Mycoplasma mycoides* subsp. *mycoides* type SC (MmmSC), the causative agent of CBPP, from the MmmLC and Mmc organisms. ELISA using purified F2, H2, cysteine proteases and/or metacercarial antigens was found useful to detect fasciolosis under field conditions in cattle and buffaloes. Good correlation between IFAT, dot-ELISA and PCR-assays in diagnosis of *Babesia bigemina* infection in bovine calves was observed. Duplex-PCR was found reliable for detection of *Aeromonas* from foods with rapidity, sensitivity and specificity. The PCR of 29 kDa gene was found useful for the molecular diagnosis of avian-pox virus infection in scabs and lymphocytes of the infected birds.

### *Vaccines*

Live attenuated goat-pox vaccine conferred complete protection up to 1 year post-immunization in goats, and the vaccine was safe in pregnant animals at the recommended field dose ($10^2$ $TCID_{50}$). Foot-and-mouth disease cell culture-based vaccine using a metabolisable lipid emulsion adjuvant, elicited good antibody response in vaccinated cattle under experimental conditions. Naked DNA-based vaccines developed against rabies, canine parvovirus, infectious bursal disease (IBD) and inclusion body hepatitis (IBH/FAV4) were evaluated for their potential to generate protective immunity in experimental animals. Encouraging results were obtained in preliminary trials. Rabies glycoprotein gene and canine parvovirus VP2 gene were expressed in bicistronic expression (pIQEX) system. The combined vaccine was safe and potent when tested in dogs. Infectious bursal disease VP2 gene and exon gene of FAV4 (inclusion body hepatitis) based DNA vaccines gave encouraging results when used alone and/or in combination in chickens. Turkey-pox virus passaged in chicken embryos (25 passages) and CEF cell culture (40 passages) showed good protective index in chicks against challenge with virulent virus at second and eighth week post-

#### Herbal medicines

- *In vitro* trials on aqueous extracts of *Jamun* bark revealed reduction in goat-pox virus concentration by 4 log units.
- Alcoholic extract of *Tinospora cordifolia* (*Golie*), *Curcuma longa* (*Haldi*), *Withiania somnifera* (*Ashwagandha*) or juice of *Allium sativum* (garlic) either alone or in combination reduced the lead burden from the blood, liver and kidney, and lead-induced lipid peroxidation in the liver and kidney when tested in rats.
- *Tinospora cordifolia* and *Withania somnifera* (*Ashwagandha*) reduced the cadmium burden from liver and kidney in rats.
- Methanolic extract of *Curcuma longa* (*Haldi*) and aqueous extract of *Emblica officinalis* (Amla) exhibited 63% and 56% antibacterial activity, respectively, against bovine mastitis caused by *Staphylococcus aureus, Streptococcus agalactiae* and coliform bacilli.

#### Development of an area specific mineral mixture for the livestock of Uttaranchal and Uttar Pradesh

Deficiency of essential minerals in soil vis-à-vis feeds and fodder adversely affects the health and productivity of livestock which thrive on these feeds and fodder. Consequently, the farmers face recurring economic losses, despite availability of adequate but unbalanced feed. Extensive survey in Uttar Pradesh and Uttaranchal, on the status of various essential dietary minerals in the soil, feeds and fodder and livestock (blood/serum) revealed that the feeds and fodder grown on these soils were mainly deficient in phosphorus, zinc, copper and iodine followed by calcium, magnesium, cobalt and selenium of variable intensity. Most of the cattle and buffaloes of these 2 states suffered from composite mineral deficiencies evidenced by low production, reproductive and other clinical disorders, low blood/serum levels of several essential dietary minerals, etc. Supplementation of mineral mixture, formulated for a specific area, in diets of growing and lacting crossbred cattle and buffaloes for 90 days, significantly increased the growth rate and daily average milk yield, as compared to non-supplemented group. The area-specific mineral mixture formulations are being successfully commercialized.

Lactating cow suffering from hypocalcemia showing lateral kinking of neck, characteristic of milk fever

**Detoxified *Karanj* cake as protein substitute for economic mutton production**

*Karanj*-cake, left as residue after oil extraction is hitherto wasted. Its 45 lakh trees have annual production potential of 13 lakh MT of seeds from various parts of India, that could be utilized as a protein source for mutton production. Its use as animal feed is restricted due to the presence of toxic karanjin, a furanoflavonoid.

The growth rate, feed conversion efficiency, digestibility and retention of nutrients in lambs fed on diet containing water washed SKC (replacing 50% soybean-meal) in the concentrate mixture were comparable with that of control having soybean-meal as protein supplement. Significant clinical manifestations were not observed in terms of blood biochemical and enzyme profile as well as, immune response and rumen fermentation pattern in lambs fed diet containing water washed SKC. The dressing percentage and yield of primal cuts were comparable among lambs fed control and water washed SKC diets. No untoward taste or odour was imparted to the meat due to SKC feeding. Neither pathological lesions in different vital organs nor bone abnormalities could be noticed due to feeding of water washed SKC. The feed cost of unit meat production and live weight gain (kg) was reduced by Rs 19.83 and 6.83%, respectively, because of feeding of water washed SKC.

inoculation, respectively. The PLG microsphere based Ranikhet disease (F) vaccine provided good humoral and cell- mediated immunity including mucosal IgA antibody response and afforded protection against virus challenge up to 70% till sixth week post-immunization in poultry. The PLG microsphere based combined (Ranikhet disease + infectious bursal disease) vaccine afforded 60% protection against RD as well as, moderate resistance against IBD till sixth week post-immunization. The glycoprotein antigens of 34 and 29 kDa isolated from *Hyalomma anatolicum anatolicum* and *Boophilus microplus*, respectively, conferred protection against experimental challenge infections for at least up to 30 weeks. A saponified bivalent *Pasturella multocida* vaccine containing serotype B : 2 and A : 1 conferred 100% protection in buffalo calves against challenge for both the serotypes. A low volume (2 ml) saponified haemorrhagic septicaemia vaccine conferred up to 100% protection in calves challenged up to 12 months post immunization.

**Assessment of indigenous technologies**

On-farm trial of indigenous technologies revealed promising efficacy of—pigeon waste to induce estrus in post-partum anoestrous animals; pigeon waste with jaggery to induce estrus symptoms in heifers; stone fruit (*Bel*), *takala* (*Cassia tora*) flower juice and *sheesham* leaves paste, juice of *urhul* (*Hibiscus sinensis*) flowers and paste of bark of pojo (*Litsaea anthapoly*) to check diarrhoea in small and large animals; *babool*, *jamun* bark and peach leaves with fresh milk in curing FMD lesions in animals; and *kala jeera* in haemorrhgic septicaemia.

**Animal feed resources and nutrition**

The district wise information on feed resources for the last 15 years was compiled and thematic maps were prepared. The information was brought out in the form of compact disc for Punjab, Haryana, Gujarat and Orissa. The compact disc is useful for developmental agencies and private industries to utilize the information for livestock development activities and planning business strategies.

Primary data on feeding practices, type of feeds/fodder/top feeds available, quantity offered, type of animals and socio-economic aspects were collected from different categories of farmers in rainfed and coastal zones of Karnataka. Commonly available feeds and fodders and unconventional feeds collected were analyzed for micro- and macro-nutrients to identify the limiting nutrients on existing feeding systems. Intervention through strategic supplementation of deficient nutrients could improve productivity and profitability.

- District-wise information on feed resources compiled
- Paddy crop residues contain more moisture at harvesting compared to course grain crops
- Technology for detoxification of castor-cake passed on for commercialization
- Total mixed ration with 2 kg grain fodder proved economical ration for milch cow
- Encapsulated choline-chloride feeding increased milk yield
- Bromo-chloromethane capsule in diet of rams reduced methane production
- Fallen tree leaves @ 20% could be safely added to complete feed block
- Cu and Zn in diet improved micronutrients and mineral-dependent enzymes
- Drying (80°C for 4–7 hr) reduced aflatoxin in diets
- Maize substitution up to 75% by sorghum proved economical feed for CARI-Sonali

The grain-straw ratios for major crops in Tamil Nadu and Andhra Pradesh from crop cutting survey data were worked out. The grain-straw ratios for paddy in Andhra Pradesh and Tamil Nadu were 1 : 1.14 and 1 : 1.06, respectively. In Tamil Nadu, the pod-haulm ratio for groundnut and cane-top ratio for sugarcane was worked out to be 1 : 3.5 and 1 : 0.21, respectively. The analysis of driage co-efficients of crop residues revealed that paddy crop residues at the time of harvest contain more moisture (50 to 58%) compared to coarse grain crops like *jowar* (48%) and groundnut (45%). Estimation of driage coefficients of major crops for other states of the country is in progress.

**Improving locally available feed resources**

*In vitro* and *in sacco* degradability studies of different green forage and concentrate based total mixed ration have been conducted. The *in vitro* and *in sacco* degradability of dry matter and organic matter were similar. However, *in sacco* degradability of crude protein was considerably higher compared to *in vitro* degradability. The study indicated that probably the coarse fodder utilization capability is considerably higher in mithun.

**Cattle**

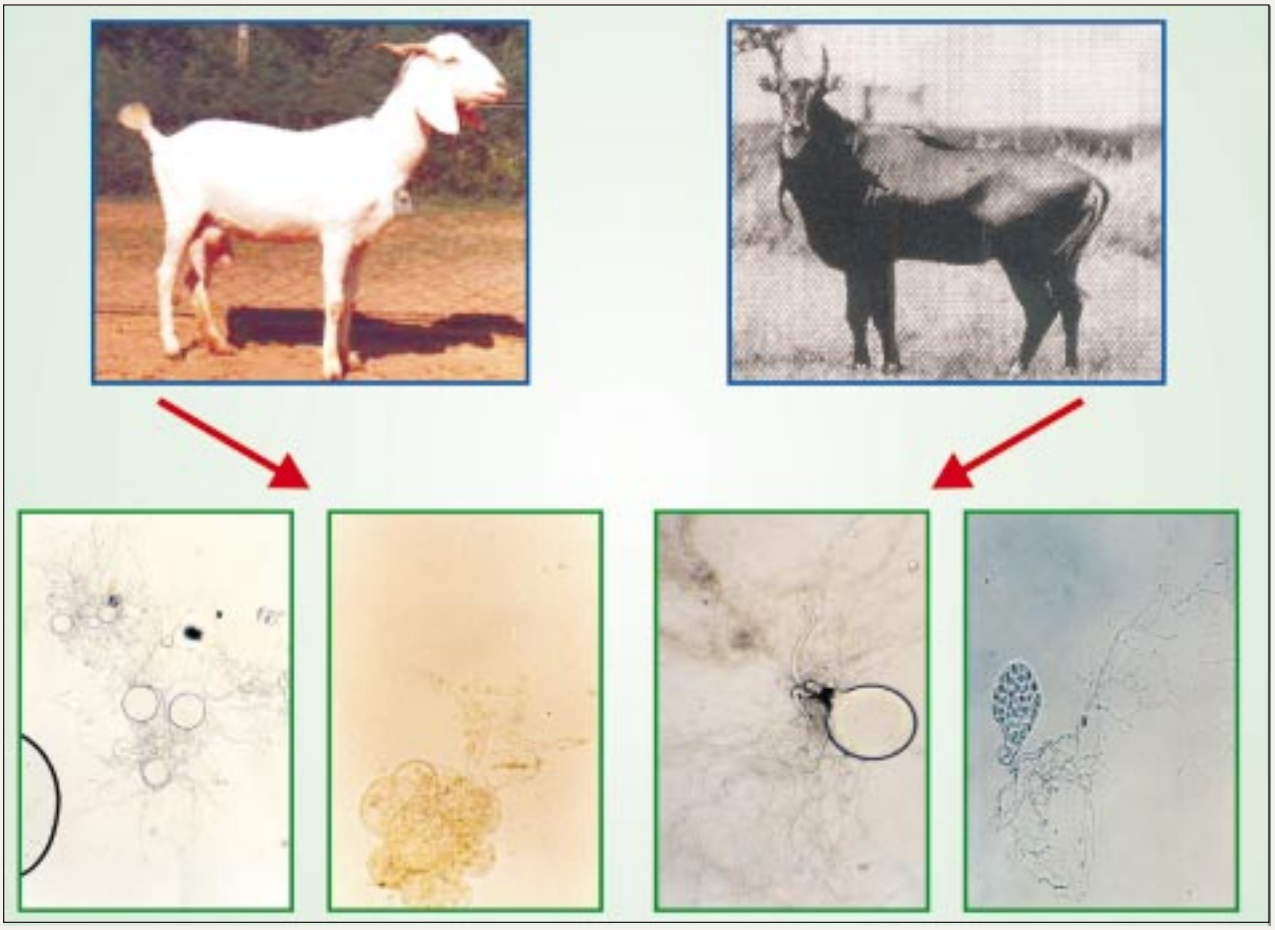
*Utilization and treatment of conventional and non-conventional livestock feed:* Technologies were developed for detoxification of castor-cake and utilization of sunflower heads as livestock feed. The detoxification technology for castor-cake was passed on for commercialization. The technologies have resulted in addition of 6 lakh tonnes of high protein castor-cake and 11 lakh tonnes of sunflower heads as potential feed resources. Roasted soybean-cake (160°C for 30 min) proved to be a good source of by-pass protein in the diet of ruminants. A methodology was optimized for determination of 18 organophosphorus and 10 more persistent organochlorine pesticides using HPLC. A binary gradient elution was developed which separated all the components within 60 min run. Formaldehyde treated mustard-cake could be fed with its improved bypass protein value, and it enhances the production performance of the lactating crossbred cows. *Babul* pods could be used as a source of energy in ruminant ration, and could be incorporated up to 20% in the concentrate mixture of lactating crossbred cows. Use of 2% activated charcoal (AC) as an antidote given to growing Karan Fries (KF) male calves, being fed on a diet containing 25 ppm chlorpyriphos (CPP), showed a protective effect in the diet of crossbred calves. Monensin supplementation significantly increased growth rate in crossbred heifers. Feeding of a total mixed ration containing concentrate: wheat straw in the ratio of 70: 30 with 2 kg green fodder resulted in production of milk at a cheaper cost from crossbred cows compared to the diet containing higher quantity of green fodder. Encapsulated choline chloride (ECC) feeding increased milk yield by 7.3% (0.911 kg/animal/day) and increased milk fat content by 4.8%, and lactose by 3.9%. The As and Cd content in feed samples collected from some industrial towns in Haryana were higher than the maximum permissible level. The As is released up to 97% following its dietary supplementation at 50 ppm. Dietary Cd supplementation @ 10 ppm reduced Zn and Cu retention in crossbred cows. Analysis of heavy metals in soil, fodder, feed and milk indicated that lead and cadmium were at non-detectable levels in all samples from all areas analysed. The Cu, Mn and Fe were high in almost all samples, whereas Zn was deficient in most of the samples. Supplementation of zinc in the diet improved the cell-mediated immune response in buffaloes. Crossbred cattle (112) having reproductive problems were screened for their micronutrient status. The problematic animals were supplemented with deficient area specific mineral salts. All the supplemented animals showed improvement in health condition within 15–30 days of supplementation. Anoestrus animals of sexual maturity cycled within 30 days, animals below 2 years age cycled in 3–4 months. In all about 80% of cattle supplemented with mineral salts got confirmed pregnancy. Supplementation of area-specific mineral mixture increased growth rate and daily average milk yield.

***Detoxification and nutritional improvement of unconventional and poor quality feeds:*** Hydrolysable tannins, condensed tannins and saponins at 5% (w/w), significantly reduced total gas production *in vitro* in wheat straw, white clover, subabool (*Leucaena leucocephala*) and mulberry (*Morus alba*). Condensed tannins at 5% level gave significant protection against protein degradation, and saponin (1.3 mg/ml) revealed maximum microbial protein synthesis and efficiency. Bacterial biotransformation of the toxin precocene-II resulted in a gradual decrease in its concentration and complete utilization of the toxin at 18 hr of incubation. Supplementing bromo-chloromethane capsule in diet reduced methane production in rams without any adverse effect on their performance. *In vitro* studies with different bioactive compounds and inclusion of urea in the diet of ruminants also decreased methanogenesis in the rumen.

***Biotechnological approaches for increasing productivity:*** Isolation and characterization of *Butyrivibrio fibrisolvens* was carried out and different strains of the organism were obtained. New shuttle vector pBS43 was used for cloning the cellulase gene and transformed *Escherichia coli* DH5alpha. Transformation with *Butyrivibrio* revealed that the organism was refractive to transformation.

Solid state fermentation (SSF) of green hybrid napier (steamed ST), untreated (UT) and urea treated (UrT) was carried out using

**Effect of rumen fungi on poor quality roughages**



Rumen fungal species isolated from blue bulls and goats

Goats have tough time in digesting the pasture, as grasses dry off during summer, peak winter and drought. Under these unfavorable conditions, goats may hardly digest 40–50% of what they eat, which affects their productivity. Some exotic animals like nilgai (*Boselaphus tragocamelus*) in the same habitat sustain their productivity under such a harsh condition, owing to presence of improved strains of anaerobic fungi in their rumen. Potential role of anaerobic fungi is exhibited by the considerable evidences which show positive relationship between presence of anaerobic fungi in the rumen and voluntary intake of herbage diets of low digestibility. Association of rumen fungi with improved digestibility of poor quality roughages containing higher proportion of lignin and fibre is also established. *Neocallimastix, Piromyces* and *Orpinomyces* were found in rumen of both nilgai and goats. Improved activities of carbomethyl cellulase, microcrystaline cellulase, xylanase and ß-glucosidase in the rumen of nilgai were observed. Amplification of cellulase C gene (430 bp approximately) using PCR against specific primer confirmed the presence of *Orpinomces* isolated from the rumen of blue bulls (nilgai) at molecular level. Information on fibre digesting enzymatic activities of rumen fungi from both host species are being collected for inoculation of efficient strain of exotic rumen fungi in goats rumen for improved intake, digestibility and productivity on low grade roughage.

*P.sajorcaju* to assess the changes in its proximate composition and enzyme profile. Protein content of hybrid napier increased in the UT and ST after fermentation. Lignin content decreased in the fermented samples. Properties of CM cellulase isolated from *P. sajorcaju* were elucidated.

**Buffalo**

At the CIRB Sub-Campus, Nabha, nutrient requirements of Nili Ravi heifers were estimated at 103.3 to 129.5 Kcal/kg $W^{0.75}$ ME at various body weights and the maintenance requirement for crude protein was found in the range of 6.49 to 9.49 g/kg $W^{0.75}$.

For 1g gain in body weight, the growth requirement of metabolisable energy was in the range of 6.18–12.91 Kcal at different body weights, while for CP these were 0.24–0.42 g and for metabolisable protein these were 0.18–0.31 g. Nutritional requirement of buffaloes during the last quarter of their pregnancy could be fulfilled by feeding them on a ration containing medium protein (10.5% DCP) and high energy (58% TDN). Buffaloes fed on such ration gave birth to healthy calves and yielded more milk. Buffaloes fed on TMR showed higher milk production than on conventional feeding system on a peri-urban dairy.

***Feeding practices:*** Survey of feeding practices in two districts of Haryana State indicated that the feeds and fodders fed to buffaloes were deficient mainly in zinc, manganese and copper. This was responsible for a high incidence of anestrus in rural buffaloes, which could be corrected by feeding area specific mineral mixture formulated at the institute for particular areas. On comparison of daily intake requirements prescribed by feeding standards, animals kept by farmers in Punjab were receiving calcium, phosphorus, zinc and copper at 90, 48, 39 and 39% levels, respectively, which accounted for moderate to severe deficiency of these minerals.

***Complete feed blocks for buffaloes:*** Keeping in view the constraints of storing dry fodder and importance of making available balanced ration to buffaloes of various categories, 'complete feed blocks' were prepared. Feeding of these blocks improved the overall dry-matter intake and further improved digestibility of crude protein, ether extract and fibre.

***Cellulose and xylanase mixture:*** Supplementation of mixture of cellulase and xylanase improved the digesting and daily body weight gain from 510 to 560 g in buffalo calves. Feeding of green fodder enhanced the total CLA content in buffalo milk.

**Sheep**

***Development of feed and fodder resources:*** Dry fodder yield and biomass production of groundnut in strip cropping was significantly higher as compared to sole cropping. At the ARC Bikaner, the weed free field produced maximum fodder yield with maximum net profit.

***Performance of sheep flock maintained on degraded rangeland:*** Performance of sheep flock maintained on degraded rangeland located near the institute, was monitored. A strategic supplementary feeding schedule based on the experiments conducted during the last 3 years on feed intake and nutrient utilization in sheep grazing on community grazing lands during different physiological stages and different seasons in semi-arid region of Rajasthan, was developed for adoption under the field.

***Evaluation of fermentation rate using* in-vitro *gas production technique:*** Different concentrate ingredients commonly used in sheep feeding were evaluated for fermentation rate kinetics using *in vitro* gas production technique. Sheep with poor growth rate when fed on 300 g/day concentrate supplement with trypsin, showed significant increase in the digestibility of fibre and decrease in fat digestibility. However, there was drastic decrease in microbial protein production (50%) and nitrogen balance (60%) in these sheep.

**Improvement of feed resources and nutrient utilization in raising animal production**

Information related to different livestock species and availability of feed resources, their nutrient contents as well as information on traditional feeding system in the north eastern region is being compiled. *Blemkar*, *domkar*, *sylulli* and *phrengpa* trees are commonly used as fodder in Arunachal Pradesh for feeding yak. In Sikkim, trees are commonly used fodder, *amilisho*, *nebaro*, *gagun* and *ber* for feeding of livestock.

***Feeding of complete feed block during scarcity period:*** During drought or famine, fallen tree leaves can be used as a component of complete feed block (CFB), and can safely be added up to 20% level. In the nutritional studies for mutton production it was observed that the dry matter intake in pre-weaning phase was higher in lambs fed on butyrate dose. Chokla rams receiving (25%-above-requirement) ration produced more greasy fleece (1,058 g) than, rams fed on below required or normal ration.

***Bioavailability of micronutrients:*** Bioavailability of Cu and Zn in sheep was 43.20 and 24.80% more when supplemented through organic sources (chelated–AA) compared to inorganic sources. Availability of Ca and P were better in adult sheep fed organic sources of Cu and Zn even at higher levels of these minerals in the diet. Digestibility of DM and OM did not differ significantly in sheep fed diets supplemented with organic and inorganic sources of Cu and Zn. Micronutrients (Ca, Mg, P, Cu and Zn) status and mineral-dependent enzymes (ceruloplasmin, Cu-Zn superoxide dismutase, alkaline phosphatase) activities in blood plasma were studied in sheep fed different levels of Cu and Zn in the diets. Increased supplementation of Cu and Zn in the diet resulted in increased levels of these minerals and mineral-dependent enzyme activities in the blood plasma.

***Feeding of afltoxin contaminated feed to sheep:*** Drying of aflatoxin contaminated feed in hot air oven (80°C for 4–6 hr) or in natural sunlight (2 days, 14 hr) resulted in significant reduction in aflatoxin content. Feeding of aflatoxin contaminated feed to sheep after drying either in hot air oven or in sunlight did not affect the performance. Hence, drying of feed is quite effective and practical way of reducing the aflatoxin content.

**Goat**

***Organophosphorus pesticides in animal feed and their excretion in goat:*** A binary gradient elution programme on HPLC was developed for the determination of 18 commonly used organophosphorus pesticides under Indian conditions and 10 persistent organochlorine pesticides. About 85% monocrotophos was degraded within 48 hr of incubation. Under *in vitro* conditions activated charcoal was a better antidote than zeolite. On supplementing activated charcoal to a diet contaminated with monocrotophos in lactating goats, nutrient digestibility and acetocholinesterase, serum creatinine and serum transminases (GOT and GPT) increased. There was 27% reduction in the excretion of monocrootphos in milk.

**Rabbit**

At the NTRS Garsa, Himachal Pradesh, adult Angora male fed on 110 g of concentrate/day required 7.84 kg dry matter for producing 100 g of wool, and rabbits fed on 80 g concentrated and 250 g fresh mulberry leaves required 9.12 kg dry matter for producing 100 g wool.

**Pig**

At the AICRP on Pigs, Tirupati centre, 100% fish-meal was successfully replaced in pig ration with amino acids supplement. The IVRI centre recommended the feasibility of lowering the use of maize in pig ration from 50 to 35%, and increasing the percentage of wheat bran to 47% from around 20%. Nutritional trial in the Khanapara campus of AAU, indicated the possibility of replacing the concentrate requirement up to 30% with colocasia, fish-meal with silkworm pupae and mustard oil-cake.

**Camel**

***Evaluation of locally available feed and fodder:*** The lactating camels given complete feed blocks (CFB) indicated significantly higher average daily gain (1,117.42 g/d) than the MC group (227.27 g/d) indicating that feeding management system has profound effect on body weight changes. While feed refusal was 27.66% of offered fodder in MC, it was 10.58% in CFB indicating that if all the feed ingredients are mixed and compressed into feed blocks, the wastage of feed will be significantly reduced. Further feed intake also significantly increased in CBF group increasing milk yield and composition. The DMI (kg/100 kg body weight) was higher in CFB. Higher CP digestibility in complete feed blocks was attributed to higher dietary CP level. Complete feed blocks promoted rumen microbial growth and activity thereby resulting in increased digestibility of poor quality roughages. The feeding of CFB to camels resulted in significantly higher intake of DM, DCP and TDN on metabolic body weight basis. Higher intakes of DCP, TDN and ME values in CFB fed camels were on account of higher DMI and digestibility.

The average intake of Na, K, P and Mg was higher in CFB.The drinking water was significant source of Na macro-mineral as compared to other minerals and accounted for 22-45% of total Na intake/d. Significantly higher apparent absorption of Na, Ca, P and Mg from the gut was recorded in CFB camels as compared to those of MC camels while K absorption was statistically similar between 2 groups because the potassium levels are generally higher in all plants and their parts.

**Yak**

Information regarding common husbandry practices and feeding regimes, viz. feeds, fodder and tree leaves commonly fed to the yaks, was collected from some of the yak rearing pockets of Arunachal Pradesh. Proximate composition of feeds, fodders and tree leaves was estimated.

**Mithun**

The nutrient digestibility and level of tree leaves incorporation were estimated in total mixed ration (TMR) for mithuns. Addition of mixed tree leaves up to 50% of TMR was good green roughage source to meet the nutrient requirement in mithun.

**Poultry**

***Updating nutrient requirements and their bio-availability:*** Requirements of laying quails, heavy body weight and white breasted lines, developed at the CARI were—protein 18.2%, lysine 1.0%, methionine 0.45%, threonine 0.74% and metabolizable energy 2,900 kcal/kg of diet; and the dietary protein could be reduced by 1.8% in diet provided the ideal amino acids profile is maintained. The CARI-Red chickens developed at the CARI require metabolizable energy (ME) 2,800 kcal/kg, CP 11.9% and lysine 0.47% during growing stage (12–21 weeks); ME 2,600 kcal/kg, CP 16.2%, lysine 0.80% and methionine 0.35% from 24–36 weeks laying period; and ME 2,600 kcal/kg, CP 14.7%, lysine 0.6% and methionine 0.30% during 36–48 weeks of laying. The naked neck × WL layers required a dietary level of 2.5% calcium and 55 mg/kg zinc for optimum utilization of different minerals.

***New feed resources for poultry feeding:*** Diets containing different proportions of pearl millet, either as such or reconstituted without or with enzyme addition accrued similar body weight gain, feed intake, and feed conversion efficiency in growing quails. Meal and sunflower seed-meal in combination either in maize, maize–pearl millet, maize–sorghum and pearl millet–sorghum based diet replacing soybean-meal supported optimum egg production during second phase of laying cycle of CARI-Sonali hens. Diet containing sunflower-meal as sole protein

supplement with enzyme accrued more egg production with superior feed utilization efficiency. Partial replacement of maize up to 75% by sorghum or utilization of cereal mixture (maize + sorghum + pearl millet @ 1 : 1 : 1) was beneficial for economic production of CARI-Sonali hens.

***Augmenting nutritive value of poultry feeds:*** Probiotics, viz. MOS or FOS (1 g/kg) and lactose (30 g/kg) could be used as suitable substitute for growth promoting antibiotic BMD) in broiler quail. Optimum dietary levels of probiotics in laying quails feed were 1 g/kg for MOS and FOS and 20 g/kg for lactose, which had a positive influence on production performance, immune function and competitive exclusion. Formic acid (1%) and propionic acid (1%) in diet, significantly increased body weight gain, feed efficiency and reduced microbial count in feed and caecal contents. Inclusion of 0.4% aluminium as aluminium sulphate in normal layer diet for 8 days was beneficial as assessed by post-moulting performance of hens.

***Incriminating substances in diet and their amelioration remedies:*** Broiler chicks could tolerate 30 and 15ppm of fenvalerate and methyl parathione, respectively, in diets containing enhanced mineral supplements. Interaction of castor bean-meal (CBM) toxin with fenvalerate and methyl parathion was significant and synergistic in broilers. The detoxification methods used for CBM (roasting + KI, 35 ppm) and insecticides (activated charcoal, 0.25%) appreciably reduced the concomitant toxicity resulting out of the interaction.

**Cattle**

***Effect of physiological and nutritional intervention:*** Deficiency of certain minerals, especially zinc and high blood urea nitrogen levels were possible causative factors in several animals with reproductive problems. Nutritional supplementations/ modulations are being made to ameliorate the problems and follow up is being done.

**Buffalo**

Heat exposure reduced the lymphocyte proliferation rate and increased plasma cortisol levels in growing and adult buffaloes. Heat load was higher in Karan Fries cows compared to Sahiwal and buffaloes. Different mitogens affected lymphocyte proliferation index in growing buffaloes. Response of phytohaemagglutinin (PHA), tetanus toxoid and Con A was more in 1–2 months old animals compared to 3–4 months old or adult buffaloes. Photobiotin and photodigoxigenin bleached DNA expression and cloning vectors could be efficiently used for transfection of capacitated and electroporated buffalo spermatozoa to act as a vehicle for the transfer of the same to the ova. The analysis of expression and localization of mRNA encoding IGF-I and IGF-II in buffalo ovary was done by semiquantitative RT-PCR. Both IGF-I and –II were expressed in whole follicles of different sizes and granulosa cells from these follicles. Amplified partial IGF-1 cDNA was cloned in PCR-II vector (*in vitrogen*) and got custom sequenced. TNF-$\alpha$ and its receptor-1(TNFRI) were expressed in whole follicles, granulosa cells from the follicles and post-ovulatory structures in buffalo ovary. FSH(100 ng/ml) showed stimulatory effect on expression of IGF-II and TNF-$\alpha$ in granulosa cells *in vitro*.

Anestrus in peri-pubertal buffalo heifers and early postpartum buffaloes were studied with ultrasonographic monitoring of ovarian activity and progesterone profiles. Attempts were made to simulate the physiological events associated with development, growth and ovulation during spontaneous estrous cycle, with exogenous hormonal supplementation. Mimicking luteal phase with exogenous administration of a synthetic analogue of progesterone in anestrus buffaloes, supplemented with eCG, not only induced estrus in approximately 90% of treated animals and resulted in good fertility of over 60% to fixed time inseminations. Using Ovsynch-Plus it was found that ovulations in response to second GnRH were essential for conception in treated animals.

The high incidence of backward motility in buffalo semen frozen during summer, resulting in rejection of a large number of ejaculates, was overcome with a modified semen freezing protocol involving addition of glycerol at initial stage of dilution. This protocol resulted into successful freezing of approximately 20% more ejaculates, leading to increased frozen semen production. Stage of glycerolization did not affect morphology of buffalo

- Isolation and purification of buffalo pituitary gonadoptropin hormone are being carried out
- Addition of glycerol at initial stage of dilution increased frozen semen production
- Ram effect was more pronounced in multiparous ewes
- Sirohi bucks appear to be the best suited to combat thermal stress
- Rumen of a goat seems to act as water reservoir and might meet the animal's demand when grazing away from water source
- Effect of freeze-thawing on goat semen was studied
- For estrous synchronization in pigs, 300 and 340 mg progesterone was suitable
- Modulating prolactin levels improved egg production in non-descript birds also
- Growth promoters improved growth up to 2 weeks of age in poultry
- Egg production in quails stopped in stressed birds
- Stress increased fat deposition in abdomen, breast and liver muscles
- Estrus was successfully synchronized in yaks by using $PGF_2\alpha$ and GnRH

**Isolation and purification of buffalo hormones**

Hormones and related biological materials are not easily available and are quite expensive. Such materials are especially not available for buffaloes. To overcome this, isolation and purification of buffalo pituitary gonadotropic hormones, production of antibodies to them as well as for steroid hormones are being carried out. Isolation and partial purification of FSH and prolactin were completed. FSH activity in the partially purified extract was studied *in in-vitro* culture. Antisera for progesterone and oestradiol were raised. The complete nucleotide sequences of coding exons of buffalo growth hormone gene were worked out and some unique substitutions of nucleotides were identified. Sequences of the beta-subunit of luteinizing hormone gene cDNA were deduced and at least five different SSCP variants were identified.

spermatozoa, except the finding of a high incidence of sharp kink in the tail, which appeared associated with the apparent backward motility of sperm cells. The spermatozoa from fertile buffalo bulls were better equipped to combat the oxidative stress compared to the infertile bulls in terms of antioxidant enzymes and antioxidant status. The level of production and mode of action of reactive oxygen species (ROS), viz. hydrogen peroxide and superoxide anion during *in vitro* capacitation of buffalo spermatozoa was established. Buffalo sperm *in vitro* capacitation by superoxide anion ($O_2$), hydrogen peroxide ($H_2O_2$) and nitric oxide (NO) was modulated through tyrosine phosphorylation of different groups of proteins. Nitric oxide modulated the tyrosine phosphorylation of p38 and p20 whereas $O_2$ and $H_2O_2$ modulated the phosphorylation of p95 and p78.

Various functional tests on semen-seminal plasma as well as sperm were standardized for buffalo semen. Preliminary work on identification of molecular markers revealed differences in protein electrophoretic profile in semen from bulls of different fertility status.

## Sheep

Active immunization against inhibin-based peptide immunogens induced multiple ovulations and increased the ovulation rate from 3- to 7-folds over nearly 3 years period in Malpura sheep. Collection of transferable quality embryos and the birth of live offspring from inhibin immunized Malpura sheep confirmed that the multiple ovulations resulted in production of viable embryos which could produce live offspring. Reintroduction of rams to ewes after isolation of 90 days during non-breeding season for 30 days resulted in induction of estrus. Similarly, reintroduction of rams to ewes following 30 days isolation resulted in synchronization of estrus in the next 30 days. The response of multiparous ewes to ram effect was much more pronounced compared to nulliparous ewes. Progesterone levels estimated in blood samples collected during isolation period from January to March suggested that this breed of ewes enter into anoestrus season during February. The thyroid hormone profile revealed that the thyroid activity is reduced during non-breeding season. Further this approach can be used to advance the age of sexual maturity in sheep. The body condition scoring (BCS) of the 88 adult Bharat merino ewes was evaluated. The ewes having 2.5, 3.0, 3.5, 4.0 BCS were marked as group 1, group 2, group 3 and group 4, respectively. The intensity of sexual behaviour was lower in 2.5 BCS as compared to 3.5 BCS ewes. The estrus duration of group 1 ewes was significantly lower compared to group 2 ewes.

***Freezability of Garole sheep embryos:*** Embryos (14) of morula stage were frozen using glycerol based freezing media and slow freezing method in programmable cell freezer. Active immunization during off-breeding season (winter) did not result in improvement of ovulation rate as compared to that of control after first and third booster dose. The forced RFLP-PCR technique confirmed the Garole lambs produced through embryo transfer. The study indicates possibility of producing Garole lambs of heavier birth weight in large size recipients for their faster multiplication and conservation.

***Single transcervical artificial insemination technique:*** A fertility trail was conducted in 100 cycling Bharat Merino ewes by single transcervical artificial insemination in 1 cycle using frozen-thawed semen. The ewes that did not return to estrus after two cycles were subjected to ultrasonography between 40 to 60 days for confirmation of pregnancy. The number of ewes that were marked conceived on non-return to estrus and pregnancy diagnosis were 25 and 20, respectively.

## Goat

***Adaptability of goats:*** Sirohi, Jamunapari, Marwari and Barbari goats were evaluated for their adaptability during summer. Sirohi and Jamunapari bucks were able to loose excess heat through more efficient mechanism of higher sweating rate. Marwari bucks used respiratory evaporative heat loss to a greater extent than other breeds mainly due to their long shaggy hair coat that interfered in cutaneous evaporative heat loss. Barbari bucks utilized both efficient sweating mechanism and higher respiratory evaporative heat loss. The higher demand of heat loss in Barbari bucks was possibly because of more heat load due to higher metabolic rate in this breed compared to other 3 breeds. The cardiac activity in Barbari was also higher than the other 3 breeds.

Sirohi bucks had consistently significanty lower mean rectal temperature in all the thermal environments than that in Marwari, Jamunapari and Barbari bucks indicating inherent lower body temperature of this breed. The metabolic rate was also lower in

this breed compared to the other 3 breeds. The bucks of all the 4 breeds reduced their metabolic rate during hot thermal environment. Water intake and urine excretion in Sirohi bucks was also significantly lower than the other 3 breeds. Physiologically, Sirohi bucks appear to be the best suited to combat the thermal stress in semi-arid climate.

Exposure to solar radiation during cool period resulted in greater reduction in metabolic rate in black Marwari and dark tan Sirohi goats when compared with corresponding metabolic rate under shade in cool period and under solar radiation during hot period. Absorption of proportionately more incident solar radiation impinging on animal body appears to be beneficial during cool period as this energy can be utilized for thermoregulatory needs of the body. Black or dark coat colour in breeds of desert i.e. Marwari and Sirohi seems to be thus an adaptation for energy economy. Thus, the critical season of the year for the desert goat like Marwari seems to be the winters. Considering the fact that winter is the time when food in the desert is least available and energy requirements of the goats for thermo-regulation and for reproduction are high, any saving of their energy expenditure may indeed be crucial for their survival.

During water scarcity, goats conserved body water excretion by decreasing feed intake and urine excretion, voiding faeces more drier and reducing sweating rate. Water deprived goats allowed their body temperature to rise with decreased respiratory rate. Under normal conditions when water is available *ad lib*, a rise in body temperature will be accompanied with increase in respiratory rate. In water deprived bucks, respiratory rate declined to reduce the water loss through respiratory evaporation. An increase in the heart rate due to water deprivation was observed in all the 4 breeds and in three environments. It is expected that water deprivation will reduce the metabolic heat production, since feed intake is reduced. Heart rate under such circumstances should show a declining trend, but reduction in plasma volume due to dehydration and increase in blood viscosity seems to be the probable reasons for increase in heart rate in the present investigation.

The bucks quickly replenished their body weight when drinking water became available. The amount ingested compensated approximately the same to that of the amount lost during dehydration in cool and moderate periods. In hot environment, the bucks imbibed more water than their body weight loss. The rumen of goats seems to act as water reservoir as it drinks voluminous amount of water in few minutes. This rumen water reservoir might meet the animal's demand while grazing far away from water sources in arid conditions.

***Cryopreservation of* in-vitro *produce embryos:*** Cryopreservation of *in vitro* produced embryos at 2- to 8-cell stage were performed using 1.5M glycerol as a cryoprotectant by conventional freezing protocol.

***Hormonal profile and ovulation characteristics in Jamunapari goats:*** Level of circulating progesterone hormone in Jamunapari ranged from 0.58±0.12 ng/ml to 8.35±2.60 ng/ml; concentration remained lowest (0.58±0.12 ng/ml) on the day of oestrus and increased gradually to reach a peak level of 8.35±2.60 ng/ml on the day 14th of the cycle and again reached to basal level on the day of oestrus (0.40±0.15ng/ml).Ovulation in this breed occurred during 30–36 hr following natural oestrus. Right ovary was more functional than left. The optimum time for mating to maximize reproduction rate in this breed is 12 hr after the onset of oestrus.

***Enzymes and proteins in goat reproductive fluids:*** Analysis of follicular fluid, cervical mucus, uterine fluid and seminal plasma revealed that maximum total protein concentration was in follicular fluid followed by seminal plasma while uterine flushing and cervical mucus contained much less total protein. The acid phosphatase, alkaline phosphatase and GOT activity was also highest in seminal plasma compared to enzyme activities in uterine flushings, follicular fluid and cervical mucus. GPT activity was higher in follicular fluid and seminal plasma, uterine flushing and cervical mucus possessed nearly similar enzyme activity.

**Equine**

***Cryopreserved semen of Marwari horses:*** Equine semen is far less tolerant to the process of cryopreservation as compared to other species. Concentration of glycerol and equilibration time affects the post-thaw motility of frozen semen. Freezing media containing 3% glycerol was superior than that containing 5% glycerol on the basis of post-thaw motility, whereas equilibration time had no effect on stallion semen freezability. Thawing at 45°C for 15 sec was superior for obtaining better post-thaw motility in frozen stallion spermatozoa.

**Camel**

***Work performance of camel:*** The camel can pull one tyne plough for longer duration (5 hr 33 to 43 min) than two (4 hr 40 to 44 min) and three tyne (4 hr 10 to 22 min) ploughs. But, three tyne plough cover more area (5,135 to 6,020 $m^2$) in relatively shorter period of time as compare to two (5,341 to 5,782 $m^2$) and one tyne (5,721 to 5,821 $m^2$) ploughs. Camel farmers reported that one tyne plough is most commonly used than two and three tyne ploughs. The farmers were of the view that their camels can work throughout the day with one rest of around 2 hr with one tyne plough.

***Evaluation of camel milk:*** Significant higher value of lysozyme activity was observed in camel colostrum in comparison

of camel milk. The pH of camel whole raw milk samples were adjusted to 6, 5, 4, 3 and 2 using 0.1 acetic acid. The highest loss of 95% in insulin activity was recorded at pH 2 and 3.

***Developing RIA facilities for reproductive hormones in camel:*** Estradiol-17 beta (E2) and progesterone (P4) profiles were studied in camels at different reproductive stages.

***Peripheral plasma progesterone profile:*** Peripheral plasma progesterone profiles were monitored from day 0 to day 29, either daily or on alternate days to evaluate efficiency of hCG to induced ovulation. Nearly 40% of buserelin treated and inseminated female camels have definitely ovulated and developed a normal corpus luteum.

**Poultry**

***Effect of modulating prolactin blood levels on egg production:*** Physiological approach of modulating blood prolactin hormone levels in birds showed an increase in egg production by about 4% in farm layer birds. Approaches of immunizing against prolactin or vasoactive intestinal peptide (VIP) and controlling prolactin release using bromocriptine were applied. Girirani birds showed an increased egg production of up to 15% (from 25th weeks of age to 70th week of age) in birds immunized against VIP and prolactin. Against a normal of 160–180 eggs for one production cycle, the maximum egg production went up to 240 eggs. This showed that modulating prolactin levels improve egg production even in non-descript birds.

***Effect of estrogen—progesterone on egg production:*** Egg production in *desi* fowl (Assel × Kadaknath) increased up to 4 egg/bird by administrating the estrogen-progesterone preparation at 15th week of age for 15 days of supplement in feed. Egg production in *desi* fowl (CARI Red × Assel Pela – CARI Nirbhik) could be increased up to 6.00 egg/bird from 20–33 weeks of age by administrating the drug through feed for 9 days at 21st week of age. It was further concluded that the pre-pubertal age of bird is extremely critical to administer the drug for enhancement of egg production. This critical period vary from species to species.

***Standardized melatonin estimation by HPLC:*** Melatonin level in intestine (jejunum) was estimated using high performance liquid chromatography (HPLC). The HPLC method was standardized by altering stationary and mobile phase, buffer etc. This method gave satisfactory results. The sensitivity was 20 pg and detection time about 8 min.

***Standardization of pinealectomy technique:*** Pinealectomy was performed in 1-2 day-old chicks under general anesthesia. The technique for pinealectomy in day-old chicks was standardized but still more refinement is required.

***Rearing and management practices of turkey:*** During 6–10 weeks period the turkey poults raised under cage brooding systems, weighed 240 g higher compared to floor brooding systems. At 10–12 weeks of age, floor reared poults had better FCR than that of cage reared poults (3.0 vs 3.47). Humoral immune response ($Log_2$ value of HA titre in response to 1% SRBC) was better in floor reared poults (8.75) than those in cage rearing system (6.91). Body weight of poults fed either of the growth promoters (virginiamycin and prebiotics) up to 2 weeks of age improved significantly. Both the growth promoters increased body weight at 4 weeks of age but, virginiamycin supplemented feed further increased the body weight significantly up to 8 weeks of age. Thereafter, the growth promoters failed to increase the body weight. There was no difference in the FCR values even if the growth promoters were supplemented in the diet.

**Rutting behaviour of camel under different management conditions**

Rutting behavioural frequency and intensity parameters of daily exposed male group (close to adult females) and unexposed group did not indicate difference in behavioural pattern up to third week of November (onset of winter). From last week onward all these parameters became apparent, and significant differences were observed between 2 groups. The plasma cortisol and testosterone levels varied significantly between groups from fourth week onwards. The DM intake and body weights of groups differed significantly from third week onwards. Early sexual behavior/rut signs in adult mature male camels are apparent when exposed close to adult female camels (regularly for 20–30 min daily) at least for 2 weeks during onset of winter.

***Manipulation of embryonic and post-hatch growth:*** Glucose injection on either 14th or 18th day of incubation in to the yolk sac of embryo had better chick to egg weight ratio, and higher levels of plasma protein and uric acid levels at day-old, implying higher anabolism as well as catabolism of protein. This site (yolk sac) can be used as route for future *in ovo* injection. Carbohydrate (glucose, fructose and ribose) injected birds obtained 33–42 g more weight at 4 weeks of age than that of control. Humoral immune response ($Log_2$ value of HA titre in response to 1% SRBC) at 14–21 days of age was higher in glucose and fructose compared to un-injected control birds; however, cell-mediated immune response (response to *in vivo* PHA-P) studied at 19th day did not show any significant difference between carbohydrate and control group.

***Environmental pollution in poultry housing:*** Ammonia (10–30 ppm) and carbon dioxide (375–600 ppm) gases measured in the different turkey sheds were within the range of recommended level. The dust concentration ranged from 0–7.81 $mg/m^3$ in turkey houses during early summer.

***Chronic stress effects:*** Average daily feed intake in group S 1

**Effect of stress in Japanese quail**

The brain AChE activity (membrane bound plus cytosolic) in chronic stressed group was significantly higher as compared to the control and acute stressed groups. The AChE activity increased as the stress prolonged. The serum AChE also followed the similar pattern. Egg production was stopped completely in both the chronic stress groups after 6 days of stress. The birds of the fourth group started laying by the end of the ninth day of stress. Egg weight, albumen weight and yolk weight except body weight did not show any significant difference between treatment and control groups. The end products of nitric oxide (nitrite and nitrate) in the brain and serum did not show any significant differences among the control and treated groups. Stress affected the acetylcholine esterase activity at CNS and peripheral levels. Serum acetylcholine esterase activity may be considered as a marker of stress in Japanese quails.

(restraint stress for 30 min) and S 2 (restrained for 60 min) reduced compared to controls thoughout the trial period. The formation of abdominal fat pad enhanced in S1 and S2 groups, about 58% increase in fat pad weight was observed in S2. There was a significant increase in the lipid fractions (phospholipid, triglyceride and cholesterol) of muscle and liver in groups S1 and S2. Similar pattern was also observed in serum of stressed groups. However, HDL-cholesterol level decreased significantly in S2 whereas levels of LDL-cholesterol drastically increased in this group. Besides, elevation of serum glucose and uric acid was noticed in S2 group. Chronic repetitive stress resulted in reduced feed intake, growth retardation and increased fat deposition in abdomen, breast muscles and liver. It also caused a deleterious alteration in the composition of serum lipoproteins in broilers.

**Yak**

Efforts were made to develop and validate a direct, simple and highly sensitive enzyme immunoassay on microtiter plates using the biotin-streptavidin amplification system and the second antibody coating for GH determination in yak plasma. Time of ovulation in relation to estrus and LH peak was determined in yaks and estrus was successfully synchronized in yak, using $PGF_2\alpha$ and GnRH. A positive correlation in breeding and non-breeding seasons between circadian changes in plasma prolactin and melatonin concentrations were recorded in these animals.

The birth weight of the yak calves is significantly affected by the month of calving. The maximum birth weight was noticed in June and it declined thereafter. Maximum number of yaks came to heat from October to January. Castration had no adverse effect on the body weight gain, dry matter intake or nutrient digestibility of growing male yaks.

***Embryo transfer technology in yak:*** The pioneering work in yak ETT was initiated which indicated, the prospect of implementing ETT for *ex-situ* conservation and for augmenting reproductive efficiency in yak. Three embryos were successfully collected non-surgically from the donor yak cow, and were transferred to a recipient.

**Mithun**

***Endocrine control of estrus behaviour in mithun:*** Typical estrus signs of cattle like vaginal mucous discharge, homosexual interaction, reduced feed intake, frequent urination and vocalisation were not observed in mithun. The visible signs recorded during study were slight restlessness, reddening and swelling of vulva and standing to be mounted. Average duration of estrus and standing heat were recorded as 67.2±7.2 and 10.5±2.7 hr, respectively. In 40% experimental animals, standing heat was absent. Nearly significant close associations were observed between estrous intensity score (EIS) and basal concentrations of plasma estradiol 17 ß (E2) and progesterone (P4). Expression of estrus in mithun is silent and for behavioural expression of estrus, progresterone (P4) level was instrumental in relation to E2 concentration of entire cycle. The low behavioural expression of estrus in mithun was probably because of overall low P4 concentration in entire estrous cycle. Highly sensitive enzymeimmunoassays for GH and LH using the biotin-streptavidin-peroxidase amplification system were validated in blood plasma of mithun on second antibody coated microtitre plates.

***Absorption efficiency of colostral immunoglobulin:*** Immunoglobulin fractions (IgG, $IgG_1$, $IgG_2$, IgA and IgM) were estimated. The serum total immunoglobulin concentration (mg/ml) recorded at 0 hr (before colostrum feeding) was 4.28 ± 1.26. After colostrum feeding, the total serum immunoglobulin concentration incurred at 6 hr (22.72 ± 6.49), attained peak concentration at 24 hr (40.93 ± 8.67) and then decreased at 72 hr (30.23 ± 6.60).

***Progesterone estimation:*** A simple, reliable and highly sensitive radioimmunoassay (RIA) was developed and validated for progesterone determination in mithun plasma.

**Milk and milk products technology**

**Dairy ghee** attenuates chemical induced mammary and gastrointestinal carcinogenesis.Dairy ghee attenuates diet-induced hypercholesterolaemia, and cow ghee is more efficacious. It also stimulates body immune system, improves antioxidative status, and increases tissue levels of conjugated linoleic acid (CLA). Anticarcinogenic, antimicrobial immunomodulatory, hypo-cholesterolemic, antioxidative and ACE inhibitory attributes of probiotic ***dahi*** and ***lassi*** were established. A process was developed

- Techniques developed for commercial manufacturer and improving shelf-life of several milk products
- *Churpi* and flavoured whey (byproduct of *churpi*) were developed from yak milk
- HACCP design for ready-to-eat sausage was prepared
- BPE @ 0.2% enhanced shelf-life of chicken-skin cutlet
- Higher bacterial counts in egg observed at retail outlets than at wholesale market or poultry farm
- Residual lead was highest in liver followed by egg and muscle
- Choudhery charkha was used to improve quality of coarse and fine yak wool
- Modified hand knitting technique improved 200% value of yak wool product

for manufacture of long-life ***dalia*** **dessert** in ready-to-serve (RTS) form using a rotary sterilizer. The improved processes for ***kheer*** mix and **rabri** were developed. Process for a ***lassi*****-like beverage** was standardized using rennet whey. A technology was developed for packaging and storage of ***dahi*** in eco-friendly shellac coated earthen pots. Processes were developed for instant ***rasmalai*** **mix** and instant ***basundi*** **mix**. The technology was developed for improving the quality of cow milk ***khoa*** by adding WPC prepared by ultrafiltration technique. Other technologies were developed for the production of good quality *chakka*, *shrikhand* and *chhana* and *chhana* based sweets, *rasogolla* and *savswah* with higher yield and higher milk solids recovery using ultrafiltration process. **Flavoured milk beverage** was standardized at the SRS, Bangalore, for the production of a carbonated beverage. The injection of carbon dioxide into the milk beverage decreased pH of the product. Presence of dissolved carbon dioxide in the beverage did inhibit the growth of microbes in the samples. Upgraded technology for preparation of *kalan*, a traditional concentrated *dahi*-based product from Kerala, was developed at the SRS, Bangalore. Packaging of this product in flexible pouches followed by controlled heating (below 100°C) increased the shelf-life to more than 3 months. Retort processing was more useful for commercializing this product. A prototype refrigerated twin-screw forming system (plasticizer) was developed to manufacture **recombined butter** (Butter-G) from ghee in a continuous manner. The unit, producing 100 kg butter/hr, can be scaled-up for higher capacities. The equipment is simple and hygienically designed. Good quality ***burfee*** was produced through engineering and technological modification of thin-film scraped surface heat exchanger. A third stage SSHE with better operational control, and sugar dosing mechanism was incorporated in the continuous *khoa*-making machine. A number of presentable prototype equipment to produce **indigenous milk products** are available for regular demonstration to the end users. The mechanized process for ***kunda*** manufacture reduced time of manufacture and energy consumption. A protein fraction having applicability in preparation of **infant formula** was obtained. **A plasmid based food-grade cloning** and expression vector host system was developed for *Lactobacilli* for first time in India. Food grade bacteriocin based biopreservative formulation was developed and found effective in enhancing shelf life of *paneer* and *khoa*. A laboratory scale process for **calcium fortification of milk** was developed. Thermal stability and calcium bioavailability of such milk was studied. A laboratory scale process for preparation of coconut filled ***Gouda*** **cheese** was developed. The applicability of estimation methods of lactic acid in milk, in presence of additives, was assessed. There was no interference of neutralizers and preservatives in estimation of lactic acid by either AOAC or IDF method. The Bieber's test heitherto used for detection of almond oil adulteration with kernel oil, was modified to detect adulteration of ghee with 5-10% vegetable oils. Three-phase-partitioning (TPP)

### Goat milk—a future health food

Goat milk is known for its nutritional and medicinal qualities. Goat milk may be designed to best fit consumer need by genetic manipulation. Genotyping at CSN1S1 locus can be carried out in Indian goat breeds for improving both quality and quantity of milk. The allelic distributions of the $\alpha s_1$-casein in the Indian goats were quite different from European goats. SDS-PAGE and DNA analysis revealed that majority of Indian goat breeds and non-descript goats were carrying A, B, C, D, E, F allele at $\alpha s_1$-casein locus. However A, B alleles were observed in highest proportion in Indian goat breeds. F allele was observed in Beetal, Marwari, Chegu and non-descript goats of Madhya Pradesh region and in less than 1% of population. The gene frequency of allele A in Indian goats varies from 0.68 and 1.00 and allele B varies from 0.098 and 0.23. Milk proteome analysis of different breeds was carried out by 2-D gel electrophoresis.

### Low cholesterol ghee developed

Taking lead amongst the dairy research, scientists working on preparation of low-cholesterol food products world over, a process was developed for preparation of low-cholesterol ghee with 90% of dietary cholesterol removed in the process, at the NDRI, Karnal. The low-cholesterol ghee prepared by newly developed process would prove to be a boon to cholesterol conscious consumers. The process developed does not have any limitations in terms of prohibitive cost and quantitative/ qualitative loss of milk fat, and perfectly meets the standard specifications of ghee under Prevention of Food Adulteration and AGMARK rules. The process developed at this institute is presently for laboratory scale. A patent is being filed for the newly developed process.

**Preservation of chicken skin-meat cutlets by natural preservatives**

Processing of chicken skin-meat cutlets with 0.2% BPE enhanced the shelf-life of the product up to 17 days under refrigeration (4±1°C) and 32 days under frozen (–18°C) storage conditions.

was applied to fractionate whey proteins.

***Mechanized rasogolla manufacturing plant:*** Rasogolla, one of the most popular dairy sweets of the Indian subcontinent, is gaining popularity in the other parts of the world with the spread of the Indian diaspora around the globe. The process for rasogolla manufacture was mechanized by inventing a continuous *chhana* ball forming system. In the final step, the chhana balls are cooked in sugar syrup for obtaining spongy *rasogolla*. For this purpose, a continuous cooker has been developed, where optimum cooking conditions such are concentration of sugar syrup and heat flux are maintained at optimum level to obtain the desirable qualities of spongy *rasogolla*.

**Churpi *and butter making:*** The process control points of *churpi* making practiced by yak farmers in their traditional way were investigated. The performance of traditional process equipment (butter churn, *churpi* making basket, etc.) was determined. The standardized method provides more yield of *churpi* and butter per kg of milk and the products are more hygienic with longer keeping quality.

***Utilization of whey—a byproduct of* churpi *making:*** The whey has been converted into salted/sweetened health drink with pineapple and jeera flavours. The process technology is simple and can be adapted at farmer's level on small scale. The consumers and sensory panelists evaluated the products as 'excellent' to 'good'. The keeping quality of the whey health drink (salted/sweetened) has been 2 weeks at refrigerated temperature of 4–5°C.

**Meat and meat products technology**

***Sheep:*** Mutton samples were analyzed for DDT, Aldrin, Endrin, Dieldrin, Endosulfan, Heptochlor and BHC by GLC with ECD. None of the above compound was detected.

***Goat:*** Old Sirohi goats had average carcass weight of 23.98 kg and dressing percentage of 44.85%. The yield of spice extract stock solution (SES) was 200±20 ml for a 600 w/v (100g spice mixture + 500 ml distilled water) mixture. Addition of 75% spice extract solution in the formulation was rated best by the semi-trained panelists. Combination of hurdles had definite influence on microbiological characteristics of stored sausages. Microbiological status of the stored sausages suggests that the product prepared by combined treatment could be stored for 30 days. Coliform counts were not detected throughout the storage. Average carcass weight was 15.12 kg for male Muzaffarnagari lambs and 13.30 kg for female lambs and the dressing percentages were 43.29 and 44.28% respectively. Average carcass weight of the Barbari goats was 11.37 kg and the dressing percentage was 44.94. HACCP design for the production of ready-to-eat cooked sausage was prepared and presented.

***Rabbit:*** The per cent inedible offal yield was higher in males (21.86%) than that of females, and was higher in grower (25.30%) compared to adult stock (21.80%).

***Yak:*** Meat samples were collected from Nyukmadung farm and local areas of Dirang, West Kameng district of Arunachal Pradesh. Vitamin $B_1$, $B_2$ and vitamin E estimations were completed.

***Pig:*** Formulations for low salt, low fat, medium fibre pork meat balls were developed.

***Poultry:*** *Retort processing of chicken chunkalona from culled hen meat:* A retort process was standardized for the shelf-life extension of value-added premium product from the less desirable tough meat of spent hen. Retort-processing of chicken chunkalona containing spent (culled) hen meat (SHM) (60%), skin-gizzard-heart (15%) in natural proportion and marinated broiler meat chunks (25%) in combination with non-meat binders and extenders yielded a delicious, restructured, shelf-stable product. Retort- processed (1kg/cm$^2$; 30 min) product containing either 200 ppm α-tocopherol acetate or 200 ppm BHA and packaged in retortable, flexible laminated (aluminum foil-PP) pouches could be safely stored up to 2 weeks and 2 months at mean ambient (25°C; 62% RH) and refrigeration temperature (5±1°C; 80–85% RH) respectively.

*Development of value-added egg product:* Process of preparing batter-breaded egg rings, a delicious snack food prepared from whole egg liquid, was standardized. The rings battered in 25% rice flour + 15% black gram flour coating was most acceptable and had refrigerated (4±1°C) shelf-life of 12 days in aerobic packaging with satisfactory microbiological and sensory quality. The cost of formulating 1 kg egg rings was estimated to be Rs 39.04.

*Residues of harmful substances in poultry products:* The

**Surveillance of bacteriological quality of chicken eggs**

Occurrence of pathogens such as *Salmonella* and *Escherichia coli* in chicken eggs collected from poultry farms located in Uttaranchal region and local markets of Bareilly was 2.90% and 12.36%, respectively. Molecular technique of detection of *Salmonella* from chicken eggs using his j gene was standardized. Higher bacterial counts (total mesophilic count) were found in eggs collected from retail outlets than those collected from wholesale market and fresh eggs from poultry farms.

**Camel milk lotion/cream**

Organic camel milk lotion was prepared by adding preservatives. Initial evaluation of lotion indicated positive impact on imparting shine to the skin without any oiliness and also improved the roughness of the skin.

residual level of lead was highest in liver (0.35 ppm) followed by egg (0.3 ppm) and muscle (0.2 ppm) in poultry. The levels of arsenic in egg, muscle and liver were recorded as 0.35, 0.25 and 0.35 ppm respectively. In muscle the level of BHC ranged from 0.05–0.1 ppm, whereas, in liver and adipose fat it ranged from 0.1 to 0.2 ppm and 0.2–0.5 ppm, respectively. Per cent occurrence of BHC was higher in adipose tissue (33%) during August–November. The residual concentration of DDT was 0.08–0.2 ppm in muscle, 0.15–0.25 ppm in liver and 0.2–0.3 ppm in adipose tissues. Malathion and aflatoxin B1 levels were very low (0.05–1.0 ppm).

Processing technologies and formulations for use of vegetables, eggs and byproducts in meat products and high valued meat bites – chicken, mutton and combination were developed. A process was developed for the production of chicken soup from deboned frames, as a byproduct. Value added products of nutritional merit from chicken necks with bone and buffalo offal meats (tripe, heart and head meat) were developed.

**Wool**

***Quality analysis of Magra sheep wool:*** At the ARC Bikaner, study carried out on Magra wool samples of spring clip of 1-year old animals to find out the lustre through subjective means, revealed overall rating of 3.75 on 5 grade scale, which can be termed as very good luster.

**Knitwear from corase yak wool**

It is very difficult to make value added handicraft from coarse yak wool. Hand knitting technique with minor modifications made it possible to make pullovers, caps, hand gloves, etc using corase wool span.. The value addition was to the tune of 200%.

***Coarse yak wool spinning using Choudhery Charkha:*** The traditional hand spinners are in operation for converting fine yak wool yarn (single and double ply thread). It is very difficult to make thread from coarse yak wool using traditional spinners. These are also very slow and only few old crafts men can operate and fabricate them. To improve the speed and quality of coarse and fine yak wool yarn Choudhery Charkha was introduced. The Charkha was successfully adapted for both coarse and fine wool yarn making and tribal ladies were trained in Charkha operation. In LPT Unit 5–6 kg yarn was made using Charkha.

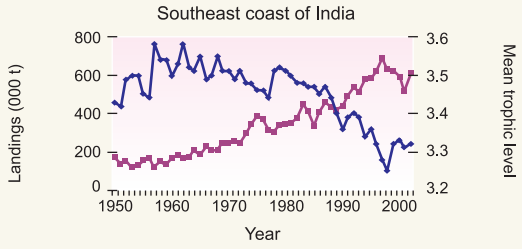
# Fish Production and Processing

## Marine Sector

***Estimation of marine fish production:*** The marine fish production in India during 2004 has been estimated as 2.54 million tonnes, with a decrease of 1.9% compared to the previous year. The pelagic finfishes constituted 54%, demersal fishes 26%, crustaceans 15% and molluscs 5% of the total landings. The estimate of region-wise production showed that the north-east region, comprising West Bengal and Orissa coasts contributed 10.8% to the total production. South-east region consisting of Andhra Pradesh, Tamil Nadu and Pondicherry coasts contributed 24.1%. The north-west region comprising Maharashtra and Gujarat coasts contributed 30.0% of the total, and south-west region comprising Kerala, Karnataka and Goa coasts recorded a maximum of 35.2%. Of the total landings, 68% was from mechanized sector, 25% from motorized and the rest 7% artisanal sector during the year 2004. Among the commercially important groups, oil sardine contributed 15% of the total landings during 2004, followed by penaeid prawns (7%), Indian Mackerel (6%), threadfin breams, croakers,ribbonfishes and non-penaeid prawns (5% each). Analysis of trophic level of 707 species of commercially exploited marine fish and shellfish revealed that the production level is declining due to intense fishing and large predatory fishes are being replaced by small sized fish on the south-east coast of India. This result underlines the need for a shift toward ecosystem-based marine fisheries management.

***Marine Fisheries Census, 2005:*** The first phase of the national marine fisheries census under the scheme "Strengthening of Database and Information Network for the Fisheries Sector" of the Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, in all coastal States except Tamil Nadu, was successfully completed. Information was collected on the number of fishing villages, landing centres, fishermen population, active fishermen, fishing crafts and gears including the infrastructure facilities for planning development programmes in different maritime states of India. The census was also focused on getting information on characteristics of the fisherfolk including their community, educational and occupational status, membership in co-operative societies, etc. besides their holdings of craft and gears.

- National Fisheries Census (except Tamil Nadu) completed
- Fiberglass reinforced plastic carp hatchery was developed
- Breeding technologies developed for yellow catfish and cat fish pabda
- Captive breeding of spiny eel was successfully done
- Cages were found useful for *in-situ* stocking
- Fishery survey of high attitude lakes of Ladakh was completed
- Molecular characterization of Indian strain of white muscle disease virus was completed
- Nested RT-PCR diagnostic kit developed for *Microbrachium rosenbergii* noda virus
- National musssle seed calendar was developed
- Low cost feeds for ornamental fish, golden mahseer and mud carb, were developed
- Check list of macro-fauna and flora of Gulf of Mannar a Marine Biosphere Reserve completed
- Genetic characterization of golden mahaseer and rohu through microsatellite was completed
- FRP boats provided to help fishermen in the wake of the destruction caused by tsunami



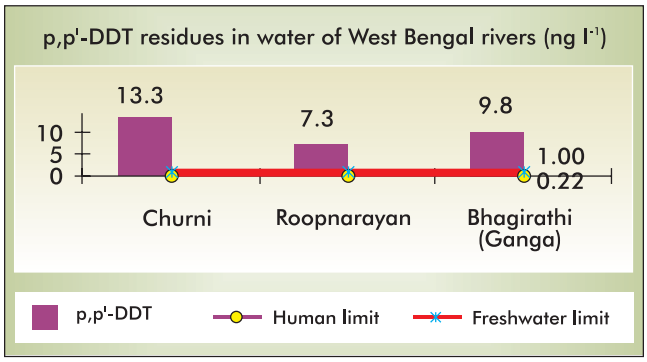

## Inland Sector

***Development of river and reservoir database management module system:*** A software was developed to store river and reservoir database. This software contains sub-modules, viz. data entry module for adding new records; modification module to modify the wrong entry; deletion module for dropping the record; and report generation module. Each sub-module has the provision to store, retrieve and manipulate different sets of parameters like sediment, water quality, biological and fishery data systematically. The modules in this software are useful for retrieving any data of river/reservoir for comparison and further analysis to suggest management actions for reservoir fishery management.

***Status of ecology and fisheries in reservoirs of Karnataka, Tamil Nadu and Uttar Pradesh:*** Investigations were conducted on the ecology and fisheries of Dandhroul, Chandraprabha, Tanola and Hinauti reservoirs located in Gangetic basin and Kabini and Mettur reservoirs of the Cauvery basin. All the reservoirs located in Uttar Pradesh are productive and their fishery is dominated by the major carps. Kabini reservoir was medium productive, and its fishery was dominated by catfishes (*Ompok bimaculatus*, *Mystus cavasius*) and the exotic fishes (*Tilapia mossambicus*). Most of the reservoirs located in Karnataka except Varati and Chakra are medium productive and the fish yield in these reservoirs was around 40kg/ha/year.

***Metals and pesticide contamination level in Rivers Churni, Roopnarayan, and Bhagirathi:*** The DDT concentrations in waters of Rivers Churni, Roopnarayan and Bhagirathi were higher than permissible limits (0.22 ng /l, EPA) specified for aquatic organisms and their consumers. The level of DDT concentration in fish flesh was much below the permissible limits suggested for human consumption. The mean Cu, Zn, Cd and Pb contents in the fish flesh of Churni river were within the permissible limit for human consumption.

The impact of pollutants were also evaluated in *Rita rita* and *Labeo rohita* in river Churni. In the test fishes, elevated levels of creatinine, bilirubin, triglyceride and cortisol were evident in blood.




***Fisheries of Hooghly and Mahanadi estuarine ecosystems:*** An estimated fish catch of 64,645.7 metric tonnes was recorded during the current year at Hooghly estuary, which was 22.5% lower than that of the previous year. The fish catch in the freshwater tidal zone of the estuary registered an increase by 11.5% over previous year. Similarly, juvenile of hilsa (*Tenulosailisha*) showed an increase of 117% from the level recorded in the previous year.

In catch composition of the Mahanadi estuarine ecosystem, dominance of miscellaneous fish group (46.0%) was observed. Amongst the various fish species, contribution of *Mugil cephalus* was highest (18.4%), followed by *Liza parsia* (15.3%), *L. calcarifer* (10.6%) and *Tenulosa ilisha* (9.7%).

**SUCCESS STORY**

**Institution Village Linkage Programme (IVLP) for Technology Assessment and Refinement in the Coastal Agro Ecosystem of Ernakulam in Kerala**

Sylvi Figerado, a farmer has succeeded in improving the farm productivity of his 2-acre pond with training imparted on scientific farming on monoculture of juvenile crabs under IVL. He has earned a profit of Rs 49,500 and Rs 50,000 from a single harvest in the first and second year respectively. Presently, apart from the monoculture of juvenile crabs, he is rearing the high-yielding variety of Kuttanad ducks and getting around 40-50 eggs a day at Rs 2.50/egg. He says to other farmers that, "Now whenever I am in need of money, I just sell the crabs and earn the required amount in no time."

## Freshwater aquaculture

***Portable FRP carp hatchery for carp seed production:*** An eco-hatchery for carp breeding made of fiberglass reinforced plastics (FRP) was developed. It is suitable for breeding 10–12 kg of carps in field conditions. The hatching tank is cylindrical and can hold the net egg incubation volume of 1,200 litres. The eggs hatch in 14–18 hr and remain in the tank for 72 hr. The spawn is collected through PVC hose pipes in portable carp hatchery unit spawn collection tank. It has a capacity of hatching 12 lakh eggs. The egg/spawn collection tank is a rectangular tank with a capacity of 250 litres. The system is light weight, easy to transport and it can be connected and dismantled easily. The cost of the complete FRP hatchery unit is approximately Rs 70,000 and can be operated easily by small fish farmers.

***Seed production of yellow catfish:*** Success has been achieved in breeding of an endangered yellow catfish, *Horabagrus brachysoma* under captive conditions. The per cent fertilization and hatching of eggs were 67±10.21 and 38±6.48, respectively. The fry were reared

Portable fish carp hatchery

for fingerling production and fed with completely compound diet, and they grew to 746±32.48 mg in weight in 30 days.

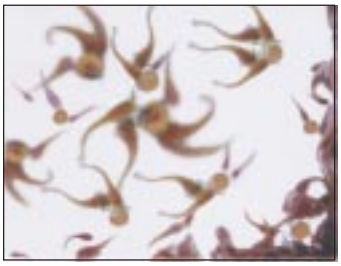
*Horabagrus brachysoma* fingerlings

***Breeding and culture technology of* Ompok pabda:** The breeding and culture technology of an endangered catfish pabda (*Ompok pabda*) was developed. Marketable size fish can be produced within 3 months.

***Captive breeding of spiny eel:*** Successful attempts were made to breed spiny eel, *Mastacembelus aculeatus* under captive conditions. The per cent fertilization and hatching of *M. aculeatus* eggs were 71±12.76 and 51±12.19, respectively. The growth trend from larvae to fry was 37±212 mg during 30 days rearing while fry to fingerling was 200±16.55 mg during a 45 days rearing.

***Larval feed for baby magur:*** To meet the nutritional requirements of magur larvae, a palatable weaning feed "Starter-M" for baby magur was developed. Starter-M is a highly nutritious feed which contains a minimum of 33% crude protein and 8% fat. The feed is also enriched with vitamins and minerals, ensuring faster growth with high survivability of larvae.

***Carp seed production in cages:*** Fingerlings of rohu, *Labeo rohita* (62.9 mm in length and 6.12 g in weight) were reared at different stocking densities, i.e. 1,000 and 2,000 each in 10 $m^2$ size cages in Krishna reservoir. After 80 days, growth and survival were assessed to be 195.4 mm/68.25 g in 1,000 stocking density and 173.8 mm/55.5 g in 2,000 stocking density, with respective average increments of 1.09 and 0.87 g/day. The juvenile fishes from cages were stocked in Krishna reservoir near Praksam Barrage. The survival was 88.4% in the former and 80.5% in the latter, showing ample scope for utilizing cages for *in-situ* stocking of open water bodies.



Magur larvae on active feeding of Starter-M

***Aeromonasis in carps:*** The pathogenesis and pathology of the disease, *Aeromonas* septicaemia in major and minor carps showed clinical *septicaemia* with dropsy, haemolytic and blood coagulation disorders, increased blood glucose, cortisol, chloride and triglyceride levels. *A. hydrophila* isolates from disease condition were highly virulent and pathogenic compared to isolates from healthy fish and better quality of water.

***Coldwater fish and fishery resources of Uttaranchal:*** The perimeter and area of open water bodies of Kumaon region of Uttaranchal were ascertained by using GIS. Based on satellite imageries the lakes Bhimtal, Nainital, Sattal, Naukuchiatal and Garurtal have an area of 45.13, 54.29, 48.9 and 5.7 ha, respectively, with the perimeters of 4.3, 4.6, 6.2, 3.1 and 1.3 km, respectively.

***Development of database of upland fishes of India:*** Computerized database on coldwater fishes of India was designed to compile the wealth of these fishes and make available to the researchers and anglers, along with details of principal game fishes, role of sport fishery in development of tourism and principal fishing sites in different riverine ecosystems. The generation of database on the biological wealth of various upland ecosystems would ultimately help in developing strategies for the proper management and conservation of native fish germplasm.

Data on 45 coldwater fish species inhabiting Himalayan waters, belonging to different sub-families like Cyprininae (*Carassius*, *Ctenopharyngodon*, *Cyprinus*, *Labeo*, *Neolissochelius*, *Puntius*, *Tor*), Cultrinae (*Chela*, *Salmostoma*); Rasborinae (*Barilius*, *Brachydanio*, *Danio*, *Raiamas*,*Rasbora*); Schizothoracinae (*Diptychus*, *Gymnocypris*, *Ptychobarbus*, *Schizothorax*, *Schozothoraichthys*); Garrinae (*Crossochelius*, *Garra*); Balitotinae (*Balitora*, *Bhavania*); Nemacheilinae (*Nemachelius*, *Triplophya*); Botinae (*Botia*); *Sisoridae* (*Bagarius*, *Exostoma*, *Glytosternum*, *Glyptosternum*); Salmonidae (*Onchorhyncus*, *Salmo trutta*) along with details of available game fishes, principal fishing sites of Uttaranchal have been computerized as a database.

**SUCCESS STORY**

**Pen and Cage culture in Wetland and small Reservoirs**

The Central Institute of Fisheries Research Institute, Barrackpore has successfully developed package of practices to raise the carp and freshwater prawn seed and to grow them to table size in enclosures, *viz*. pens and cages installed in small reservoirs and wetlands. In Assam, 100 pens ranging from 37.5 to 1,100 $m^2$. covering 2.73 ha were installed in beels, viz. Shankar, Goruchora, Samaguri, Charan, Kumri, Haribhanga, 46 Morakollang, Rowmari, Borghuli and Dek in the districts of Golaghat, Nagoan, Morigaon and Goalpara of Assam. This technology was used to raise the right size of fish seed to stock the beel for improving its fish yield. In the pens, different species of carps, viz. *Labeo rohita, Catla catla, Cirrhinus mrigala*, *Labeogonius* registered a maximum individual growth of 295 g, 265 g, 110 g and 75 g, respectively, in 3–5 months. The beels were managed by the cooperative societies. In Assam, pen culture of carps in beels was promoted for micro-financing. This technology has been adopted in small reservoirs and wetlands in West Bengal, Assam, Karnataka and Tamil Nadu with encouraging results.

**SUCCESS STORY**

**Fibreglass Canoes for Traditional Fishing**

At the Central Institute of Fisheries Technology, Cochin, a small size fibreglass reinforced plastic (FRP)(length- 5.78 m breadth (middle): 0.82 m; depth (middle) : 0.385 m) canoes was designed, developed and constructed, which is suitable for use in backwaters, near-shore waters and beels. A 40-day long training-cum-demonstration programme was carried out in Assam to provide hands-on training in the fabrication of FRP canoes. Three different types of canoes, which are commonly used in Assam, particularly in beel fishing, were fabricated after taking out a mould of the original wooden canoes. With these moulds, any number of canoes can be fabricated at a cost of Rs 23,000. This breakthrough has attracted the attention of other state governments in the region. The canoes are maintenance-free, long-lasting and affordable. The State Government of Assam is proposing to make 100 canoes using this technology.

***Limnology and fishery of high altitude lakes of Ladakh:*** A survey was conducted on high altitude lakes, located between 3,500–5,000 m above mean sea level, Tso Morari and Pangong of Ladakh and Tsomgo, Memencho, Kupup Tso, Manjula of Sikkim, to generate a baseline data on their limnology and fishery. These lakes are either oligotrophic or ultra-oligotrophic and normally remain ice-bound for 4–5 months in a year. No indigenous fish fauna was recorded from these lakes.

***Development of broodstock of rainbow trout:*** Culture of eyed ova of the rainbow trout, *Onchorynchus mykiss* was taken up at Champawat fish farm at a raised temperature of 28ºC. The fish stocked in January, 2005 has shown a remarkable growth i.e. 200 mm in length and 60–70 g in weight during 10 months.

***Feed for golden mahseer:*** Feeding trials with formulated diets having 40% dietary protein gave better growth performance and feed efficiency in golden mahseer as compared to conventional feed and commercial feeds. Food consumption and growth increased with increase in the number of meals per day up to 3 meals/day. The polycarboxylic organic acid and citric acid found in citrus group of fruits was a safe feed stimulant for mahseer.

***Improved traditional culture of tiger shrimp* Penaeus monodon:** Experiments on the culture of tiger shrimp, *Penaeus monodon* were conducted in 3 tide-fed ponds having area of 1,620 $m^2$, 3,750 $m^2$ and 1,840 $m^2$, with hatchery seed stocked @ 10, 6, 10/$m^2$.

Rainbow trout showed remarkable growth at Champawat fish farm

The shrimps were harvested at the end of 118–131 days of culture and the production obtained varied from 1,150 to 1,965 kg/ha/crop.

***Pond culture of Kuruma shrimp:*** Culture of kuruma shrimp, *Marsupenaeus japonicus* was attempted in a 0.9 ha pond at Sirkazhi, Tamil Nadu. The shrimps reached average final size of 12.5g in 113 days and registered a survival rate of 83%. The total quantity of shrimps harvested was 916.3 kg and the production worked out to be 1,018.1 kg/ ha/crop.

***Fin and shellfish resources of brackishwater Vembanad lake:*** Vembanad Lake is the largest brackishwater lake along the south-west coast of India, spreading over a distance of nearly 100 km,with an area of approximately 256 sq. km. The rivers - Achankovil, Manimala, Pampa, Meenachil and Muvattupuzha release their water to southern part of the lake and the rivers—Periyar and Chalakkudy, join the lake in the northern end. The lake was identified as one of the "Ramsar Sites" in 2002. The lake is the most productive brackishwater body along this part of the country and the annual fish landings from Vembanad are around 20,000 metric tonnes, dominated by penaeids, freshwater prawns, crabs, mullets, pearl spot and clams. The finfish and shellfish resources of this lake were documented,comprising 169 species.

***Molecular characterization and diagnosis of the Indian strain of white muscle disease virus:*** The white muscle disease virus was purified from white muscle disease-infected larvae of the giant freshwater prawn, *Macrobrachium rosenbergii*. Viral bands were collected and PCR reaction was performed, which gave 859 bp product, corresponding to the *Mr*NV. The sequence had 100% match with the 2.8 kb *Mr*NV genome available in the gene bank indicating the genetic similarity of the Indian and French West Indies strain.

***Development of a nested RT-PCR diagnostic kit for* Macrobrachium rosenbergii *nodavirus:*** A nested RT-PCR

diagnostic kit to detect white muscle disease in giant freshwater prawn *Macrobrachium rosenbergii* was developed. PCR screening of broodstock of *M. rosenbergii* can significantly reduce the risk of crop failure due to white tail disease (WTD) or white muscle disease (WMD) in culture systems.

***Introduction of automation in mussel farming:*** A low cost mussel seeder for seeding mussels and mussel harvester to strip the mussels from the culture ropes was designed and developed. The efficiency of mussel seeder and mussel harvester were successfully demonstrated to farmers.

***National mussel seed calendar developed:*** A national mussel seed calendar and seed distribution were prepared on a GIS platform as a guide to entrepreneurs on suitability of areas, farming and seasons of mussel spat fall.

***Pellet feed for mud crab fattening:*** *Scylla Pushti*, a formulated pellet diet, with 47% crude protein, 10% lipid, 18% crude ash and 17.8 MJ/kg gross energy was developed with indigenous raw materials, and additives for fattening mud crabs in coastal saline ponds. The pellet feed is economically viable, eco-friendly, easy to transport, store and dispense. The feed has been successfully used as a substitute for the traditional feeds for fattening.

***Development of LOA aluminium boat for reservoirs and rivers:*** A 5.22m LOA aluminium boat for fishing and related activities in reservoirs and rivers has been developed. This new boat is corrosion-resistant and light in weight.

***Standardization of process parameters for curing jelly fish:*** The process parameters for curing jelly fish by treating with varying concentrations of salt and alum were standardised. Yield of the finished product was 6–7%. The product is of high demand in Japan, Indonesia and Singapore.

Scylla Pushti is an economical pellet feed for mud crab

Mussel harvester was developed

***Development of fish tunnel dryer:*** A fish tunnel dryer using solar energy was developed, that uses forced convection system, and is superior to natural convection type dryers because of reduced risk of spoilage and increased capacity. The advantages

Prototype of the 5.20 m LoA alumimium alloy craft developed at the CIFT

**SUCCESS STORY**

**Utilisation of Prawn Shell Waste**

At the Central Institute of Fisheries Technology, Cochin, a technology for production of chitin, chitosan and glucosamine hydrochloride from prawn shell waste was developed. The chitin, chitosan and glucosamine hydrochloride are used as a dietary supplement for controlling obesity and arthritis, as a polymer flocculent, dye fixing and water treatment. The technology has been transferred to private sector in India and abroad. A patent has already been filed for production of high bulk density chitosan and high purity glucosamine hydrochloride from shrimp shell waste.

of this dryer are—hygienic drying conditions; protection against dust, insects, birds, rodents and climatic conditions; reduction of drying time; minimum mass loss; operation without fuel consumption, improved quality and low operation cost.

Processing of Jelly fish

The eco-friendly tunnel fish dryer

***Biodiversity of the Gulf of Manner:*** A checklist of macro-fauna and flora containing 139 families and 3,065 species of the Gulf of Mannar a Marine Biosphere Reserve was completed.The checklist includes diversity of sea grass (13), sea weeds (131), sponges (275), gorgonids (22), corals (128), sea anemones (117), crustaceans (351), molluscs (771), echinoderms (70), other echinoderms (194), cephalocordata (6), urochordata (59), hemichordata (1), fishes (580), sea turtles (5), sea snakes (20) and marine mammals (11).

***Database of fishes in computer disk:*** The database of the different aspects has been prepared in CD form.

**Bioenriched feed for ornamental fish**

A compound fish feed using indigenous ingredients supplemented with a fermented product was formulated for the marine aquarium fishes. Bioenrichment of the ingredients was done by using food grade microbes. The feed in the size range 1 mm to 3 mm to suit the different growing stages and species is manufactured using extrusion process in a twin-screw extruder with perfect finish. Twin-screw extrusion technology improves the texture, digestibility, stability as also the shelf-life of the feed because of reduced microbial load. This cost-effective feed was successfully used for rearing of clown fish from fry to broodstock.

Clown fish

Bioenriched ornamental fish feed

- Ornamental fishes—information on their classification, distribution, habitat, morphological features, fishing sites, seasons, etc.
- Sport fishes of India—information on 34 species covering distribution, fishing season, angling sites, size, colouration, morphology, habit and habitat, state, water body and localities. Out of 34 species, 26 are freshwater game fishes whereas 8 are estuarine and sea game fishes
- Exotic food fishes—information on their classification, distribution, habitat, morphological features, fishing sites, etc.
- Alien fishes and quarantine information system' (AFQIS)
- Bibliographic database on aquatic species introductions (BIDASI -2005)
- Fish chromosome world—containing cytogenetic and other information

A user-friendly computer software, named, 'Fish Chromosome Search Software' was developed by incorporating information on 126 fin-fish species belonging to 34 families under nine orders.

***Development of fish germplasm bank:*** Specimens (1,007) of 17 fish species were collected from aquatic habitats of the North-east region and added to the NE regional live genebank. In Assam 11 fish collection stations were identified for collecting targeted threatened fish species to be added to the bank. Of the 115 fish species of the NE region considered exclusively as ornamental fishes, 70 species were identified and documented with images.

***Genetic characterization of golden mahseer:*** Mahaseer was genetically profiled for their population structure in their natural range of distribution. Distinct genetic structure was observed in different natural populations of golden mahseer, *Tor putitora*. Further, genetic profiling of genus *Tor* revealed that *T. putitora* and *T. tor* were genetically closer to each other, whereas, *T. khudree* and *T. mussallah* had greater genetic differences.

***Gene banking:*** Fish species (26) including 2 endangered, 18 riverine stocks and 6 hatchery stocks were maintained at the NBFGR live fish genebank at Lucknow. Breeding trials were conducted for *Channa marulius*, *Labeo dyocheilus*, *Labeo rohita* and *Notopterus notopterus*.

***Fish disease and quarantine:*** Studies were conducted on isolation and detection of monogenian parasites of freshwater exotic fishes, using molecular techniques. Nucleic acid of exotic bacterial pathogens, i.e. *Aeromonas salmonicida* and *Yersinia ruckeri*, affecting the ornamental fishes, was obtained from referral laboratories for their use in polymerase chain reaction as positive controls. A PCR was also standardized for bacterial pathogens, viz. *Aeromonas hydrophila* and *Edwardsiella tarda*, of ornamental fishes, by using the isolates maintained in the microbiology laboratory.

***Genetic characterization of* Tenualosa ilisha *using molecular markers:*** The RAPD technique was applied to delineate the hilsa stocks migrating to the Ganga-Padma and Hooghly-Matlah estuary. The UPGMA dendrogram clusters indicate that the migrating population of *Tenualosa ilisha* of Ganga-Padma and Hooghly-Matlah ecosystems belong to two different populations.

**SUCCESS STORY**

**Ready-to-serve Fish Curry in Flexible Pouches**

At the Central Institute of Fisheries Technology, Cochin, the process of production of fish curry in retortabale flexible pouch using over pressure autoclave was successfully developed and standardised. The flexible pouch can perform the packaging function equally well as metal cans, and is free from the disadvantages met within them. The technical guidance on production of retort pouch products has been given by the Institute to private sector for commercial exploitation.

***Rohu microsatellite markers developed:*** Polymorphic microsatellite markers (12) have been isolated and characterized from rohu genome. Most of the loci exhibited cross-species amplification in bata, kalbasu, mrigal, catla, common carp, grass carp.The genetic differentiation in *Labeo bata* is being addressed using some of these microsatellites.

**Survey of fish fauna in river and lakes of Arunachal Pradesh**

The fish fauna of river and streams of the Deopani, Epipani, Diha, Enjupani, Dibang of Arunachal Pradesh was documented. Among the surveyed streams, 26 fish species dominated by *Tor putitora T. progenies*, *Neolissochilus hexagonolepis*, *N. hexastichus*, *Schizothorax richardsonii*. *Schizothoraichthys progastus* and *Labeo dyocheilus* were recorded. These water bodies are having abundant stock of chacolate mahseer and minor carps.

**Demonstration of cage culture in NEH states**

Fish rearing 10 $m^2$ cuboid shape cages made of conduit pipes were installed in Nongmahir reservoir (90 ha area) in Meghalaya in May 2005. Each cage is kept within a floating bamboo catwalk for easy management and handling of cages during the culture period. The catwalk is buoyed up with the help of closed and airtight HDP barrels (100 litre capacity). The entire cage complex is anchored in mid-water.

The cages were stocked @ of 300/$m^2$ for fingerling raising and 30/$m^2$ for grow out phase with carp fingerlings. Fry of catla, rohu, mrigal, kalbasu and silver barbs showed a survival rate of 50% with a growth of 15–20 g in 60 days. In the grow out phase, the production was estimated at 8 kg/ $m^2$.

# Agricultural Engineering and Technology

- A light weight power tiller developed for use on small plots and terrace cultivation in hilly regions
- Tractor-mounted check-row planter developed with row spacing of 1,000 mm
- A semi-automatic tractor-mounted three-row plug type vegetable transplanter developed for tomato, cauliflower, chillies and brinjal and found economically viable in places where labour wages are more than Rs 60/day

**Tractor-operated Machinery**

***Inclined plate planter:*** The 6-row tractor-mounted inclined plate planter was adopted for sowing intercrop on broad beds. A bed shaping/forming attachment was added as an integral part in the refined design of the planter. The planter was used for sowing of intercrop of soybean + pigeonpea on broad beds of 1,550 mm size (top width) at CIAE Farm. During field trials for sowing of three rows of soybean with two rows of pigeonpea at 300 mm row-to-row spacing, field capacity of planter was 0.42 ha/hr with an effective width of coverage of 1,850 mm. Field efficiency of planter was 64%.

***Check-row planter:*** MPKV, Rahuri Centre of AICRP on FIM has developed a tractor-mounted check-row planter with row spacing of 1,000 mm. It consists of main frame of 230 mm length, three seed boxes with metering device, three furrow openers, power transmission unit and marker. The check row planter was evaluated at forward speed of operation of 2.87 km/hr. The working width was 2,700 mm. The depth of planting, row spacing and seed rate were 52 mm, 902 mm and 1.21 kg/ha, respectively. The field capacity, field efficiency and cost of operation were 0.613 ha/hr, 79.09% and Rs 250/ha, respectively. The number of hills and plant population were 7,572/ha and 11,995/ha, respectively.

***Three-row plug type vegetable transplanter:*** TNAU, Coimbatore Centre of AICRP on FIM has developed a tractor-mounted semi-automatic three-row plug type vegetable transplanter for tomato, cauliflower, chillies and brinjal seedlings. The machine works on the principle of dropping-potted plants from a certain height to the ground. The impact of the seedling with soil block helps in its placement. The unit consists of main frame with hitching system, ground wheel, shoe type, furrow openers, compaction wheel, operators seat, plug type metering mechanism and two depth control wheels. The machine of 350 kg weight can be operated using 45 hp tractor. It employs press wheels inclined at an angle of 15° with the vertical as soil covering device.

The cost of the machine is Rs 22,000. The machine can be operated with1.4 km/hr forward speed. It is economically viable in places where labour wages are more than Rs 60/day. The field capacity of the transplanter is 0.140 ha/hr and field efficiency 75% for transplanting chilli, brinjal and tomato with 450 mm row spacing.

MPKV check-row planter

TNAU three-row plug type vegetable transplanter

***Turmeric digger:*** MPKV, Rahuri Centre of AICRP on FIM has developed a tractor-mounted turmeric digger suitable for harvesting turmeric sown on ridges at 600–750 mm row spacing. The unit consists of main frame, digging ridger and gathering unit. Two digging blades with shank were fixed on the frame spaced at a distance of 320 mm. A bar is attached with blades for separation of turmeric bulbs from the soil. The unit was evaluated for harvesting turmeric (Salem variety) at a forward speed of operation of 2.45 km/hr at soil moisture (db) of 18–25% in medium black soil. The field capacity and field efficiency were 0.175 ha/hr and 64.38%, respectively at working depth of 102 mm. The average damage of rhizomes was 6.94%. The average digging efficiency was 95%. The cost of operation was Rs 1,489/ha as compared to Rs 3,500/ha with conventional method of manual digging with fork.

***High capacity thresher:*** AAU, Jorhat Centre of AICRP on FIM carried out feasibility testing of tractor-operated axial flow paddy thresher (Bharat) for total 50 hr. It gave output capacity of 5.6 t/hr. The fuel consumption was 4 l/t. The thresher saved 88% labour as compared to conventional practice.

***Rotary field shredder for sugarcane:*** TNAU, Coimbatore Center of AICRP on FIM has developed a tractor-mounted rotary field shredder for shredding the sugarcane trash and crop residues

TNAU rotary field shredder for shredding sugarcane trash and crop residues

left in the field after harvesting sugarcane. For sugarcane grown in ridges and furrows, especially in ratoon crop, the unit can be operated with the tractor pto drive without damaging the ratoon crop. The unit consists of rotary member, gear box and transmission system. The field capacity of the unit was 0.37 ha/hr. It costs Rs 75,000.

***Banana stem shredder:*** MPKV, Rahuri Centre of AICRP on FIM has developed a tractor-mounted banana stem shredder. It consists of main frame, shredding unit, feeding unit and power transmission unit. The power is transmitted from tractor pto to shredding unit. The shredding unit was operated at 750 rpm.

***Paddy straw chopper-cum-spreader:*** CCS HAU, Hisar Centre of AICRP on FIM conducted feasibility trials of tractor-operated paddy straw chopper-cum-spreader in 12.5 ha. The machine was tested with the combination of straw bailer/knotter. The field capacity was 0.8 ha/hr. The comparative cost of straw management with different combination was Rs 920, 800, 890 and 338/ha by using chopper + bailer, chopper + zero till, chopper + rotavator and chopper + burning of straw, respectively.

**Power-tiller-operated Machinery**

***PAU light weight power tiller:*** A light weight power tiller powered by 3.58 kW engine for use on small plots and terrace cultivation in hilly region was developed. It can also be used for wide spaced row crops (cotton, castor, pigeonpea and sugarcane) for interculture. The machine consists of power transmission system, two MS wheels, a frame and a rotary. The rotary blades can be used for weeding or seedbed preparation. The working width of the light weight power tiller was 450 mm (adjustable). The rotary equipment of light weight power tiller was evaluated for weeding in cotton and sugarcane crops. The field capacity was 0.09 ha/hr at forward speed of operation of 2.1 km/hr. The weeding index was 91.3% at 60 mm depth and 94.6% at 100 mm depth of operation.

***CIAE light weight power tiller:*** The light weight power tiller is provided with petrol-start-kerosene-run engine of 3.75 kW. It was evaluated for puddling operation. Puddling operation was performed with the standing water of 60 mm depth in the field. The average bulk density of soil before and after puddling operation was 0.91 and 0.66 g/cc. The weed intensity before puddling operation was 45 g/m$^2$ (dry weight basis) with average height of 417.5 mm. No weeds were found after two operations of power tiller. The power tiller was operated at the forward speed of 2.42 km/hr. The effective field capacity was 0.096 and 0.11 ha/hr during first and second operations. Thus total time required to

CIAE light weight power tiller in puddling operation

complete two puddling operations was 19.51 hr/ha. The puddling index was 54.45% and cone index in depth zone of 0-200 mm of puddle bed was 0.55 MPa. The average depth of puddle land was 139 mm. The fuel consumption was 1.55 l/hr (kerosene). Cost of operation of power tiller was worked out to be Rs 68.59/hr and Rs 1,328/ha.

***Earthing-cum-fertilizer applicators:*** A power tiller-mounted unit suitable for earthing-up-cum-fertilizer application in wide row sugarcane crop has been developed by MPKV, Rahuri Centre of AICRP on FIM. The earthing-up unit consists of single ridger

Power tiller mounted earthing-cum-fertilizer applicator for wide row sugarcane crop is developed by MPKV

body (20 kg weight), an auxillary bar of 500 mm height and 25 mm diameter provided for fixing it to fertilizer box. The fertilizer application unit consists of long trapezoidal shape fertilizer box of 460 mm × 40 mm with 25 kg fertilizer capacity. The unit employs cup-feed type metering mechanism having four cups (18 g capacity each) on fertilizer rotors. Provision of auxillary chamber facilitates free fertilizer delivery. The unit was evaluated in sugarcane (CO 86032) at 1,200 mm row spacing and 105 mm depth of tilling operation. The working width was 600 mm. The average depth of fertilizer placement was 75 mm. The average weeding efficiency was 80.31%. At forward speed of operation of 1.169 km/hr, the machine gave field capacity of 0.50 ha/hr with field efficiency of 89.80%. The cost of operation was Rs 1,493/ha as compared to Rs 4,500/ha by conventional methods, i.e. *khurpi* for weeding and interculture and manual broadcasting of fertilizer. The equipment also saved Rs 1,257/ha as compared to weeding and earthing-up operations by bullock-drawn implements with manual broadcasting of fertilizer.

***Vertical conveyor reaper:*** HPKV, Palampur centre of AICRP on FIM conducted feasibility testing of power tiller-mounted vertical conveyor reaper (NDUAT design) for wheat crop. The average plant height and grain moisture content at harvest were 680 mm and 9.8% (wb), respectively. The field capacity and field efficiency were 0.13 ha/hr and 61.5% at forward speed of operation of 1.8 km/hr. The cost of harvesting was Rs 747/ha. The reaper saved 40% cost of operation as compared to sickle harvesting.

***Maize dehusker-cum-sheller:*** HPKV, Palampur Centre of AICRP on FIM carried feasibility testing of power tiller-operated maize dehusker-cum-sheller for 25 hr. The average output capacity of sheller was 162 kg/hr with 1.2–1.5% grain breakage. The sheller was operated at 612 rpm. The costs of shelling and labour requirement were Rs 69/q and 1.2 man-hr/q, respectively. The cob moisture content, feed rate and fuel consumption were 15–17% (db), 205 kg/hr and 0.98 l/hr, respectively. The capacity was 12 times more than tubular hand maize sheller.

***Manure spreader:*** TNAU, Coimbatore Centre of AICRP on FIM has developed power tiller-operated manure spreader. The unit consists of main frame, manure tub, conveying mechanism, spreading mechanism and adjustable rear aperture. For controlling the quantity of manure fed to spreader, adjustable door was provided in the rear end of the manure tub. The field capacity of the manure spreader was 0.62 ha/hr. The cost of spreading

TNAU power tiller operated manure spreader. It has the field capacity of 0.62 ha/hr

manure was Rs 91/ha. The savings in cost and time of operation were 85% and 94% as compared to manual method of manure spreading.

***Shredder-cum-in situ incorporator***: TNAU, Coimbatore Centre of AICRP on FIM has developed power tiller-operated roto shredder-cum-*in situ* incorporator. It consists of shredder assembly, power transmission system, hitch frame and rotary tiller attachment. The unit provided fine degree of pulverization enabling the rapid and homogeneous mixing of straw with soil. The field capacity and field efficiency were 0.08 ha/hr and 67.89%, respectively.

**Stationary Machinery**

***Power weeder:*** ANGRAU, Hyderabad Centre of AICRP on FIM conducted four feasibility trials of power weeder in sugarcane

Shredder-cum-in situ incorporator developed by TNAU has the field capacity of 0.08 ha/hr

- Feasibility testing conducted for four different types of manually-operated paddy drum seeders
- Self-propelled mini combine adapted for efficient harvesting and threshing of safflower
- Self-propelled fodder harvester evaluated with crop gathering mechanism for berseem mixed with mustard

sown at 60 cm row spacing. The field capacity, weeding efficiency and plant damage varied from 0.10 to 0.13 ha/hr, 65–75% and 2–3.5%, respectively. The average cost of weeding was Rs 600/ha. The speed of power weeder varied from 2.3 to 2.5 km/hr in different trials with effective working width of 55 cm.

UAS, Raichur Centre of AICRP on FIM conducted feasibility testing in red loam soil. The power weeder gave field capacity of 0.076–0.081 and weeding efficiency of 67–71% corresponding to soil moisture (db) of 17.89–18.11%. The working width, fuel consumption and working depth were 480 mm, 0.90–1.1 l/hr and 500–550 mm, respectively.

AAI, Allahabad Centre of AICRP on FIM conducted feasibility testing of power weeder in total 6.25 ha. The equipment was operated at a speed of 1.9 km/hr at soil moisture (db) of 18%. The field capacity and weeding efficiency were 0.053 ha/hr and 95%, respectively. The depth of tilling varied from 40 to 50 mm. The plant damage was 1.7%. The cost of operation was Rs 968/ha as compared to Rs 1,440/ha in conventional method of manual weeding with *khurpi*. The equipment saved 90.40% operating time and 32.78% in cost of weeding as compared to hand weeding by *khurpi*.

***Sunflower thresher:*** MPKV, Rahuri centre of AICRP on FIM conducted feasibility testing of power-operated sunflower thresher (PAU design). The average grain straw ratio was 0.67%. The moisture content of sunflower seed was 14–16% (d.b.). The average threshing and cleaning efficiency were 99.12% and 86.74%, respectively. The average output capacity was 6.12 q/hr. The cost of operation was Rs 56/q. There was saving of 62.84% in threshing over commercial sunflower thresher. The PFT trials of thresher were conducted for total 116 hr.

***Flow through paddy thresher:*** AAI, Allahabad Centre of AICRP on FIM conducted feasibility testing of flow through paddy thresher for total 77 hr. The thresher was operated at threshing

Flow through paddy thresher. The threshing efficiency and output capacity has been estimated at 99% and 1,300 kg/hr, respectively

drum speed of 955 rpm. The grain moisture (wb) was 12.59%. The threshing efficiency and output capacity were 99% and 1,300 kg/hr, respectively. The broken grain per cent varied from 0.6 to 1.1%. The cost of operation was Rs 18/q. It saved 72% in cost of operation as compared to manual threshing and time from 85 to 92% than conventional method.

***Groundnut pod stripper:*** IIT, Kharagpur centre conducted testing of ANGRAU power-operated groundnut pod stripper. The centre incorporated feeding chute and screen to separate soil from groundnut. The stripper powered with 4.84 kW diesel engine was operated at 250 rpm. The output capacity, stripping efficiency, and cost of stripping were 90 kg/hr, 93%; and Rs 92/q, respectively. The fuel consumption and labour requirement were 0.75 l/hr and 3.33 man-hr/q, respectively. These modifications improved stripping efficiency (95%) and output capacity (120 kg/hr). The modified unit gave cost of stripping of Rs 50/q.

**Manually-operated Machinery**

***Rice seeder:*** AAU, Jorhat Centre of AICRP on FIM conducted feasibility testing of four different types of manually operated paddy drum seeders (24, 20, 12 and 8 kg wt). The mechanical drum seeders resulted in saving in time over manual line sowing conventional practice which varied from 78 to 95%. The most efficient operation (95% saving in time) was performed by plastic drum seeder. The operation speed of seeders varied from 1.88 to 2.61 km/hr. The field capacity varied from 0.139 to 0.283 ha/hr.

The grain yield with the use of different seeders varied from 2.94 to 3.28 t/ha.

***Machine for making bamboo sticks:*** A prototype of simple manually-operated machine for making sticks of bamboo for use in manufacture of incense sticks (*agarbattis*), has been developed at CIAE, Bhopal. The capacity of the machine is about 5 kg of sticks per person-day (8 hr). The estimated cost of the prototype is about Rs 3,000. The machine is capable of providing gainful supplementary employment, with reduced drudgery and risk of injuries to the rural people living in areas contiguous to bamboo forests.

**Self-propelled Machinery**

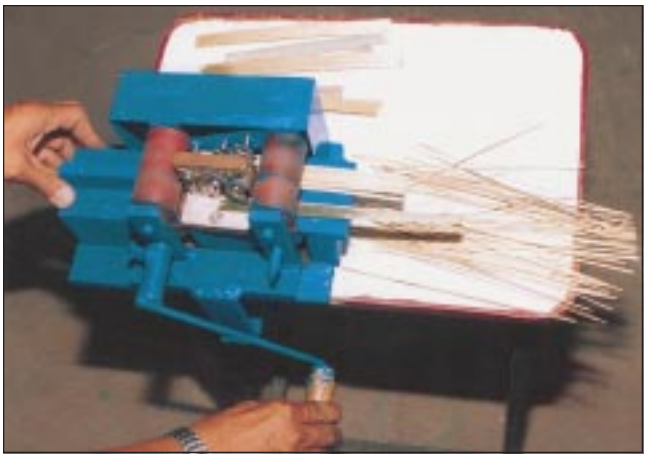
***Tree climber:*** TNAU, Coimbatore Centre of AICRP on FIM has developed a tree climber free from any accident risk during its operation. The climber made of MS square pipe consists of two components. The components are connected by adjustable belts. The upper component is provided with a seating arrangement and lower component is having provision for holding the foot.

With tree climber the operator can safely climb a tree of 10 m height in 1.5 minutes

The rubber cushioning is provided at the portion of frames, which comes in contact with tree to avoid any damage to the tree. By standing on the lower component, the upper component can be moved up or down over the tree. The operator can safely climb a tree of 10 m height in 1.5 min. It costs Rs 2,000.

***Vertical conveyor reaper:*** AAU, Jorhat Centre of AICRP on FIM conducted feasibility tests of self-propelled vertical conveyor reaper for harvesting rice. The machine gave effective field capacity of 0.176 ha/hr at forward speed of operation of 3.63 km/hr. It saved 94% in labour over conventional method of manual harvesting with sickle.

***Mini-combine for safflower***: For efficient harvesting and threshing of safflower crop, MPKV, Rahuri Centre of AICRP on



Bamboo stick making machine developed by CIAE has the capacity of 5 kg sticks/person-day (8 hr)

FIM has adapted a self-propelled mini combine after incorporating modifications in threshing and cleaning section. The mini combine is equipped with 4.4 kW engine. The unit is provided with a cutter bar of 1,000 mm length. It has been modified by introducing blower, straw outlet and sieve shaker. The cylinder concave was also replaced as per the suitability of safflower crop. The cylinder speed was increased to 14 m/sec. The provision of straw outlet was made at the other end of cylinder. A louvere was fitted to the side of cylinder where the material flowing through the concave was conveyed to the sieve. The seed and straw were separated using 7.8 mm hole size sieve and straw blower. The machine was evaluated for harvesting safflower and soybean crops. The average plant height and row spacing were 575 mm and 450 mm, respectively. It was operated at forward speed of operation of 1.53 km/hr for harvesting. The average stem diameter at cutting height was 6.95 mm for safflower at 140 mm height of cut. The cut crop was passed to the threshing section through conveyor. The working width was 900 mm. The actual field capacity and field efficiency were 0.11 ha/hr and 80.26%, respectively. The threshing and cleaning efficiencies were 100% and 90.73%, respectively. The total losses were 5.05%. The cost of operation was Rs 1,365/ha.

***Fodder harvester:*** PAU, Ludhiana centre evaluated self-

- Tractor-mounted turmeric digger found suitable for harvesting turmeric sown on ridges as 600-750 mm row spacing
- Feasibility testing conducted for power-operated sunflower thresher
- Power tiller-operated manure spreader developed. The savings in cost and time of operation were 85% and 94% than manual method of manure spreading
- A manually-operated device for mechanizing the operation of stick making for incense sticks developed on request of Madhya Pradesh State Minor Forest Produce (T&D) Co-operation Federation Ltd

**SUCCESS STORY**

### Self-propelled Rice Transplanter

KAU, Tavanur Centre carried out feasibility testing of 8-row riding type Yanji self-propelled rice transplanter. The transplanter has overall dimensions of 2,400 × 2,300 × 1,200 mm and its weight is 305 kg. It is equipped with 3.5 hp diesel engine which provides positive displacement of seedlings in the soil leaving minimum missing hills. Because of the float the transplanter did not face any problem of sinking in different soil conditions. During field trials the machine operator was accompanied with two labourers to check and regulate the mat seedlings. The Yanji transplanter has provision to regulate spacing between hills (120-140 mm) and adjustment for seedlings/hill (2-8 nos.). It costs Rs 1.30 lakh and field capacity was found 2,025 $m^2$/hr. The seedlings/hill and missing hills were 2.25 and 7.30%, respectively. At planting depth of 60 mm and row spacing of 238 mm the hill spacing varied from 120 to 140 mm. It saved 40% time, 78% labour and 46% in cost of operation. It also saved 35% seed.

The Centre raised nursery using 50-55 kg/ha seed rate in 75 $m^2$ area. Seedlings of 16-22 days were used for self-propelled rice transplanter. Demonstration of raising mat seedlings without polythene sheets on the roof top of the terraced houses of farmers were successfully taken up at Kadavalloor Panchayat in Thrissur district. An area of 4.6 ha was transplanted with the use of such seedlings which reduced the requirement of separate nursery area and time gap between harvesting and transplanting. In Kole lands at Kattukambal in Thrissur district raising of mat type nursery and transplanting for 17 ha area was performed by trained woman workers. In Thuzhur Panchayat of Thrissur district village women accomplished mechanized transplanting operation efficiently.

The transplanter was also found suitable for low-lying clayey fields in Malappuram, Thrissur and Palakkad districts. At Puthssery and Anakkara Panchayat, trainings were organized for 28 farm women and 4 unemployed youth in addition to on-farm training of mechanized rice transplanting.

At present 125 units are working in the state reducing the labour requirement to one-fourth and cost of cultivation to half.

**SUCCESS STORY**

### Tractor-mounted Multipurpose Implement for Sugarcane

Tractor-mounted multipurpose equipment for sugarcane has been developed by IISR, Lucknow Centre of AICRP on FIM. There are two versions of this equipment. The first model is a three-row sugarcane planter mode. The equipment can be used as (i) 9-tyne cultivator, (ii) for intercultural operation, and (iii) earthing-up operations with minor adjustments. It can also be used as seed drill and paddy puddler. Attachments costing Rs 1,600 and Rs 4,000 are needed to use the equipment as seed-drill and puddler, respectively. The second model is basically a two-row sugarcane planter. For land preparation the equipment can be used as tractor-operated 9-tyne cultivator. For interculture it can be used for intercultural operation in sugarcane field. The field capacity in interculture mode is 0.72 ha/hr. Three inter-row spaces are intercultured in a single pass. For earthing-up, three-rows of cane can be covered by this equipment with a field capacity of 0.66 ha/hr. For puddling, beater type sub-unit is mounted with the main frame of the equipment having field capacity of 0.35 ha/hr.



Tractor-mounted multipurpose equipment under interculture mode (a), in seed drill mode (b) and in puddling operation (c)

The tractor-drawn multipurpose equipment was tested in interculture mode for sugarcane (Copt 90223) spaced at 750 mm. The forward speed of operation, field capacity and cane damage were 4.20 km/hr, 0.72 ha/hr and 3.5%, respectively.

The earthing-up mode of tractor-drawn multipurpose equipment was tested for sugarcane with row spacing of 750 mm. At tractor forward speed of operation of 4 km/hr, the field capacity was 0.66 ha/hr. The working width of equipment was 2,500 mm.


This machine can perform six functions by fitting different attachments. It can work as two- or three-row sugarcane cutter planter, nine row cultivator, interculture equipment, puddling equipment, earthing equipment, paddy-puddler and seed-drill.

Demonstrations were organized for farmers and manufacturers under different soil and crop conditions in 80 ha. The manufacturing of multipurpose equipment has been taken up by M/s Sunrise Industries, Barabanki who have already marketed 50 units.

propelled fodder harvester with crop gathering mechanism for berseem mixed with mustard. To eliminate problems in transmission system of crop gathering mechanism, two guiding shields were employed on both sides behind the cutter bar to make a windrow of the cut fodder. The harvester was operated at forward speed of 1.5–2 km/hr. The effective cutting width was 1,250 mm. The

height of cut and fuel consumption varied from 35 to 50 mm and 0.5 to 0.6 l/hr, respectively. The field capacity varied from 0.12 to 0.15 ha/hr with field efficiency from 55 to 62%. The labour requirement varied from 34 to 40 man-hr/ha.

**Mechanized Farming in Hill Region**

To mechanize rice sowing in hills, six-row manual mat type rice transplanter (PAU model) was evaluated by HPKV, Palampur Centre of AICRP on FIM at farmer's field for feasibility in villages namely lower and upper Lambagaon, Kothi Pahara, Barli, Kothi, Ghar, Bayara and Malan in 2.5 ha. The transplanter was operated at 20 cm row spacing and 10–15 cm plant spacing. The average field capacity and field efficiency was 0.033 ha/hr and 56%, respectively. The labour requirement was 61 man-hr/ha as compared to 250 man-h by conventional method. The cost of operation of equipment was Rs 488/ha as compared to Rs 2,000/ha with hand transplanting method. The field trials gave 3–4 plants/hill. There was saving of 68% in cost of transplanting including nursery raising compared to hand transplanting with root washed seedlings.

***Anthropometric and strength data of agricultural workers:*** AICRP on ESA started a programme on collection of anthropometric and strength data of agricultural workers through its co-operating centres as well as ad-hoc research schemes. Keeping into consideration the design requirements of agricultural hand tools and machinery, 79 body dimensions and 16 strength parameters have been identified for inclusion in the survey. At present, the data collection work is being carried out by 7 ESA centres and 7 ad-hoc schemes in 13 states. For measurement of body dimensions the equipment used is either the Harpenden Anthropometer or Siber Hegner Anthropometer or IIT, Kharagpur Anthropometer. For measurement of strength parameters, a strength measurement set-up developed at CIAE Bhopal is being used. Till date, data on 79 body dimensions for 8,241 agricultural workers from ten states and strength data on 16 parameters for 2,536 workers from three states have been collected. The mean stature and weight of agricultural workers on the basis of data collected so far worked out to be 163 cm and 53.8 kg, respectively for male workers and 151.2 cm and 45.9 kg, respectively for female workers.

***Status of adoption of safety measures on threshers:*** PAU Centre carried out a study to know the status of adoption of safety measures on threshers. The centre surveyed the threshers made by 30 manufacturers.

In all the spike tooth type threshers feeding chute was used and the chute dimensions were as per the BIS standard (IS 9020-2002). In Harambha type threshers only 36% manufacturers were providing safe centre-to-centre distance between conveyor rollers (> 1,200 mm) and about 44% of manufacturers were providing safe length of cover at feed inlet side (≥ 450 mm). In 75% cases only the feed reversing system was provided. In 30% cases only full covering over transmission system was provided, whereas in remaining cases only partial covering was provided. About 69% of manufacturers were not aware of recommended measurements for the conveyor dimensions.

- To mechanize rice sowing in hills, six-row manual mat-type rice transplanters evaluated at farmers' fields for feasibility
- Tractor-mounted multipurpose equipment for sugarcane developed with two versions
- For more cost-effecive and energy-efficient rice-wheat system, the cultivation operation mechanized for timeliness of field operation and to reduce energy demand
- Study carried out to know the status of adoption of safety measures on threshers
- Double gear type pedal-operated paddy thresher developed and evaluated with 15 women workers

**SUCCESS STORY**

**PAU Self-propelled Walk Behind Type Sprayer**

Crop spraying in most parts of Punjab is carried out with knapsack sprayers. Output from these sprayers is not uniform. Tractor-operated sprayers are not popular because of unsuitability of tyre width for the row spacing of 200 mm. To solve these problems, PAU, Ludhiana Centre developed light weight boom sprayer with narrow rubber wheels.

PAU self propelled walking type sprayer in operation

The sprayer was evaluated at Departmental research farm for spraying weedicide. After initial trials, machine was tested at 20 farmer's fields covering 70 ha for wheat crop, 10-15 days after first irrigation. The tank was filled with water and weedicide was added as per recommendation. The field capacity varies from 0.7 to 0.8 ha/hr at forward speed of operation from 2.5 to 3 km/hr. There is saving in labour requirement by up to 80% and cost of operation by 50% as compared to knapsack sprayer. The design has been taken up by a manufacturer for commercialization and ten units have been sold.

Only 40% of the manufacturers were providing operator's manual. Cautionary notice for proper working of machines was provided by 27% of the manufacturers. The centre also surveyed available threshers with 20 farmers and it was observed that only 20% of the threshers had ISI certified feeding chutes. In 15% of the threshers the transmission system was not covered at all, whereas it was partially covered in 35% and fully covered in the 50% of the threshers. It was also observed that in 20% cases the farmers have removed the covers provided by the manufacturers. None of the farmers were aware of the recommended dimensions of the safe feeding systems. About 60% of the farmers expressed the need of adjustable feeding platform and 85% of the farmers preferred to have automatic feeding provision.

***Status of adoption of safety features of chaff cutters:*** PAU Centre carried out a study to know the status of adoption of safety features on chaff cutters made by 29 manufacturers in Punjab. About 69% of the manufacturers did not provide gear reversal mechanism. Cutting mechanism was found to have no safety features namely flywheel locking device, front safety guard and covers on each blade and emergency stop control as specified in BIS standards (IS: 11459-1995, specification for power-operated chaff cutter and IS 7898-2001, manually-operated chaff cutter). 90% of the manufacturers did not provide belt cover/shields and pulley covers. Almost all the manufacturers were not providing instruction plate, caution notice and operator's manual. Only two manufacturers out of 29 were providing feeding chute of recommended size (900 mm). Gear cover was not available in 24% of the cases and flywheel cover was absent in 40% of the

Vibration isolator attached under the seat of a tractor

**SUCCESS STORY**

**Mechanization of Rice-Wheat Cropping System**

To make the rice - wheat system more cost - effective and energy efficient the cultivation operations were mechanized for timeliness of field operations and to reduce energy demand, cost of production, production losses and drudgery of the tasks involved following conservation approach. Mechanized cultivation of transplanted rice compared to the farmers' practice (grain yield, t/ha=4.62 and benefit : cost ratio=1.78) showed 16.9% higher grain yield with 30.8% increased benefit : cost ratio. Zero and minimum tillage-seeding of wheat were time, fuel and cost effective for 62.4-71.8, 50.7-69.1 and 49.8 - 68.3% respectively than the conventional tillage (03-passes)–seeding (time, hr/ha = 12.35, fuel used, l/hr = 39.5 and cost of operation, Rs/ha 2,174). The conservation tillage wheat was advantageous in terms of higher net income and benefit : cost ratio for 11.53-16.02 and 15.4-21.9% respectively over the conventional practice (net income, Rs/ha =17,955 and benefit : cost ratio=2.63).

Cultivation of wheat on permanent beds gave 7.9% higher grain yield and 26.5% higher benefit : cost ratio, besides saving 33.3% of irrigation water compared to conventional sown (grain yield, t/h = 4.46, benefit : cost ratio = 2.63 and water requirement, mm/ha = 600). Mechanized harvesting by combine harvester was cost effective for 35.7% over reaper thresher combination (cost of harvesting and threshing, Rs/ha = 2,311) and 67% over manual harvesting and threshing (Rs/ha = 4,500), besides ensuring timeliness with reduced losses to late matured crop. Retrieval of wheat straw by straw combine (straw recovery = 55%) after grain combining was profitable for Rs 1,800/ha and by straw baler for rice (straw recovery = 45%). The profit margin was Rs 650/ha in place of burning of straw in the field by farmers.

Mechanized transplanting of rice

Zero till drilling

Strip till drilling

Roto till drilling

Seven improved equipment and eight cultivation practices were developed based on feedback from farmers. The technology transfer activities included 38 on-farm trials with 42 adopted farmers, 344 FLDs covering 907 ha in 40 villages, 14 trainings for 267 beneficiaries and 20 fields. Five manufacturers have taken manufacturing of these equipment for rice–wheat cropping system and farmers have started adopting the improved equipment.

cases. None of the users had operator's manual for their chaff cutters.

***Anti-vibration devices for increased comfort:*** For power tiller and tractor operators, anti-vibration devices for increasing comfort were developed.

*Power tiller operators.* The TNAU Centre of AICRP on ESA has developed vibration isolators for engine, handle bar and handle of the power tiller and tested their efficacy for attenuation of vibrations transmitted to the operator. The provision of isolators resulted in reduction of handle vibration by about 50% and the same was demonstrated to the power tiller manufacturers for adoption.

*Tractor operators.* The TNAU Centre of AICRP on ESA has developed vibration isolator for tractor seat and tested it for attenuation of vibrations transmitted to the operator. The provision of isolator below the seat helped in reducing the vertical vibrations transmitted to the operator by 30-80% in different operations at speeds ranging from 2.5 to 4.5 km/hr. The unit was demonstrated to tractor manufacturers for adoption.

**Ergonomical Evaluation of Tools and Equipment by Women Workers**

The following equipment were ergonomically evaluated using women workers:

***Irrigation pedal pump:*** The OUAT Centre evaluated a pedal pump for irrigation with 15 women workers. Its output was 3,290 l/hr at 3.4 m suction height. The mean working heart rate of the workers was 120 beats/min and the ΔHR (increase in heart rate over resting) 50 beats/min. The mean oxygen consumption rate of the workers was observed to be 0.63 l/min.

***Pedal-operated paddy thresher:*** The OUAT Centre of AICRP on ESA developed a double gear type pedal-operated paddy thresher. It was evaluated with 15 women workers. Mean heart rate during work was observed to be 127 beats/min and the mean change in heat rate values was 55 beats/min. The oxygen consumption rate was 0.86 l/min. The output of the thresher was 30 kg/hr. As the physiological workload is on higher side it is recommended to operate the thresher by two women workers in tandem so as to get comfort as well as output.

Ergonomic evaluation of irrigation pedal pump

Ergonomic evaluation of cotton stalk puller

Ergonomic evaluation of groundnut stripper

***Four-row paddy transplanter:*** The CRRI four-row paddy transplanter was evaluated with 15 women workers. The mean heart rate during work was 138 beats/min and the ΔHR value was 68 beats/min. The oxygen consumption rate was observed to be 1.0 l/min. Output per hour with the four row unit was 0.017 ha/hr.

***Two-row paddy transplanter:*** The CRRI two-row paddy transplanter was evaluated with 15 women workers. The mean heart rate during work was 135 beats/min and the ΔHR value was 65 beats/min. The oxygen consumption rate was observed to be 0.99 l/min. Output with the two-row unit was 0.008 ha/hr.

***Cotton stalk puller:*** The TNAU Centre of AICRP on ESA refined the existing design of cotton stalk puller and evaluated it with 10 subjects. The mean heart rate during work was observed to be 125 beats/min and the ΔHR values was 41 beats/min. The oxygen consumption rate was 0.535 l/min. Output with this equipment was 0.028 ha/hr. The performance of the refined equipment was better than the original unit and it can be recommended for adoption.

***Groundnut stripper:*** The TNAU Centre of AICRP on ESA

refined the existing design of groundnut stripper available at TNAU. It was evaluated with ten women workers and the mean working heart rate was observed to be 93 beats/min and the ΔHR as 15 beats/min. In a day one worker can strip about 88 kg of pods and four workers can work simultaneously with this equipment.

***Four-row paddy seeder:*** The TNAU Centre evaluated four-row paddy seeder with ten women workers. The mean heart rate of the workers during operation was 139 beats/min and the ?HR being 48 beats/min. Two women are employed in cyclic system for operation of this equipment. After filling the seeds in the drum it takes about 25 minutes to get it emptied. Then the another worker fills the drum with seeds and operate the equipment for 25 minutes, whereas the first operator takes rest. This system helps to enhance comfort of the operator and also in maintaining efficiency of the implement. Output with this equipment was observed to be 0.06 ha/hr.

***Fruit harvester:*** The KKV make fruit harvester was refined by TNAU Centre of AICRP on ESA and it was evaluated with ten women workers for sapota harvesting. Mean heart rate during work was 114 beats/min and the ΔHR was 35 beats/min. The oxygen consumption rate was observed to be 0.460 l/min. The output with this unit was 420 fruits/hr.

Ergonomic evaluation of fruit harvester

***Sugarcane stripper:*** The IISR design of sugarcane stripper was evaluated with 15 men and 15 women workers at OUAT, Bhubaneswar of AICRP on ESA. The mean heart rate during work with this equipment was observed to be 119 beats/min and 116 beats/min for men and women workers, respectively. The corresponding ΔHR values were 42 beats/min and 47 beats/min whereas the oxygen consumption rates were 0.57 l/min and 0.51 l/min. The output values per hour were 49 kg/hr for men and 46 kg/hr for women workers.

**Effect of Pearling on Recovery of High Quality Low Fat Degermed Maize**

CIAE model grain pearler was evaluated for pearling of maize grain, which facilitates the removal of germ from the kernel and preparation of maize flour and semolina for further development of extruded products. Cleaned and graded maize was initially conditioned to 22% moisture content (wet basis) and then tempered for 8 hr. Then it is fed to grain pearler for pearling for different durations. The effect of pearling was seen on complete degermed maize recovery. The degermed maize recovery was obtained as 46.6, 74.7, 76.0 and 76.3% for 5, 10, 15 and 20 minutes pearling, respectively. Among the above duration of pearling, 10 minute pearling of maize having 22% moisture content is considered to be optimum duration of pearling giving degermed maize recovery to the tune of 75%. The fat content of degermed maize was found significantly lower, whereas protein content was comparable with whole maize kernel. Ash content of degermed maize kernel was also lower which is desired for the development of low fibre food products from the flour of degermed maize.

**Effect of Pre-milling Treatment on *dal* Recovery**

Pigeonpea grains treated with cottonseed oil at different moisture contents (8–12%) were milled to see the effect of pre-milling treatment. 10% moisture content (wb), in the 0.2% cottonseed oil treatment and 12 seconds milling time was found optimum for milling of pigeonpea. Maximum gota recovery of 58% was observed at optimum condition. Milling efficiency at optimum condition was about 89%. A study was conducted to observe the effect of moisture content on per cent pitting of pigeonpea. Moisture content of the pigeonpea varied from 6 to 14%. Pitting of the grain was done using CIAE, *dal* mill. The per cent pitting increased up to 10% moisture content and then decreased. Maximum pitting of 80.5% was observed at 10% moisture content (wb) and surface of about 50% grains was cracked during pitting.

- Grain pearler evaluated for pearling of maize grain
- An integrated paddy dryer using biomass, solar and electricity developed
- Finger millet selected for effective combination with soy cereals for preparation of biscuits and extruded convenience ready-to-eat food products
- Vegetarian kabab prepared using soybean tofu, Bengalgram splits in different combinations
- Project profiles on processing of mustard, wheat soy, milk, pulses, spices, cattle feed, fruit and vegetables, and rural godowns drafted
- Arecanut dehusker designed and evaluated. The manual dehusker has been in great demand in Karnataka.

**Technology for Processing of Wild Pomegranate for Quality Anardana**

Keeping present day demand, technology has been developed at CIPHET, Abohar for processing of wild pomegranate to get anardana with desirable quality parameters. Cabinet cross flow drying at 55 for 7 hr produces the quality anardana with desirable

range of acidity (6.4%), vitamin C as ascorbic acid (15.5 mg/100 g) and red colour (41.71 as L value on hunter Lab colorimeter). The product when packed in 200 gauge LDPE has been found effective in retaining the quality parameters up to one year.

**Integrated Paddy Dryer**

An integrated paddy dryer (1 tonne capacity) using biomass, solar (30 panels of 1.5 m × 0.9 m) and electricity (10 kW) as sources of heat was developed at CIPHET, Ludhiana. The energy required to dry paddy from 22% to 14% in 6 hr was calculated and collector area was determined. Iron fillings were provided in each panel to store thermal energy during peak hours and release slowly during off sunshine hours. The solar air heaters were evaluated for their performance at no load condition with varying flow rates. The maximum outlet air temperature was 83°C at a flow rate of 2.08 $m^3$/min, whereas outlet air temperature was 40°C. The maximum air temperature was observed between 1 and 2 PM. The average flow rates were 1.15, 1.62 and 2.08 $m^3$/min with one, two and three blowers running respectively. Drying of paddy from 22.5% to 13.9% moisture content took 6 hr. The fast drying is due to the high solar insulation.

**Rural Level Production of Potato Chips**

A pedal-operated potato peeler of 1.5 t/day capacity was developed and tested. All food contact parts of the machine have been made of stainless steel to avoid corrosion or any other infection to potato chips. The peeling efficiency of the peeler is above 90%. Estimated cost of the machine is approximately Rs 7,000.

**Evaluation of Integral Extrusion-Expelling Unit**

As soybean is a low oil bearing material containing only 20% oil and also has a relatively hard seed grain, mechanical expression of oil from soybean requires many passes and pre-treatments. Extrusion-expelling overcomes this and recover almost 70% of oil in a single pass. However it has two separate units, one as extruder and another as expeller causing inconvenience in operation. An integral unit consisting of the feature of both has been developed and evaluated for its performance. The first section of the integral extrusion expelling unit works as extruder, whereas the later half of the unit works as an expeller. The unit is capable of expression of good quality soy oil in single pass without adversely affecting the cake quality. The unit was operated with a die having no restriction at the end as well as with restriction. The experiments were carried out using five levels of feed moisture, three levels of particle size and three levels of rpm. The maximum oil recovery of 72% was achieved using soy grit at 98 rpm in a single pass.

**Soy-Finger millet Based Biscuit and Extruded Product**

Refined wheat flour, the major ingredients for biscuits was substituted with four levels of finger millet flour in standard SPU recipe of soy-fortified biscuits. As level of finger millet flour incorporation increased, protein content of the biscuit decreased but the fat content and spread factor increased. Sensory panel assessments for appearance, colour and texture indicated that biscuits containing 80% flour of finger millet and 10% skim milk

Soy-finger millet based biscuits. The process and recipe have been standardized and is ready for commercial application

The extruded products have been prepared by substituting maize with finger millet

Vegetarian kabab has been prepared using soybean tofu and Bengalgram splits in different combinations

**SUCCESS STORY**

**Operational Research Project on Agro Processing Centres**

Thirteen agro-processing centres have been established by Bangalore centre of AICRP on Post Harvest Engineering and Technology. In the APCs such as Aradeshahalli, Kuthinagere, Muthanallur and Babygrama, many ragi based food products like ragi malt, ragi roasted flour, ragi papad, ragi biscuit, etc. are being produced and marketed. Packaged ragi flour from APCs has penetrated into the nearby Bangalore city outlets and has been well received and becoming more and more popular. There were many enquiry's from various Self-Help Groups of the region to establish more APCs in their respective areas with PHT Scheme's technical support. PHT Centre of Bangalore has been identified as the nodal centre for conducting a short course on "Post harvest processing and agro-processing centers for value addition in rural areas

powder produced biscuits of acceptable quality and has nutritional value of 10.3% protein. Accordingly the process and recipe for soy-finger millet based biscuits were standardized and is ready for commercial application. The estimated cost of the product is Rs 47/kg product.

Extruded products were prepared by substituting maize with finger millet at three different levels incorporating soy flour at 10% levels in 90 : 10 maize : soy combination and studied the effect on sectional expansion index, longitudinal expansion index and volumetric expansion index, specific length and water-holding capacity decreased. Sectional expansion index decreased, whereas longitudinal expansion index and volumetric expansion index, specific length and water-holding capacity increased. As the level of millet fortification increased, the diameter, moisture content, specific length, water-holding capacity decreased. Incorporation of 10% soyflour and 25% finger millet flour produced extruded products of acceptable quality and had nutritional profile of 11.1% protein. The estimated cost of the product is Rs 35/kg.

**Tofu-based Vegetarian Kabab**

A vegetarian kabab has been prepared using soybean tofu, Bengalgram splits (*dal*) in different combinations, viz. 50 : 50, 60 : 40, 70 : 30 and 80 : 20 with spices. Sensory evaluation revealed that the product prepared with 60:40 (tofu : Bengalgram) ratio was adjudged as the best. Nutritional evaluation of the products indicated that the protein content decreased with increase in proportion of tofu, ranged between 8.87 and 11.19g/100g on fresh weight basis. Crude fat remained almost constant at about 10.2%. The quality of the product was also assured by microbiological evaluation with respect to total bacteria ($2–4 \times 10^3$) yeast and moulds (12–14) per g. The product could be kept safe for 4 days under refrigeration while at room temperature (about 29–32° and 80–85% RH) it could be kept for one day.

**Post-harvest Technology for Rural/Micro Entrepreneurs**

Project profiles on processing of mustard, wheat, soymilk, pulses, spices, cattle feed, fruit and vegetables and rural godowns have been drafted. The project profiles include information on the raw materials, processed products (mustard oil, wheat flour, ground spices, *dal*, soymilk, cattle feed, pickles, jams, jellies), production of raw material (state wise), market demand, process, quality standards, equipment required, list of equipment manufacturers etc. Financial analysis (total capital investment, annual profit, break even point, benefit : cost ratio, IRR and repayment schedule etc.) for each project has been carried out as per banker's methodology. Custom hiring was also considered while conducting financial analysis on milling of mustard, wheat and spices.

**Development of Intermediate Moisture Coconut Chips**

Modified atmosphere packaging technique for mature fresh coconut kernel has been developed in which the fresh kernel could be stored at 25°C for 6 months. Bottling of the kernel along with filling liquid medium would extend the shelf-life of fresh kernel to 3 months. Bottling of kernel cans could further enhance storage life of fresh kernel. Mature fresh coconut kernel paste with preservative could be bottled for the storage period of the paste to 3 months. The storage life of the fresh kernel paste could be further increased by actual canning of the paste. Vacuum packing in PVC film of thickness 0.0952 mm would extend the storage period of ball copra and cup copra to 4 months. A pilot scale fluidized bed dryer of capacity 200 coconuts per batch for drying fresh coconut kernel has been developed. The dryer mainly consists of a blower, heat distribution system and drying chamber. The agricultural waste furnace was used as heat source.

**Machinery for Coconut Processing and Optimization of Drying Parameters**

***Coconut modified splitting device:*** The modified coconut splitting device performance was evaluated and the efficiency was found 514 nuts/hr. The coconut knife bevel angle was standardized as 25° for minimum splitting force of 0.155 N. The nut water drained into a collecting chamber from where it moved into a bucket though a pipe. After splitting the nuts, roll side ways and was collected automatically. The advantage of this device is that any unskilled person could operate with less strain and chances for hand injury are almost eliminated.

***Power-operated de-shelling machine:*** The de-shelling machine was modified. The lip angle of the flight was fixed at 70°

**SUCCESS STORY**

**Soy-based Cottage Level Enterprises**

Simple and low cost technologies have been developed for cottage scale at Soybean Processing and Utilization Centre, CIAE Bhopal. The Centre has also started entrepreneurship development programme for upcoming entrepreneurs in 1995 for production of good quality acceptable soy-based products at cottage scale. The training is imparted on three major topics : soymilk and paneer production, production of fullfat soyflour and soy fortified bakery products, and soy based snack foods.

So far 659 participants have been trained in 64 batches on the above three topics and more than 163 soy- based cottage level enterprises have been set up based on these trainings in Punjab, Haryana, Maharashtra, Madhya Pradesh, Gujrat, Utter Pradesh, etc.

based on preliminary tests conducted, so that the nuts can fall freely from the flight uniformly in the de-shelling chamber. The de-shelling machine was tested for its performance evaluation with partially dried copra having moisture content of 66.4–25.7% db. The optimum average moisture content for de-shelling was 35% db At 35% (db) moisture content the de-shelling efficiency was 82.5%. The effect of number of rotations on the de-shelling efficiency was explored at moisture content 35% db. Nuts (400 half cups) were loaded manually and the machine was operated.

At 30 rotations the efficiency of the machine was 85.64%, at 40 rotations the efficiency was 92.16% and this further increased to 93.5% by rotating 50 and 60 times. Hence, the optimum number of rotations was fixed as 40. The de-shelling time based on the speed of reduction gear output was four minutes. The relationship existing between moisture content and de-shelling efficiency was non-linear. The cost of de-shelling machine was Rs 27,100. The cost of de-shelling 1,000 nuts was Rs 53/1,000 nuts. The cost involved in de-shelling using human labour was Rs 36/1,000 nuts but the time taken is more than four times as compared to machine.

***Development of copra dryer:*** Copra dryer was designed, developed and evaluated to dry coconut in 24 hr. The capacity of the dryer developed was 1,000 nuts per batch. The heating chamber was designed such that smoke does not come into contact with copra. Specially designed rolling in fuel trays were fabricated to hold coconut shell for burning. The burner designed generated heat for 5 hr without tending and the heat is retained for one more hour. The drying air temperature in the drying chamber was 80°C. The quality of copra obtained was light brown in colour. The oil content was 62.48–63.55%, indicate no loss of oil from copra dried at drying air temperature 80°C. The thermal efficiency of dryer at full load was 25.25–26.48% but decreased when the load was reduced to half to 9.41%. The cost of the dryer was Rs 15,000. The cost of drying one kg copra in the dryer was Rs 5.33. The cost of drying one nut excluding the cost of nut works out to be Re 0.93.

***Commercialization of arecanut dehusker:*** The AICRP on PHT, Bangalore Centre has designed and evaluated arecanut dehusker. The equipment was demonstrated through KVK, Hiriyur to many Swashakthi groups of women. Based on feedback, the outlet of the dehusker was modified for operational convenience.

**Use of Plastics in Paddy Thresher**

At VPKAS, Almora polycarbonate sheet were utilized in development of pedal-operated paddy thresher-cum-pearler. The machine was basically designed and developed for hilly region where the weight of the machine is the major concern. The GI sheet replaced by polycarbonate sheet of 1 mm thickness, reduced the total weight of the machine to 40 kg. The total weight reduction was 10% and provided better look. The machine appears to be less noise producing during operation as compared to the metal body. Also it reduced the probability of injury hazards during operation. The plastic body has another advantage of being rust proof. The frame of the machine is made of angle iron and MS pipe. The machine is manually operated by single man/ woman. The output capacity of the machine is 80–100 kg/hr and its efficiency was found to be 98%. Its approximate cost is Rs 3,500.

**Plastic Mulch Laying Machine**

The trials of machine were conducted at CIAE Farm and at IIVR, Varanasi on 0.3 ha using white colour plastic sheet of 25 micron thickness. Plastic sheets from 5 to 30 micron thickness and up to 1,500 mm width could be used on the machine. CIAE,

Plastic mulch laying machine. Plastic sheets from 5 to 30 micron thickness and up to 1,500 mm width can be used on the machine

Bhopal Centre of AICRP on FIM conducted feasibility testing of plastic mulch laying machine in 0.2 ha for groundnut crop with 1,100 mm mulch width. The machine was set for 800 mm plastic mulch bed. Sowing on the plastic mulch beds was performed manually at 200 mm row and plant spacing. The field capacity and field efficiency of the machine were 0.16 ha/hr and 58.7%, respectively. The labour requirement was 12.5 man-hr/ha with the use of machine as compared to 278 man-hr/ha in manual mulching practice. The cost of operation was Rs 1,544/ha in comparison to Rs 3,336/ha in conventional practice.

**Live Fish Transportation System**

A cycle rickshaw based system developed at CIPHET, Ludhiana was used for live fish transportation. An insulated box having outer size of length 135 mm, height 860 mm and width 840 mm was fabricated with double wall mild steel iron sheet. Thermo-coal insulation was provided between the iron walls. This box is mounted on the standard cycle rickshaw. The box can hold 8 numbers of plastic crates of size 540 × 360 × 295 mm in two layers of four crates each. The total capacity of icebox is 150 kg of fish with 80% filling of each plastic crate and 1:1 ratio of ice and fish. This was evaluated with the freshwater fish (Catla). The ice and fish is arranged in alternate layer. The top and bottom layer is filled by ice.

**Drying of Onion and Chilli in Greenhouse**

A study on application of greenhouse for drying onion slices has been conducted at CIPHET, Abohar The overall acceptability was found better in the samples pretreated with 0.3% KMS, followed by 0.5% NaCl and control. The slices dried in forced ventilated polyhouse gave better acceptability with better rehydration ratio, followed by slices dried in low cost polyhouse with chimney and open sun-drying.

Drying of chilli in polyhouse was studied at PAU, Ludhiana and it was found that the total drying time for the drying of chillies in green house and open air drying was 8–9 days and 9–11 days, respectively which was 1–2 days less than the open air drying to attain the moisture content equal to the moisture content of the green house dried chillies. Moreover the dust and other impurities had to be sieved in open air drying before use which took extra time and labour. The relative humidity and the temperature followed the exponential trend. The capsaicin content of the green house dried chillies was higher by 10% than the open air-dried chillies.

**Packaging Fruits and Vegetables**

Studies on packaging of selected fruits and vegetables was conducted at CIPHET, Abohar and it was found that: Shrink wrapping of kinnow fruit drastically reduced the weight loss as compared to unwrapped fruits. Acidity and ascorbic acid decreased while total soluble solids increased during storage. Changes in biochemical composition were almost inconsistent for different plastic films. However, plastic film (LDPE) with least thickness (20 and 25 m) was found to be worthwhile proposition for individual shrink wrapping of kinnow fruit due to their delaying effect on fruit deterioration. The results indicated that shrink wrapped fruit stored at low temperature could be kept up to ten weeks as against four weeks at ambient condition.

**Fish Feeders**

At CIFA, Bhubaneshwar, three demand fish feeders, each of capacity 30 l (13 kg feed) were installed in three different silos with 3, 6 and 9 $m^3$ water volumes and 0.8, 1.6 and 2.4 m water depths, respectively during December 2004. In other three similar silos the fish feeding was done by feeding trays and they were treated as controls. The efficiency of demand feeders was found better in comparison to control in different silos irrespective of depth.

**Soil Solarization for Weed Control**

An experiment on soil solarization for weed control in brinjal nursery was carried out at PAU, Ludhiana and it was found that maximal soil temperature at a depth of 5 cm reached nearly 60°C under polyethylene covered plots, whereas it was only 51°C in the uncovered plots. There was large increase in temperature in the upper soil layer (5 cm) under polyethylene with increase of 8-10°C in maximal soil temperature compared with unmulched soil. The maximal temperature lasted for 2-3 hr. The number of days when the maximum soil temperature equalled or exceeded 50, 55 or 60°C under different treatments was also observed. Solarization reduced total dry matter accumulation and density of weeds at 15, 30 and 45 days after the PE films had been removed. Weed dry matter accumulation was reduced from 241.1 g/$m^2$ in control plots to 10.4 g/$m^2$ in solarized soil for 45 days.

***Performance evaluation of modified double roller gin:*** The improved double roller gin developed is sturdy and operator friendly. It consumes 30% less energy than conventional machine.

***Evaluation trials on stick machine and saw band cleaner:*** A stick machine and saw cylinder cleaner designed and developed at CIRCOT, Mumbai were evaluated for their performance with four mechanically picked cotton varieties, viz. CNH 120 MB, GSH 2, CNH 123 and PKV 081. It was noted that the cleaning system could effectively improve the grade of the lint and there was no deleterious effect on fibre attributes.

***Burning behaviour of cotton bales:*** Studies on burning behaviour of cotton bales were carried out for M/s. New India Assurance Co. Ltd. The study revealed that a single bale when set on fire took only 27 hr to turn to ashes completely. The hoops remained more or less intact. Addition of inflammable material like diesel initially to sustain the fire did not reduce the time of gutting. Attempts to partially quench the fire decreased the time of gutting substantially. The fire propagates very fast in loose cotton mass along the edges of the bale.

***Effect of different mordants on dyeing of polyester–cotton blended fabrics with natural dyes:*** In a small-scale trial, about 7 m of mercerized heatset polyester:cotton blended fabric was mordanted with alum and dyed with manjishtha. For mordanting, a winch was used and dyeing was carried out on jet-dyeing machine. The dyebath exhaustion from this dyeing was 50%. The exhausted dyebath was reused to dye cotton fabric. Final exhaustion value of dyebath was 56%. The dyed fabric retained the colour even after 15 washing.

***Commercial testing:*** During this year approximately 6,500 cotton fibre sample were tested for quality evaluation and an amount of Rs 21,37,162 alone was received as test fees.

***Electronic fibre bundle strength tester:*** Manually-operated jute fibre bundle strength testing instrument, designed and developed by NIRJAFT has been in use for more than three decades. The instrument results in about 5% error in addition to the human errors involved in operation. The current electronic instrument is a newly developed precision instrument for automatic operation and recording of data digitally which will completely remove the human error. Moreover, as the instrument is totally portable, it can be used in fields as well. The results can be stored automatically in built-in memory of the instrument which can be downloaded in laboratory with PC interface. This instrument is useful to jute mills, research and testing organizations, educational institutions and jute promoting agencies.

This instrument is available in four models having different features in the price range of Rs 20,000–65,000.

***Particle board from date-palm leaves – a viable substitute of wood/plywood products:*** Date-palm leaves are suitable for making particle boards having physico-mechanical properties, viz. impact strength, tensile strength, flexural rigidity etc. and swelling properties in water at par or even better when compared with jute stick particle boards. Incorproation of filter in the form of mill waste and agricultural byproducts with thermosetting resin further improves the interfacial bond leading to better mechanical properties of the boards. Moisture content of date-palm leaf (DPL) is low and no additional chemical reagents are required to block the hydroxyl and other oxygen containing groups that attract moisture. The dimensional stability of the boards are well maintained in a wide range of atmospheric conditions. These boards can well be used in making door/window panels, book shelf, false ceiling, table top, tea-table and packaging boxes for packing fruits tea etc. Cost of DPL board will be about 50% less compared to wood/plywood products available in the market.

***Molecular characterization of lac insect lines:*** DNA isolation protocol has been standardized for single mature female lac insect. PCR conditions for screening of primers and RAPD studies were optimized. Preliminary screening of 20 lac insect lines using 8 random primers yielding positive amplicons showed that this technique would be useful for molecular characterization of lac insects at both intra- and inter-specific levels.

Electronic fibre bundle strength tester is a manually-operated device developed by NIRJAFT


Hand-operated lac grader


Hand-operated lac winnower for village level processing

***Melting profiles of waxes from seedlac of different lac producing countries:*** The melting profiles of waxes isolated from seedlac of Indian, Thai and Chinese origin were studied by differential scanning calorimetry. The Thai lac wax contained a major fraction with high melting temperature (98°C) as compared to others. The waxes extracted from seedlac of all the three countries contained two common wax fractions with similar melting temperatures (around 49 and 72°C).

***Biological control of lepidopterous lac insect predators:*** Two lepidopterous predators namely, *Eublemma amabilis* and *Pseudohypatopa pulverea* cause considerable damage (30–40%) to lac crop. *Bacilus thuringiensis* (0.05%) was found at par with endosulfan (conventional insecticide) for control of the lepidopterous predators ( 60–70%) of lac insect.

***Integration of horticulture with lac culture for higher income:*** Continuous cropping of okra, garlic and bitter gourd was done during *kharif*, *rabi* and *zaid* seasons in the inter row spaces of *Flemingia semialata* planted at single paired rows. Significantly higher lac yields were obtained under this system as compared to *F. semialata* without integration. The yield of broodlac and sticklac were 40.7 and 12.2 q/ha, respectively, which were higher by 84.4 and 87.7%, respectively, as compared to control (without vegetable crops).

***Changes in industrial parameters of lac on storage:*** During conversion of seedlac (semi-refined lac) to shellac (refined lac), oxalic acid is sometimes added by the lac industry to improve the gloss. This results in marked decrease in the flow values (fluidity) of shellac with storage. It reduces to zero within 30 months of storage due to polymerization rendering it unsuitable for industrial use. Both seedlac and shellac absorb moisture from the environment under high humid condition. Treatment with suitable antioxidant has been found to reduce this phenomenon. Storage in polybag can also be employed to minimize moisture absorption.

***Gender friendly motor-operated lac grader and lac winnower for village level processing:*** Primary processing of lac involves five major operations namely, crushing, washing, drying, winnowing and grading. Motor-operated lac grader and lac winnower have been developed for value-addition to lac at village level. The capacity of the lac grader and the lac winnower are 60 kg/hr and 500 kg/hr The machines designed are gender friendly and will be useful in reducing drudgery and improve the efficiency.

**Animal Energy**

***Portable electronic weighing machine for animals:*** The portable platform type electronic weighing machine of 1,800 mm × 1,200 mm platform pan has the capacity of 1,500 kg (least count 1%) and has provision of 12V battery and inverter for operation of scale in absence of AC power. Side and front railing have been provided on the system for control of movement of animal on the machine. Weighing system is very compact and could be dismantled and transported easily on a jeep trailer. The system is ready for field use/commercialization.

Portable electronic weighing machine for animals has the capacity of 1,500 kg (least count 1%)

***Animal rotary mode set up:*** To increase utilization of animals, the chaff cutter, winnower, castor/groundnut decorticator, *dal* mill, rice thresher were installed in villages and operated by animals in rotary mode of operation. Six units of rotary mode set up were installed in villages to run the agricultural equipment. With rotary mode of operations, the animals could be used for 28.6% more than the average annual use of 800 hr. It also resulted in saving in fuel and electricity.


Animal rotary mode set up in operation

**Renewable Sources of Energy**

***Dewatering machine for digested slurry from biogas plants:*** Palampur Centre of AICRP on RES has developed a

perforated rotating drum type slurry dewatering machine which suits 85 $m^3$ capacity biogas plants. The machine comprises slurry handling and power transmission assemblies. The filtered water is collected and drained on one side of the machine through a channel. The dewatered slurry moves downward inside the cylinder and is discharged at the lower end. The performance was found best for 4.0° inclination and 108 rpm of the cylinder and around 4,800 litres/hr slurry flow rate. The average initial total solids concentration (TSC) in the input slurry was 6.5%. The TSC of the dewatered slurry was 10.5–11% and that of the filtered water 2.4–2.5%. The dewatered slurry may be sun-dried for about a week and transported to fields for use as manure. The filtered water may be used for preparing fresh cattle dung slurry for feeding into the biogas plant. Normally around 4,000 litres of the digested slurry is discharged everyday from a 85 $m^3$ capacity biogas plant. As such the machine may suit a battery of 4–6 biogas plants of 85 $m^3$ capacity each.

***Pilot plant for anaerobic digestion of rice straw:*** SPRERI, Vallabh Vidyanagar Centre of AICRP on RES has developed and evaluated a pilot plant for anaerobic digestion of paddy straw in thermophilic temperature range. The pilot plant consists of six batch type insulated and externally heated reactors, a gas storage unit, a water heating system and necessary pump, piping, etc. The technology offers a promising alternative to large-scale burning of paddy straw in northern, western and central India and will have advantages of converting paddy straw to convenient source of energy and valuable organic matter for use as manure and avoiding serious air pollution.

***Durable biomass cook stoves for hilly terrains:*** MPUAT, Udaipur Centre of the AICRP on RES Scheme modified the designs of single pot "Chetak" and double pot "Udairaj" cook stoves on the basis of initial multilocation trials. Costs of construction for the Chetak and Udairaj stoves have been estimated to be Rs 190 and 250, respectively. The two stoves have been evaluated and average thermal efficiencies for 1 kg/hr fuel wood burning rate have been reported as 22% for the single pot Chetak stove and 26% for the double pot Udairaj stove.

***High rate anaerobic treatment system for sago industry effluent:*** A 10 $m^3$ capacity high rate biomethanation system for treatment of effluent was installed in a sago factory located in Erode district of Tamil Nadu. The system has been commissioned and is under operation with 1 day hydraulic retention period. The reactor operated for 130 days during the peak season, i.e. March–July, 2005 and for 30 days during off season i.e. July–August, 2005. Around 7,000 litres/day of effluent having COD in the range of 4,900–5,300 mg/litre was treated in the reactor and average biogas yield of 9.2 $m^3$/day was obtained. Methane content of the biogas was 74.5%. The average reductions in total solids, volatile solids, BOD and COD have been reported to be 80.2%, 71.6%, 89.4% and 84.6%, respectively. The sago factories in the region normally produce around 25,000 litres of effluent everyday. A full capacity high rate reactor may produce 35–40 $m^3$ of biogas everyday which may replace around 50% of the fuelwood requirements of the factory. The fuelwood is used for drying of sago granules.

***Use of ethanol as diesel engine fuel:*** Emulsifications of ethanol-diesel fuel blend using 1-butanol as surfactant carried out by GBPUAT, Pantnagar Centre of AICRP on RES have shown profound stability even at lower ambient temperature. The micro-emulsions of diesel fuel with anhydrous (200° proof) and aqueous (195°, 190°, 185°, 180° and 170° proof) ethanol using 1-butanol as surfactant were prepared by splash blending the constituents in different proportions at room temperature (29–34°C). All emulsified fuels, except those prepared with 170° proof ethanol, were found clear and transparent with no sign of phase separation under wide temperature regime of 0-45°C. Various micro-emulsions were found stable during 3 months long duration stability test with respect to temperature, change in viscosity, sedimentation, phase separation, foaming and pH value. A 3.73 kW Kirloskar make stationary constant speed single cylinder compression ignition engine having standard injection timing was tested as per IS : 1000 [P:8] : 1980 using high speed diesel fuel and various micro-emulsion fuels. Of all the fuels tested, diesel – 180° proof ethanol – 1 butanol emulsified in 100 : 11 : 35 parts by volume was found the best with the possibility of substituting about 31% diesel with alcohols.

***Fixed dome modified biogas plant suitable for black cotton soil region:*** The design of conventional fixed dome Janta biogas plant 2 $m^3$ was modified for adoptability in black cotton soil areas by structural improvement through use of 5 piles (20 cm diameter) up to soil depth of 3 m to form pile cap to bear the load on soil of biogas plant. The gap between the plant wall and earth were filled with stone dust to minimize the effect of soil shrinkage/swelling on the plant structure. After evaluation at CIAE Bhopal, 5 units were installed in villages at users' site on cost sharing mode. After stabilization, the plants were charged with fresh cow dung without addition of water for influent preparation. On an average, a saving of 10–20 litres of water/day/$m^3$ of plant has been possible. Use of biogas for cooking has resulted into average saving of 1,000 kg of fuelwood/year/family.

***Family size fixed dome type biogas plants for solid-state feeding of cattle dung:*** These were installed at 25 more selected rural houses located in Tamil Nadu, Karnataka, Madhya Pradesh, Assam, Punjab and Maharashtra. Compared to the common design, these plants require 80–100% less water for operation, produce up to 30% more gas, cost almost the same and

make feeding and handling of the digested slurry far more easier. The space required for drying of the digested slurry is also reduced by one-fourth.

***Walk-in type solar tunnel dryer:*** It was developed by MPUAT, Udaipur Centre and has recently been adopted for drying goose berry pulp and hand made paper sheets. A 3.75 m × 21.00 m size solar tunnel dryer has been installed on a goose berry farm

Walk-in type solar tunnel dryer installed in a farm for drying goose berry pulp

in Banswara district of Rajasthan at a total cost of Rs 60,000. One ton of goose berry pulp (obtained from 1.5 tonnes of fresh fruits) loaded in the tunnel dryer at a moisture content of around 89% got dried to a moisture content of around 9% in 1–2 days depending upon ambient conditions. The cost of drying goose berry pulp in the solar tunnel dryer was lower by more than 50% as compared to electrically heated drying system.

***Open core down draught gasifier:*** For thermal applications, developed by SPRERI, Vallabh Vidyanagar Centre of the project, with a fuel burning capacity of up to 100 kg/hr has been installed in an industry in Khaira district of Gujarat to replace conventional

Open core biomass gasifier installed in an industry for chicory roasting

wood fired system for chicory roasting. The average biomass consumption of the gasifier was found 60 kg/hr and conversion efficiency was 68%. The working space in the conventional wood fired system had higher levels of carbon monoxide and nitrogen oxides as compared to producer gas based roasting system. The quality of end product (roasted chickory) in the gasifier system was found far superior to the wood fired system primarily because of uniform heating and better temperature control. The payback period for the gasifier system is estimated to be 22 months.

**Micro Irrigation System**

A low cost equipment for nutrient management through micro irrigation system was developed at PAU, Ludhiana. Four different thicknesses of orifice meter were developed for fertigation in drip irrigation system. Orifice meters are working on the Bernolioui's principle. The different thicknesses of orifice meters were 1, 0.75, 0.50 and 0.25 inch having orifice diameter 3.175 mm (1/8 inch) with fertilizer inlet of 1.588 mm (1/16 inch). The suction rates of all the orifice meter were measured with normal irrigation water under a range of operating pressures. The suction rate of water soluble fertilizer varied from 40 lph to 7.5 lph.

**Development of Screen Filter**

At CIPHET, Abohar the screen filter was designed for a low capacity and is sufficient for micro irrigation system in greenhouse. The 75 mm and 50 mm PVC pipe were used for fabricating the filter. The 50 mm PVC pipe was used as an inlet pipe and 75 mm PVC pipe was used as a casing for the filter. The 50 mm PVC pipe of 40 cm length was used as a filtering house for the filter. The circular holes were made at equal spacing on 50 mm PVC pipe and it covered with the nylon net of 80 mesh. After preliminary testing, the filter was modified with arrangement of back wash assembly system and fabricating it with 90 mm and 50 mm PVC pipe. The 90 mm PVC pipe acts as a casing and 50 mm PVC pipe acts as a filtering house of the filter. The back wash assembly helps in cleaning of the filter without detaching the filter unit from main line. It also removes the particles deposited in the filter unit time to time and thus improves the filtration efficiency. The filter was tested in the field for effect of sand silt concentrations on removal efficiency and effect of pressures on removal efficiency of the filter. The filter unit was also tested.

**Drainage Technology to Enhance Productivity of Soybean and Sequential Crop of Chickpea in Vertisols**

Field experiments were conducted at CIAE, Bhopal consecutively for the last four years in Vertisols to study the effect of drainage on soybean variety (JS 335). Recommended doses of NPK @ 20,

50 and 20 kg/ha and standard recommended cultivation practices of mechanized farming were used. Surface drains having bottom width of 30 cm, depth 45 cm and top width 90–120 cm with 0.20–0.35% bed gradient and side slope of 1: 1 were laid out using tractor-drawn ditcher. Sub-surface drainage(SSD) system was laid on one ha area with 72/80 mm corrugated and perforated PVC pipes at 20 m spacing at 1m depth. Crop condition before and after installation of SSD clearly indicated advantages of drainage system.

Surface drainage system and sub-surface drainage resulted in 35–40% and 50–54% increase in yield of soybean crop, respectively over control. Yield of subsequent crop of chickpea (JG 315) was also increased by 15% over control. Cost of forming surface drainage with tractor-drawn ditcher is Rs 450–500/ha and for sub-surface drainage with PVC pipe is Rs 35,000/ha. The pay back period for surface drainage is less than one year and that for sub-surface drainage is six years. The benefit : cost ratio of cultivating soybean with surface drainage system was 1.77. The B/C ratio of soybean cultivation with and without SSD systems in low-lying vertisols was found to be 1.36 and 0.42, respectively. Surface drains at 15–20 m spacing with 0.45 m depth and sub-surface drains at 20 m spacing with 1.0 m depth are found to be effective for draining excess water in soybean crop.

**Feasibility of Mole Drainage in Vertisols**

Mole drains are unlined cylindrical channels formed in sub-soil, which function like clay or plastic drain pipes. A tractor-drawn mole plough was designed and evaluated at CIAE, Bhopal. Mole drains were formed at a depth of 60 cm with 60 m lateral length with 75 hp tractor using mole plough in an experimental area of 0.3 ha, at three spacings (2, 4 and 6 m) and 4 replications leaving 6 m buffer strip and control plot of 0.5 ha. After installation, short lengths (1.0 m) of perforated PVC pipe of 110 mm diameter was inserted in each mole channel outlet to prevent the collapse of outlet. The mole drain outlet was then connected with a PVC sub-main in each spacing and the sub-main in turn was connected to a sump to monitor the drain performance. To enhance the productivity of soybean in Vertisols the mole drainage technology is inexpensive, effective, technically feasible and economically viable.

A low-cost screen filter, sufficient for micro-irrigation system in greenhouse

**Technology for Water Harvesting and Recycling for Sustainable Agriculture**

For sustainable agriculture water harvesting ponds and recycling of water in *kharif* and in *rabi* is necessary. The blackish clayed soils of CIAE Farm being hard rock area, availability of underground water is very less. Considering topography three dugout ponds of 2.5, 5.5 and 14 ha-m capacities were constructed on 1.3, 2.0, and 6.0 ha area, respectively with total capacity of 2.2 lakh cubic metre to irrigate 45 ha command area including 10 ha under drip irrigation. All water resources; openwells, tubewells and ponds were connected through underground HDPE pipeline grid with hydrants at 66 m to facilitate irrigation and ground water recharge. Studies revealed that water-harvesting pond can be constructed in 10–12 of watershed area with 3 m depth. The minimum run-off received is about 300 mm to fill up the pond every year. About 60–70% of stored water can be utilized for irrigating crops. Entire *kharif* and 50% of *rabi* crop can be irrigated twice with two-fold increase in yield. Excess run-off water during rainy season may be utilized for ground water recharging, 0.2–0.65 ha-m/ha excess over 0.3 ha-m/ha is available in 4 or 5 years. Water harvesting and recycling of stored water is technically feasible and economically viable (benefit : cost 1.3–2.0).

**Low Friction Foot Valve for Water Pumping Systems**

Commercially available foot valve used in water pumping systems was improved upon through material substitution and modifications in the strainer. While the material of construction was changed to polypropylene, the strainer opening area was increased to three times that of the cross-section of suction pipe. The ratio of flap opening area to the cross-section of suction pipe was 1.3 and the flat of the strainer bottom changed to an S shaped curve. In the process of these modifications the mass of the foot valve was reduced to 1.6 kg. The performance of this improved low friction foot valve (LFFV) was evaluated along with the commercially available one as per IS : 10805-1986 on the computerized test set-up. The friction co-efficient of the LFFV was found to be 0.76. While the functional head loss went down, there was an increase in the discharge rate. Energy efficiency of LFFV is estimated to be twice that of commercial one and it has a potential to increase the pumping system efficiency by 2.3%. Economic analysis, based on mass manufacture of LFFV, indicates a payback period of about three years.

**CIAE Technologies Demonstrated in Sikkim**

CIAE in collaboration with ICAR Complex for NEH Region, Gangtok and Directorate of Food Security and Agriculture of

**Trainings**

- Cotton quality evaluation and specialized training in HVI and AFIS at CIRCOT, Mumbai
- Training on ginning at GTC, Nagpur.
- Trainings on gasket shellac cement compound and lac processing and scientific methods of lac production at ILRI, Ranchi.
- Small equipment and technology for production and value-addition of horticultural and other crops of hill region and entrepreneurship development.
- Krishi Vigyan Kendra of CIAE, Bhopal, organized 54 vocational training programmes for improving cultural practices, vocational skill and standard of rural people. The Centre also organized 45 sponsored training programmes (sponsored by NATP, IFFCO, Department of Agriculture, Government of Madhya Pradesh).
- Agricultural graduates from Madhya Pradesh were trained for establishing agri-clinic or agri-business for self-employment opportunities. After the training the graduates are eligible to get individual loan of up to Rs 10 lakh or up to Rs 50 lakh as a group for setting up of agri-clinic or agri-business through NABARD. The third batch of the training programme organized during 22 November 2004 – 20 January 2005 was participated by 32 agricultural graduates.
- A training programme on processing of agro produce including soybean processing and utilization, from village Amajhir (Dist. Sehore) in collaboration with SEWA, Sehore.

Sikkim organized a two-day interaction meeting-cum-demonstration of improved agricultural implements/processing equipment at Gangtok during June 2–3, 2005. CIAE product catalogue, leaflets and other extension literature were distributed among the farmers and delegates during the demonstrations.

**Frontline Demonstration**

Frontline demonstration of improved agricultural machinery was taken up under four centrally sponsored (DAC) programmes. FLD of improved agricultural machinery for major oilseed crops was operated through 37 centres (KVKs) for training and demonstration of improved agricultural machinery. Under the programme, 14 manual, animal- and tractor-operated improved agricultural equipments were taken up for demonstration at each centre. These equipments contributed 10–70% saving in time and 20–90% saving in labour apart from contributing towards higher crop productivity.

Frontline demonstration for major pulse crops was operated through 38 centres (KVKs and centres of AICRP on FIM) for training and demonstration of improved agricultural machinery. Under the programme, 15 manual, animal- and tractor-drawn equipment were taken up for demonstration at each centre. These equipment contributed 12–60% saving in time and 15–65% saving in labour apart from contributing towards higher crop productivity.

Frontline demonstration of zero till seed-cum-fertilizer drill, strip till seed-cum-fertilizer drill and raised bed planter was taken up in 24 centres in Assam, Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh, Uttaranchal and West Bengal. A total of 245 zero till drills with target area of 2,000 ha and 30 nos of raised bed planters with target area of 300 ha were provided to the participating centres.

Frontline demonstration of improved rice wheat equipment with 15 centres in Andhra Pradesh, Assam, Chhatisgarh, Haryana, Jharkhand, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Tamil Nadu, Uttaranchal, Uttar Pradesh, Bihar and West Bengal was taken up.

**E-Directory of Farm Machinery Manufacturers**

A Directory of Agricultural Machinery and Manufacturers, containing information on machinery for various production and post-production operations in agriculture was published. The E-Directory contains all relevant information regarding the availability of various implements and post-harvest equipment in a computer readable format. It also covers many of the renewable energy technologies available in the country for the use of average farmer/farming community. Information on each item contains a brief description, broad specifications, its uses and power source requirement. At the end of each item, the source of availability in the form of postal address of the manufacturer has been provided.

**Commercialization of Manually-operated Paddy Seeder**

A light weight paddy seeder was developed and evaluated for its mechanical and ergonomical performance and was found very useful. As there was a lot of demand for this equipment in southern states, commercial launching of this equipment was done in the name of "TNAU-Maharasi direct paddy seeder" in Tamil Nadu and "Raidco-Aiswarya" in Kerala. M/s. KSNM Marketing, Coimbatore is authorized by the university for manufacture and sale of the unit in Tamil Nadu. The Regional Agro Industrial Development Co-operative of Kerala (RAIDCO) is marketing this seeder in Kerala. More then 1,000 units of this seeder have been sold by these manufacturers to the farmers.

# Agricultural Human Resource Development

Strengthening and development of agricultural education was attempted through Centres of Advanced Studies, Niche area of excellence, University level-textbook writing, National Fellows and Professional Chairs, infrastructure upgradation, faculty competence building, accreditation, incentives through best teacher award, scholarships to students and their practical training in laboratory and real life field situations. Entering into MoU with the IGNOU for cooperation in agricultural education in distance mode and cooperation with the ISRO, IGNOU and MHRD for utilization of EDUSAT by the ICAR and SAUs for agricultural education are the new initiatives which have immense potential for enriching agricultural education as well to reach the unreached.

**State agricultural universities**

***Bidhan Chandra Krishi Viswa Vidyalaya, Mohanpur:*** During the period, 115 students successfully completed their respective undergraduate programme where the number of postgraduate and Ph.D degree recipients was 141 and 39 respectively. Construction of academic buildings for faculties of Horticulture and Agriculture Engineering has been completed and operationalized to ensure proper growth and desired development of respective faculties. Internet facilities have also been extended to remaining departments and college computer facilities augmented. Establishment of a Quality Control Laboratory for horticultural crops has been initiated, utilizing a substantial grant of 2.40 million received from the Department of Food Processing and Industries, GOI. Modern instruments/equipments viz. Super Speed Centrifuge, HPLC with photo–diode array, Gas Chromatograph, Research microscope, Digital CCD camera, Tractors, Power tiller, Dataloger, 6′ Lathe, Air compressor have been added. National Workshops/Seminars, International Symposium on Weed Science and a Winter School on advance extension strategies were successfully organized. The library has been updated. Access to global information has been enhanced through VAST and digitalization of existing stock. Students of the university performed well in ICAR–JRF examination, and secured 18 fellowships. They participated in two Interuniversity Youth Festivals, and one Sports and Games meet organized by Vinoba Bhave University, Marathwada Agriculture University and Kerala Agricultural University. Faculty members participated in various symposia abroad in different capacities.

***Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishva Vidyalaya, Palampur:*** Intellectual Property Rights in College of Agriculture, for undergraduate students and Introduction to Environmental Sciences for undergraduate students in all colleges of the University have been added. The UGC framed module of this course as per the instructions of Supreme Court of India. The equipments like Geo-positioning system, Automatic Micro-weather Station, LAN-WAN Equipments, Portable photo-synthesis system, Universal fibroscope, Cryocans, Spectrophotometers and $CO_2$ Analyzer have been added out of the funds provided by the ICAR for the purpose. A national level symposium on Emerging Trends in Plant Disease Management was organized. Also, annual workshop of All India Coordinated Research on Cropping Systems and Biennial Group Meeting/Workshop of Net work Programme on White Grubs and other Soil Arthropods were organized. A state level Mela on Agricultural Mechanization was organized. Summer School on Diversification of Agriculture: need and implication for food security and quality of life was organized by the Department of Agriculture Economics.

**Extension activities of CSKHPKV**

Under extension activities, as many as 799 training programmes were organized on agriculture, livestock management and family welfare, in which about 24,938 farmers participated. Besides, University Scientists acted as resource personnel in 127 training programs organized by other developmental agencies.

Short and long duration courses were organized by the Directorate of Extension Education for scientific farming, dairy, poultry, fisheries, rabbitry, bee-keeping, home science, mushroom cultivation etc. Farmer-Scientists interaction sessions, were organized.

Agriculture Technology Information Centre (ATIC) through its Help Line facilities interacted on telephone with farmers on their problems. It also helped hill farmers in getting seeds of crops/vegetable and agriculture publications, and different products like pickles, eggs, mineral mixture, UMB bricks etc. *Kisan Melas*/Specific *Divas* (World Food Day, Women in Agriculture Day, Environment Day and Field Day/*Gosthi* etc.) were organized throughout the State.

Tree plantation, weed control, desilting of water bodies, blood donation, Pulse Polio Awareness Rally-cum-Trekking trip, lectures on topical subjects were taken up by NSS volunteers.

A National Integration Camp for NSS volunteers of State Agricultural Universities was organized under the auspices of Ministry of Youth Affairs and Sports, Government of India.

***Kerala Agricultural University, Thrissur:*** It is the third consecutive year that the Kerala Agricultural University has been rated by the ICAR at number one position in the country. The university also received the Sardar Patel outstanding ICAR Institution Award 2003. Three New PG Programmes namely Veterinary Biochemistry at M. V. Sc. level, Veterinary Public Health for Ph. D and MBA in Agri-Business Management are added from 2006–07. Intake in B. Tech. (Agricultural Engineering) has been increased to 46 from academic session 2005. A new college campus at Pookotte, Wayanad District, has been inaugurated to conduct B.V.Sc. and Animal Husbandry Programme. The Governing Body at its 196th meeting granted accreditation to the Kerala Agricultural University and its 8 constituent colleges for 3 years.

***Maharana Pratap University of Agriculture and Technology, Udaipur:*** The sixth year of the newly formed Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur has been a year of significant achievements and unique events. The threefold activities of teaching, research and extension education were carried out with vision and enthusiasm by the academic community, which facilitated to project the university as a performing one beyond threshold despite acute crunch in human and financial resources.

The academic programmes of UG and PG level in the faculties of Agriculture, Technology and Engineering, Home Science, Dairy and Food Science, Horticulture and Forestry and Fisheries were pursued with a set goal of academic excellence. As part of the quality improvement in education, the UG and PG laboratories have been modernized. Award of the ICAR has been bestowed upon three teachers. B.Tech programmes in Dairy Technology and Food Technology have been approved by the AICTE. On revision of Home Science curriculum, the common consensus was to make this more professional by having 2 years of professional skill oriented courses based on job and self-employment opportunities as part of the 4 year UG programme.

- The Academic Council of the Maharana Pratap University of Agriculture and Technology approved the establishment of department of Molecular Biology and Biotechnology during the current academic year.

Varieties of groundnut, chickpea, maize, cotton and kulthi developed by the university have been released by the Central Seed Committee in 2005.

Two training courses on Agri-clinic and Agri-Business for self-employment of graduates were also organized.

The University in collaboration with Department of Agriculture and Cooperation, Ministry of Agriculture, GoI organized a mammoth Western Region Krishi Vigyan Mela-2005 and Flower, Fruit and Vegetable Show at Rajasthan College of Agriculture campus, Udaipur. A model unit of water-harvesting structure has been developed at the KVK, Rajsamand, with financial assistance of Rs 12.12 lakh from the ICAR. The catchment area of the water pond is 90 ha and the capacity of the water-pond is 18,000 $m^3$. Based on this,the ICAR has approved 100 similar units in different KVKs of the country.

Pratap Mungphali -2 early maturing variety in 98–100 days, dry pod yield potential is 25 q/ha, 50% oil and having 69% shelling.


Pratap Chana-1 Bold seeded early maturing variety yields 12–14 q/ha.

Mother orchards of mango, *aonla*, pomegranate, custard apple, guava, lime and *ber* have been established at KVK farms. These orchards will prove instrumental in providing quality saplings to the tune of 15 lakhs in next three years, and will help in making Mewar and Hadoti region in the South-eastern part of the state into horti-bowl of the state.

***Panjabrao Deshmukh Krishividyapeeth, Akola:*** A three day Agricultural Exhibition and *Charcha Satra* were organized at Wardha in collaboration with State Department of Agriculture, Zilla parishad Wardha and Bhaba Atomic Research Centre, Mumbai, on the eve of 106th Birth Anniversary of Dr Panjabrao Deshmukh Shetkari Melawa. At Akola, a *kharif shivar pheri* was organized. The Farmers Scientist's interaction (*Charcha Satra*) programme was also organized during *Shivar pheri*. Two-days workshop on Integrated Nutrient Management was organized. A two-days workshop on Prospects and Scope of Medicinal and Aromatic

**Technologies developed at the Maharana Pratap University of Agriculture and Technology**

- Pitcher technique for fruit plants for efficient water use.
- Sirohi bucks and model backyard poultry units developed are being adopted by large number of rural households.
- IPM modules cotton and chickpea have been validated.
- Using solar energy, the state-of-the-art, *aonla* processing units have been developed for removing seeds from *aonla* fruit through shedder stone extractor machine, drying *aonla* chips in solar tunnel dryer and preparation of jelly.

plants was organized at the main campus. Winter school on organic farming for sustainable crop production was organized by Department of Agronomy.

***Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir:*** Two new programmes at Master's level Agriculture Economics and Agriculture Extension and Communication and 6 at Ph.D. level-Sericulture, Post-harvest Technology, Environmental Sciences, Animal Reproduction and Gynaecology, Veterinary Microbiology and Immunology and Veterinary Surgery and Radiology have been instituted. The Central Library made good additions of scientific books, Research Journals, Scientific and Technical Reports, Bulletins, Proceedings of the Conferences, Symposia, CD ROM databases and other miscellaneous publications.

Two-month training programme on entrepreneurship development for unemployed agricultural graduates was organized for field officers and others. Short duration training courses and workshops were organized. Three Summer/Winter School one each on ecological vulnerability and strategies for sustainable agriculture in hilly regions; recent advances in post-harvest management of temperate fruits, vegetables, flowers and condiments; and recent advances in seed production of important vegetables were organized.

***University of Agricultural Sciences, Bangalore:*** Krishi Vignana Kendra at Kandali, Hassan, has been awarded the best KVK National Award for the Biennium 2003–04. Two new KVKs have been started at Kankanady and Chamarajanagar and 5 KVKs upgraded totaling 9 KVKs. Summer/Winter Schools were held on Natural Resource Economics and Management of Water Resources in Agriculture, Teaching Methods in Agriculture and Pollution Ecology in Agro-Ecosystems. International workshop on Policy issues for Sustainable Shrimp Farming in Asia and a national symposium on Paradigms in Nematalogical Research on Bio-dynamic farming were organized. A short course on Globalization of Dairy Industry in India- Application of Forecasting Techniques, a training program on Molecular Marker Techniques for crop

- The Sher-e-Kashmir University organized the 28th Annual Convention of Vice-Chancellors of Indian Agricultural Universities Association. Its main theme was orientation of agricultural education towards future needs and opportunities

improvement and a national seminar on Extension Methodological Issues in Impact Assessment of Agricultural and Rural Development programs were held. A medium-duration rice variety, KMP-101 maturing in 130–135 days, with yield of 6.0–7.5 tonnes/ha has been released. The variety is recommended for cultivation in *kharif* and summer in southern Karnataka. A high-yielding ragi variety MR 6 with yield potential of 4.5–5.0 tonnes/ha under irrigated and 3.0–3.5 tonnes/ha in rainfed areas with 120 days duration has been released. A dual-purpose pigeonpea variety BRG 1 with 175–190 days duration and yield of 1.4 tonnes has been released for eastern dry zone.

- A total of 604 on campus and off campus training programmes were organized by Krishi Vignana Kendras which more than 20,000 participants attended

***University of Agricultural Sciences, Dharwad:*** The University has introduced automation in University Library to provide online use Public Access Catalogue, Bar Coded Member ID Card, Automation of Circulation and Internet facilities.

A Winter School on Under Exploited Foods—An Advance Strategy for Management of Metabolic Disorders was sanctioned by the ICAR. Board of Regents has approved for starting Postgraduate Diploma in Care and Education of Children with Disabilities and a certificate course in Establishment and Management of Early Childhood Education Centres in the Department of Human Development, College of Rural Home Science, Dharwad. The University Seed Unit supplied hybrids and improved varieties of seeds of different crops valued at Rs 15 lakh. The Unit has produced/targeted to produce 7,400 quintals of Breeder, 2,860 quintals of Foundation and 10,672 quintals of Certified seeds of different crops. The University organized Biannual Workshop on Sugarcane. The Agricultural Research Station, Dharwad, has brought out several hybrids and improved cotton varieties.

**Admission of Foreign Students**

During the year 2005–06, 151 students from 25 countries were given admissions in ICAR Deemed-to-be Universities and State Agricultural Universities. To meet quality residential needs of foreign students support has been provided to ten agricultural universities for construction of International students hostels.

## Summer/Winter Schools and Short Courses

Ninety-one summer and winter schools and short courses of 10 to 30 days duration were supported for organization by the ICAR Institutes and State Agricultural Universities.

**Summer/winter schools and short courses**

- Gender analysis and its application to agricultural research and extension
- Economics of dairy and dairy products
- Egg processing and quality assessment of poultry products
- Mechanization of production and post production operations in plantation crops
- Greenhouse technology for growing horticultural crops
- Interior planning and decoration: A professional perspective
- Coastal and marine environmental management
- Quantitative Development Policy Analysis Approaches and Applications
- GIS based decision support systems for sustainable agriculture
- Computer aided textile designing
- Food technologies and food business development in India.
- Technological empowerment of farm women
- Sustainable fruit production in fragile agro-ecosystem of arid regions
- Resource conservation for higher productivity and sustainability
- Mitigation of heavy metals and arsenic pollution in agricultural production systems

## Centres of Advanced Studies

Centres of Advanced Studies (CAS), offer facilities for continuing capacity building of faculty engaged in teaching at the undergraduate and postgraduate levels. This year, all the Centres have initiated improved analysis of the trainings conducted by them.

## Professional Excellence Recognition

### *University Level Textbook Writing*

- Preventive Medicine Epidemiology of Dr R.D. Sharma, Dr Mahesh Kumar and Dr. M.C. Sharma;
- Food Hygiene and Public Health of Dr A.T. Sherikar, Dr V. Bachhil and Dr D.C. Thapliyal;
- Bovine Seminal Plazma Protein of Dr S.N. Kulkarni; and
- Oyster Biology and Agriculture of Dr Kanarimham, Dr (Mrs.) V. Kirpa

## Best Teacher Award

Faculty members (27) of the SAUs and the ICAR Deemed-to-be Universities were awarded Best Teacher Award for 2005–06.

Training on Molecular Biology

Training on Plant Pathogens

Practical training in Poultry Meat Products

## Niche Area of Excellence

A new initiative launched for bringing national and international

visibility of agricultural universities in their areas of attained capabilities.

**All-India Competitive Examinations for agriculture and allied sciences**

For admissions to 15% seats in under graduate programmes in agriculture and allied science subjects, the 10th All India Competitive Examination was conducted. These were conducted for award of National Talent Scholarships (NTS) for 38 Universities (35 SAUs, CAU, BHU and Viswa Bharati), and all seats at NDRI Karnal. In this examination, 12,650 candidates appeared and 1204 were finally admitted through Counseling held during July 2005.

**Recommendation on NTS and reservation of seats**

For the first time, all candidates who joined any University falling outside their state of domicile, were awarded National Talent Scholarship (NTS) of Rs 1,000 per month. Earlier, NTS was awarded only to 230 candidates on merit at Rs 800 per month. Also, for the first time, 2% of the total seats were reserved for the candidates from specified 11 underprivileged states, not having any Agricultural University.

For admissions to 25% seats in P G programmes at 38 SAUs and three CUs (BHU, Biswa Bharti, and AMU), and 100% seats at the IARI, NDRI, CIFE, and IVRI including award of Junior Research Fellowships, competitive examinations were held. These examinations were held at 26 locations in the country in 19 major subject groups (88 subjects). Based on the number of graduates awarded JRF, following Universities are rated best; (1) University of Agricultural Sciences, Bangalore (with 41 JRF), (2) University of Agricultural Sciences, Dharwad (with 40 JRF), and (3) Kerala Agricultural University (with 33 JRF).

**EDUSAT for Agricultural Education**

Detailed planning was done for utilization of EDUSAT by the ICAR and SAUs in agricultural education and human resource development in collaboration with the ISRO, IGNOU and MHRD. The approved plan includes establishment of 50 uplink and downlink stations all-over the country in SAUs, DUs, CAU, CUs, NAARM and ICAR Headquarters.

**All-India Coordinated Research Project on Home Science**

To reduce drudgery and alleviate health hazards, training programmes on use of improved tools, revolving *pihri*, improved sickles, maize sheller and weeders were organized. To improve nutritional status, ten nutritious recipes based on cereals, pulses, and nuts were developed and evaluated for their acceptability. Trainings were conducted for skill development and instilling confidence to start profitable enterprises in areas such as cooking, food preservation, handicrafts, soft toys, fabric paintings, garments, vermi-composting, herbal products and child nursery. For motivation of farmwomen to entrepreneurial activity, linkages with private, government and non-government organizations including banks were established to form self-help groups.

**MoU with IGNOU for Cooperation in Agricultural Education in Distance Mode**

For promotion of agricultural education in difficult-to-reach areas, for faculty improvement and vocational education, MoU has been signed for jointly working of the ICAR, SAUs and IGNOU on December 21, 2005. Certificate courses namely Agri Business Management, Organic Agriculture and Developmental Agriculture have been identified for developing work programme to be taken up in Phase I.

**Scholarships and other Financial Assistance Schemes**

**Merit-cum-Means Scholarship (MCM):** This is for students belonging to economically weaker sections to undertake U.G. studies in agriculture and allied sciences. Maximum 7% students from one University are awarded scholarship at Rs 170 per month.

**Internship Assistance**: It is awarded to all final year students of B.V.Sc and Animal Husbandry programme during their Internship at Rs 400 per month besides, Rs 400 for undertaking to-and-fro journey to place of internship.

**Junior Research Fellowship (JRF)**: It is awarded to meritorious students subject-wise, based on their merit rank in the All-India Competitive Examinations conducted by the ICAR. There are in total 475 Fellowships valued Rs 5,760 per month for non-veterinary and Rs 8,000 per month for veterinary students to pursue P G degree programme. Besides, a contingency grant of Rs 6,000 per year is payable to all awardees.

**ICAR Senior Research Fellowships (SRF)**: Based on the merit in the ICAR conducted All-India Competitive Examination for award of SRF, a total of 202 fellowships are being awarded to scholars for undertaking Ph.D. research in agriculture and allied sciences. The value is Rs 8,000 per month for non-veterinary and Rs 9,500 per month for veterinary scholars in the first and second year of Ph.D. and Rs 9,000 and Rs 10,000 month for the third year. Research contingency grant of Rs 10,000 per year is payable to all.

**ICAR National Professors and National Fellows**

There are ten positions of ICAR National Professors. These include one B.P. Pal Chair for Plant Breeding and Genetics at the IARI. Of these, two were in position.

A total of 25 positions of National Fellows exist in ICAR under the scheme for creation of Professorial Chairs. Of these, 14 completed their term. Based on the work performance, extension

to 10 of these has been granted for another term.

Dr A.V.N. Paul, (IARI New Delhi) National Fellow studied the synomonal effect of cotton-crop ecosystem on the foraging capacity of *Trichogramma* spp.

- Bioassays studies with the leaf extract of *Cassia* sp. from vegetative phase showed that irrespective of the concentrations of the extract, the mean per cent parasitism was the highest for *T. brasiliensis*. In flowering phase, the mean per cent parasitism was highest for *T. achaea*

Field studies were carried out in late vegetative and flowering phase. In late vegetative phase irrespective of the *Trichogramma* species, the cotton variety Pusa 8-6-68-29 showed highest response. Hexane extracts of leaves from vegetative and flowering phase of *Cassia* sp. were prepared and bioassayed with *Trichogramma brasiliensis* and *T. achaeae* to know synomonal interactions between plants and natural enemies.

Dr K. Alagusundaram, TNAU, Coimbatore, National Fellow, worked on identifying technologies for using modified atmosphere gases to extend shelf-life of selected tropical fruits and vegetables for export markets.

Dr B.P. Singh, (CARI, Izatnagar) National Fellow, performed specialized selection on two naked neck pure broiler strains having naked neck gene (NNWP and NNCP) over 10 generations. The study revealed that both ELISA and HI methods to evaluate response against New Castle Disease vaccination are equally effective.

Dr B.M. Prasanna (IARI, New Delhi) National Fellow, worked on Molecular characterization of Indian maize landraces and allele mining for agronomically important traits. Extensive survey in 40 villages in Sikkim, spanning East Sikkim, West Sikkim, North Sikkim and South Sikkim, led to the collection of 80 accessions.

Dr D.C. Uprety, (IARI, New Delhi) National Fellow, studied detailed physiological and biochemical analysis of *Brassica* to the interactive effect of moisture stress and elevated $CO_2$. *Brassica* cultivars have developed measures to combat stress induced oxidative damage on cell membrane, both by reducing accumulation of reactive oxy species (ROS) and increasing antioxidant enzyme activities. The sustenance of the stimulatory effect of elevated $CO_2$ was observed up to the seed formation stage.

Dr J.C. Tarafdar, (CAZRI, Jodhpur) National Fellow, worked for developing a simple method for determination of metabolically active soil bacteria, fungi and actinomycetes. The method is based on the hydrolysis of fluorescein diacetate (FDA) to fluorescent green colour fluorescein. Actinomycetes 95.4%, bacteria 91.9% and fungal 92%colonies in different soils were capable of using FDA and it was found much better indicator than dehydrogenase assay.

- The work done by Dr D C Uprety includes development of open top chambers and the first South Asian Free Air $Co_2$ enrichment (FACE) technologies. These facilities were used to study the responses of *Brassica* and rice cultivars to the elevated $Co_2$

Dr Kaushalya Ramachandran, (CRIDA, Hyderabad) National Fellow is working on the project Assessment of Sustainability of Treated/Developed watersheds in Rainfed Agro-eco region of Peninsular India using GIS and Remote Sensing (2005–2010). Analysis of core issues affecting sustainability of watersheds are being analyzed. FESLM framework has been used to assess sustainability of land management practices initiated in Pamana and Dontanpalli watersheds in Ranga Reddy district and Gollapalli in Nalgonda district.

Dr D.K. Sharma, (Assam Agricultural University, Khanapara) National Fellow is working on Development of ELISA based immunodiagnostics for classical swine fever. During the year 2005, 550 tissue samples of pigs from outbreaks and slaughtered places have been screened by Sandwich ELISA. ELISA has been standardized using polyclonal sera raised in rabbit and pigs against the lapinized strain of CSF virus. More than 100 samples were found positive for viral antigen. Isolation of CSF virus from the positive tissue samples was done in PK15 cell line. Out of the 25 positive samples processed, so far from 7 samples CSF virus could be isolated.

- The work by Dr D K Sharma involved developing immunodiagnostic reagent (antigen and antisera) and to standardize ELISA based immunodiagnostic assay for rapid and confirmatory diagnosis of classical swine fever, the most feared and devastating viral disease of pigs

Dr Madhuban Gopal, (IARI New Delhi) National Fellow has worked on Decontamination of pesticide residues from edible commodities. Addition of a non-toxic reagent followed by physical treatment could reduce Chlorpyrifos toxicant present at 0.04 ppm up to 70–90%. Development and validation of residue free IPM for cabbage, chili and tomato has been completed.

Dr Alka Goel, (GBPUA&T Pantnagar) National Fellow has carried out studies to assess present status of textile articles in Uttaranchal with special reference to designing through survey. All Bhotia (100%) community use Tibetian wool (medium-coarse-type wool). Only 20% of Bhotia use Merino wool or other local goat/sheep wool with Tibetian wool. They prepare articles to provide warmth, they don't care much for aesthetics. They use weaving (mainly plain, twill and pile weaves) and hand knitting technique of fabric/garment construction. In Uttaranchal 75% of the respondents use wool fibres mainly for woven articles (Dun,

Chutka, Thulma, Asan, Loi, Pankhi, Shawl, Stole, Pakhla) and knitted articles (Sweaters, Caps, Socks, Gloves, Muffler etc.), 15% use silk, 25% respondents used cotton fibres. Only 10% respondents use blends of cotton, wool, silk. They use blend at yarn stage mainly.

Dr K L Sharma (CRIDA, Hyderabad), National Fellow worked on the project entitled Restoration of soil quality through conservation agricultural management practices and its monitoring using Integrated Soil Quality Index (ISQI) approach in rainfed production system. Soil samples from different rainfed locations were collected from the on-station long-term field experiments and farmers' fields representing predominant management practices (tillage, INM, herbicide application, green manuring, residue and fertilizer applications, cropping systems/rotations etc.). After processing, the soil samples were analyzed for various physical, chemical and biological soil quality indicators. Data pertaining to some of the centres, viz. Agra, Dantiwada, Hyderabad is being analyzed, soil quality index is being computed. At Hyderabad Centre, two experiments focusing on soil quality restoration (comprising of reduced tillage, conventional tillage, residue application and N levels, low cost INM treatments) are in progress. Field data have collected. Apart from these, the study on the emission of carbonxide as influenced by tillage and residue application under semi-arid tropical condition is also in progress.

**Emeritus Scientist Scheme**

Dr N.B. Naravani, (UAS Dharwad): A two year study indicated that groundnut harvester with 37.50 cm harvesting blade is the most suited bullock-drawn harvesting implement. A saving of 28.53 man-hours per hectare was achieved with the harvester compared to manual harvesting. The harvester yielded a highest field efficiency of 84.37%. The implement offers better balancing and comfort for operation under thick vegetative growth conditions of the irrigated crop. Groundnut pod thresher indicated a threshing efficiency of 9.20%, cleaning efficiency of 73% and a threshing capacity of 87.57 kg pods per hour. Saving in cost was Rs 20 and on man-hours per quintal of pod threshing was 16.59.

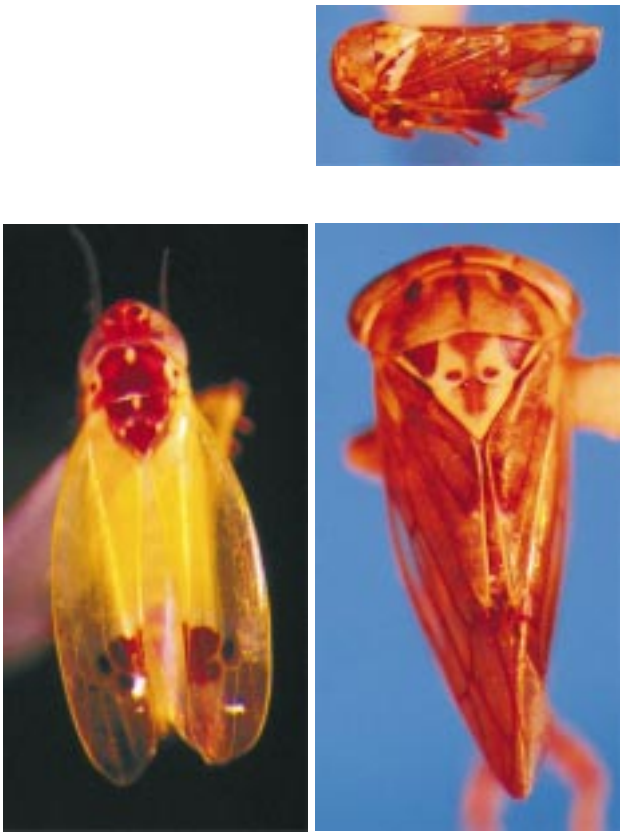
Dr D.N. Sharma, (HPKV Palampur): A two year study to record gross morphological, histological and histochemical changes in hypothalamus, hypophysis, thyroid and adrenal glands of Gaddi goats in relation to ovarian morphology during different seasons of the year was conducted at mid-hill zone of Himalayas at Palampur (315 m above mean sea level). Ovarian tissues collected over the year in different seasons revealed larger ovaries with maximum number of mature/ovulatory follicles/early corpora lutea on surface during autumn (oestrus) and smallest ovary with least number of follicles in the summer (anoestrus). Pituitary gland weighed heaviest (310–360 g) during autumn and lightest (246–278 g) in summer and measured on an average 14.4 × 10.2 × 9.8 $mm^3$ and 13.3 × 9.7 × 8.4 $mm^3$, respectively revealing all-round growth of pituitary gland in the autumn season. Microscopic examination of pituitary revealed increased population of hypertrophied basophils (gonadotrophs) in autumn in contrast to acidophils (LTH Ocytes) in the summer. Adrenal glands measured largest (Av 4.15 × 1.48 × 0.99 $cm^3$) and heaviest (Av 4.26 g) in summer and smallest (Av 1.82 × 1.27 × 0.99 $cm^3$) and lightest (Av 3.46 g) in the winter. Thyroid tissue exhibited a reversed trend of pituitary-gonadal relationship. Glands were largest (Av 4.27 × 2.16 × 0.82 $cm^3$) and heaviest (Av 8.36 g) in summer; and smallest (Av 2.38 × 1.03 × 0.80 $cm^3$) and lightest (Av 3.21 g) in autumn.

Dr J L Mangal, (CCS HAU, Hisar): Root dipping of tomato seedlings before transplanting in ascorbic acid (20ppm) solution was significantly beneficial for survival, growth, fruiting, yield and quality of fruits when plants were raised under 8.0 dS/m Ece as compared to plants raised under similar salinity levels but without any root dip treatment and root dip treatments with other chemicals. In case of onion and okra, root dipping and seed soaking for 4 hrs before planting/seedling induced significantly better plant growth, fruit yield and fruit quality under 8.0 dS/m Ece salinity.

Dr C.A. Viraktamath, (University of Agricultural Sciences): Extensive collections (10,000 specimens) of leafhoppers has been made from different parts of India. Five new species of *Krisna* have been recognized. It is showed that three new species that occur from India are distinct from the Ceylonese species *Dussana quaerenda*. This genus is endemic to peninsular India and Sri Lanka. *Vangama steneosaura* is very variable species as far as the head is concerned; this was discovered during the field trip conducted during July 2005 when breeding population of this species was collected from Subhimalayan regions of West Bengal and Sikkim. The genus *Varta* Distant that was earlier considered a synonym of the Palaearctic genus *Stymphalus* has been resurrected and a number of species from Europe, Asia and Australia, which were earlier misidentified, have been described and placed in *Varta*.

Dr M.S. Shakatawat (MPUAT, Udaipur): Two years field experiments conducted on tribal farmers field at Udaipur (Rajasthan) on maize-wheat cropping sequence has indicated that phosphorus at 60 kg $P_2O_5$/ha through PROM (Phosphate Rich Organic Manure) in maize and wheat gave highest grain yields (31.16 and 39.70 q/ha), stover and straw yield (54.52 and 55.44 q/ha), net returns (Rs 16,355 and 28,401/ha) and benefit/cost ratio of (1.84 and 2.61) of maize and wheat respectively.

Dr R. C. Tiwari (BHU Varanasi) Under a study on bioconversion, formulation and recycling of organic wastes and digested sludge



Leaf hopper pests of mango

revealed that digested sludge (DS), pressmud (PM), carpet waste (CW), poultry manure, cow dung, tree leaves and city garbage, organic wastes available locally in Varanasi region have high plant nutrient potential. Wheat grain yield data showed that application of full dose of NPK as chemical fertilizer yielded 5.37 tonnes/ha grain and 2 tonnes of each of PM + CW + DS yielded 5.75 tonnes/ha.

Dr A. Seetharam (UAS, Bangalore): A two years project on

Organic Farming of Wheat

study of core collection of fingermillet, *Eleusine coracana* for agronomic, physiological and grain quality parameters has helped in establishing a core germplasm set in fingermillet for the first time from the entire world collection of nearly 6,000 accessions at the National Active Germplasm Site (NAGS), Bangalore.

The results indicated that variability available in total core set was very large especially for productive tiller number, finger length, straw weight, ear weight, yield and total dry matter and showed high PCV value of more than 29%.

Dr. R. Manickam, (TNVASU, Namakkal): Epidemiological studies on the incidence of Leptospirosis was undertaken to assess level of its sero-prevalence in farm animals of Tamil Nadu. Out of a total 1,719 sera samples collected and analyzed, 401 sera samples were from cattle and buffaloes, 189 from sheep, 157 from goats, 247 from dogs and 725 from human beings. The percent sero positivity recorded in cattle and buffaloes was 11.72% 12.6% in sheep, 15.9% in goats, 22.7% in dogs and 54.06% in human beings. Predominant serovars found in farm animals and dogs were reported in man also strongly suggests the possible disease transmission from farm animals to man. High incidence of Leptospirosis was recorded during rainy season compared to summer, and more incidences were reported from north-eastern and Cauvery delta zones.

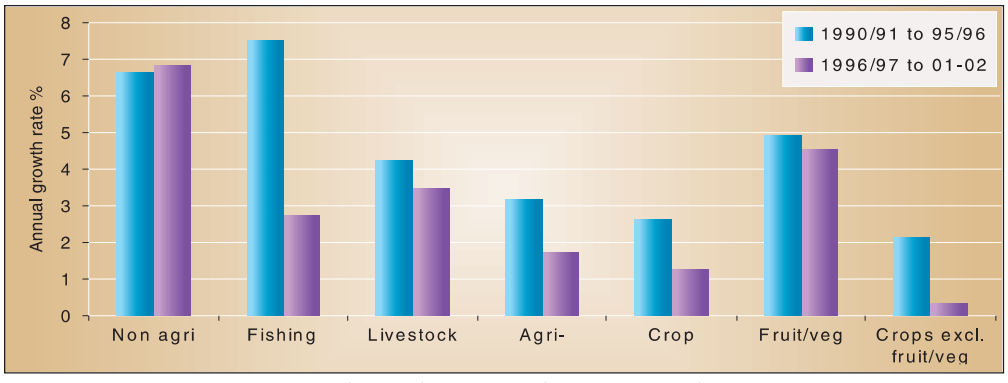
# Social Sciences and Policies

***Agricultural Marketing India—Implications for Competition:*** Markets for large number of commodities are competitive in the segment where agrocommercial firms are involved in transactions with other agrocommercial firms and are less competitive where business firms are dealing with consumers and producers. This is reflected in collusive behaviour of the buyers and imperfections at retail level. This calls for improving competition in agricultural markets particularly at farm and retail level. Alternative avenues for sale and purchase, through cooperative marketing agencies, dilute market power of private trade to some extent. Besides cooperative agencies, removing all kinds of restrictions on entry of private firms at various levels of agricultural marketing, particularly in purchase of farm produce, would intensify the competition.

The main reason for high charges and lack of competition in agricultural markets seems to be that small local players dominate the market. They are in large number but that does not improve market efficiency. They require large margins due to the large number and small operations and cannot take advantage of scale economies. There is a need to attract big business to invest and operate in agriculture market in bulk buying and selling. This would impart scale advantage that should help in better deal for consumers and producers.

***WTO agriculture negotiations and South Asian countries:*** What was projected as a benefit for South Asian Countries (SACs) from Agreement on Agriculture (AOA) and expectations based on that are yet to come true. SACs should work together in the ongoing negotiations on AOA to address their concern adequately. A common agenda for SACs should suggest that *De minimus* support in developed country should be fixed at 5% of value of output as product plus non-product support and aggregate measure of support (AMS) commitment should apply at product level. Negative support should appear as such in computing AMS. Green box should include purely non-trade distorting measures like training, inspection, extension services, infrastructural services, and public stockholding for food security purpose. There should be a cap on green box assistance in developed countries. All export subsidies should be eliminated at the earliest. Measures like export credit guarantee and insurance should be allowed only to developing countries.

- Present situation of agricultural markets in India and need of competition were studied.
- WTO agriculture negotiations vis-à-vis South Asian countries were studied
- Stagnation in public investment in agriculture is affecting agriculture growth
- GDP of agriculture is affected by both capital formation and subsidies, besides terms of trade
- An upward trend was observed in scientific productivity of ICAR-SAUs system
- The socio-economic impact of research and development efforts was studied
- Privatization of seed industry is increasing
- Productivity enhancement and substitution of low producers by high milk producers would improve milk production
- Productivity enhancement would give the rice production the required boost
- Information is becoming more and more critical input in overall rural and particularly agricultural development
- Flexible central data warehouse of agricultural resources developed
- Statistical package on agricultural research (SPAR 2.0) developed




Growth rates during pre- and post WTO periods

***Agricultural growth during the reforms:*** The growth rate analysis revealed that initial years of reforms were somewhat favourable for agricultural growth but post-WTO period witnessed sharp decline in growth rate of almost all commodity groups one by one. The current growth rates are too low to achieve the goal of 4% growth in output as envisaged in the National Agriculture Policy. Corrective measures are to be initiated soon to reverse the deceleration in agricultural growth otherwise even the growth targets of 10th Five Year Plan would be difficult to meet. Another disquieting aspect of recent growth process is that agriculture and non-agriculture sectors are on a disparate growth path. The probable causes for slowdown in agriculture growth are adverse impact of depressed international prices on domestic prices, neglect of price intervention for underdeveloped region having large growth potential, slowdown in adoption of improved technology and stagnation in public investments in agriculture for a long time.

***Determinants of capital formation and agriculture growth:*** Rate of return to private investments, which in turn depends on terms of trade and technology, is the most important determinant of private capital formation. Institutional credit supplied to agriculture as short term loan or medium and long term loan was the other determinant of private capital formation. The impact of agriculture subsidies is also positive on private investments.

Agriculture GDP is affected by both capital formation and subsidies, beside terms of trade. Instant return to Re 1 spent in subsidy is much higher compared to the instant return to Re 1 spent for public sector capital formation. However, long term return from capital formation is more than double the return from subsidies. Diverting 1% resources from subsidies to public investment raises output by more than 2%. As there is a tradeoff in resources going into subsidies v/s resources available for public investment, diverting resources from subsidies to public sector capital formation is highly desirable to ensure growth in GDP agriculture.

**Impact of subsidy and GFCF in agriculture on GDP agriculture at 1993-94 prices (value in Rs)**

| Particular | Impact |
|---|---|
| *Gain/loss due to Re 1 going in subsidy rather than public capital formation* | |
| At 10% discount rate | -2.83 |
| At 8% discount rate | -4.23 |
| Impact of shift of 1% subsidy amount to public sector capital formation on GDP agri (%) | |
| At 10% discount rate | 1.82 |
| At 8% discount rate | 2.73 |

The public agricultural research system in India comprising institutes of the Indian Council of Agricultural Research (ICAR) and the state agricultural universities (SAUs) has been evaluated and reviewed several times. This coupled with slowdown in the rate of agricultural growth after mid-1990s has created an impression of slowing down of research impacts. It is at times, observed that the research system is not able to maintain up trend in the scientific productivity, and newly emerging stresses are threatening sustainability of our agricultural systems. How far this fear is true? This question is examined by using some empirical evidence. Scientific publications and technologies are the two main outputs of agricultural research which are applied in nature.

**Trends in annual research publications of ICAR-SAU system**

| Particulars | ICAR institutes | SAUs | Total (ICAR and SAUs) | Articles per FTE[a] scientist |
|---|---|---|---|---|
| Number of articles indexed in SCI | | | | |
| 1980 | 696 | 758 | 1,454 | 0.14 |
| 1990 | 205 | 292 | 497 | 0.04 |
| 2002 | 299 | 231 | 530 | 0.05 |
| Number of articles indexed in CABA | | | | |
| 1980 | 1,090 | 1,924 | 3,014 | 0.29 |
| 1990 | 1,645 | 4,413 | 6,058 | 0.48 |
| 1998 | 2,027 | 4,637 | 6,664 | 0.51 |
| Number of articles indexed in ISA | | | | |
| 1990 | 1,170 | 4,308 | 5,478 | 0.43 |
| 2002 | 1,250 | 4,786 | 6,036 | 0.53 |

[a] Full-time equivalent (e.g., a scientist spending 50% of his time on research was considered as 0.5 FTE).

***Scientific publications:*** Scientific productivity can be assessed by using research articles indexed by three abstracting sources for agricultural and allied sciences. These are the *Science Citation Index* (SCI), the *CAB Abstracts* (CABA), and the *Indian Science Abstracts* (ISA). Total number of research publications authored by the scientists working in ICAR institutes and SAUs are taken from these 3 sources. A drastic decline in the number of the SCI-indexed publications was observed in 1990 over that in 1980. This decline is deeper for SAUs and it continued even in 2002. ICAR institutes however showed a moderate recovery in 2002. What is more worrisome is that even the institutes and universities with the best publication record could not achieve the 1980 level in

**Trends in rice variety development, 1971–2000**

| Particulars | 1971–1980 | 19810û1990 | 1991–2000 |
|---|---|---|---|
| Total number of varieties developed | 127 | 223 | 257 |
| Percentage of varieties with fine grain quality[a] | 29.1 | 34.9 | 36.5 |
| Percentage of varieties tolerant to diseases | 50.4 | 67.2 | 51.0 |
| Percentage of varieties tolerant to insect pests | 10.2 | 25.1 | 20.2 |
| Percentage of varieties developed for marginal areas[b] | 41.7 | 50.6 | 46.0 |
| Percentage of short to medium duration varieties[c] | 74.8 | 53.8 | 52.5 |

a Long slender grain type, b Rainfed upland and lowland, deepwater, saline and alkaline ecosystems; c 50% flowering in less than 100 days, Source: Based on DRR (Hyderabad) data; 6 the marginal internal rate of return to investment in irrigation ranged from 4 to 6% during the corresponding period.

2002. This clearly shows depletion of upstream or strategic research in the ICAR and SAU system. A sharp decline in the SCI-indexed articles authored by the agricultural scientists echoes the broad trend observed for the Indian science. The total number of SCI-indexed research articles authored by Indian scientists in all fields of science decreased from 14,983 in 1980 to 10,103 in 1990, but rose back to 14,028 in 2002. However, part of the slow recovery of the articles of agricultural sciences during 1990s could be attributed to a shift towards publication in Indian journals which increased in number over time. Some of these journals were also rated high by the national professional academies and assessment boards. Trends in the total number of publications of agricultural science are quite encouraging. The number of CABA-indexed publications increased from 3,014 in 1980 to 6,058 in 1990, which further rose to 6,664 in 1998. A similar trend was also observed for the ISA-indexed publications. This increase in the number of publications during 1990s is important because it is believed that the number of agricultural scientists might have gone down during this period. The number of publications per scientist per year also increased from 0.48 in 1990 to 0.51 in 1998, registering an increase of about 6% (Table 1). This clearly shows an upward trend in scientific productivity of the ICAR-SAU system. However, there are some noteworthy patterns. Nearly 80% of the papers were published in the non-SCI journals with zero impact factor and only a small proportion of the papers was published in the journals with an impact factor greater than zero but less than two. About half of the SCI-indexed and more than 70% of the total publications were authored by the scientists working in SAUs, which is expected because of their scientific strength and dominance of student research. However, the tendency to publish in the low rating journals is a matter of concern. The average impact factor even for ICAR articles was 1.1 and 1.6 for CSIR in 2002, underscoring the need for improving the quality of publications in the country.

***Technology development:*** The number of usable technologies developed is another indicator of scientific productivity, but it is very difficult to compile time-series data on them. Therefore, the trends in rice varieties developed, have been considered to indicate the broad pattern of technological contributions. Rice is one of the important crops receiving greater attention of the research system, and most other crop management technologies evolve around improved varieties. There is an upward trend in the number of varieties developed by Indian rice breeders. During the 1970s, 127 rice varieties were released, which rose to 223 in the 1980s—almost doubling the breeding productivity. The number of officially released varieties increased to 257 during the 1990s. Besides increase in the number of varieties bred, rice breeding also witnessed some qualitative changes over time. The proportion of varieties with fine quality (long slender) grain increased from 29% in 1970s to 36% in 1990s. Also, a significant increase was observed in the number of varieties developed for marginal production environments, as well as those tolerant to biotic stresses. This development led to a substantial reduction in yield variability even in the rainfed areas of eastern India. Development of hybrid rice in partnership with the International Rice Research Institute and private seed companies has established yield advantage of 15–20%. Thus, maintaining high and stable yields with improved grain quality is a major contribution of Indian plant breeding programmes. Focus was also on breeding short duration rice varieties, which constituted about half of the total varieties released during 1980s and 1990s, down from threequarters during the 1970s, owing to trade-off between yield enhancing and crop maturity reducing traits. Similar trends were also observed in breeding programmes for other crops, e.g. in maize, 50 varieties were developed during 1980–93 compared to only 45 during 1960–80. Breeding focus also shifted from varieties to hybrids during the 1980s. Now high protein maize hybrids are developed to meet the rising demand for food and feed. In wheat, till now more than 200 varieties have been released for cultivation in India, and yield potential has been increasing by 1% per year

because of the persistence improvement in plant type. After the mid-nineties, an additional yield potential of above 0.7 tonne/ha has been established on farmers' fields, which is likely to be enhanced further through exploitation of hybrid vigour in wheat breeding. The success of crop breeding programmes, coupled with the policy of open access to public material, contributed to the growth of private seed industry in the country. In horticulture, forestry and medicinal and aromatic plants, rapid multiplication of disease-free planting material by tissue culture is contributing to rapid adoption of improved varieties and higher crop yields. The resource-conservation technologies are reducing groundwater use by 5 to 30% in the rice-wheat system. The packages for integrated management of pests and plant nutrients, along with pest tolerant varieties are expected to reduce the use of pesticides to the extent of 50%. Crossbreeding and nutrition and disease management research in livestock have increased milk and meat yields and reduced mortality rates. But, the success was confined to dairy, commercial poultry and fish sector only, and subsistence livestock sector suffered because of limited commercialization of technologies which are often capital intensive, causing a scale bias.

### *Socio-economic impact*

***Economic payoffs:*** Agricultural research and development (R&D) has been assessed quantitatively by several studies conducted by national and international organizations. Investment in agricultural R&D is a 'win-win' option as it is the largest contributor to agricultural total factor productivity (TFP), which in turn reduces rural poverty significantly. Although there are considerable variations, the average rate of return to investment in agricultural research was about 70% with a median value more than 50%. These rates are very much comparable to those obtained internationally, covering both developed and developing countries. Furthermore, the marginal internal rate of return to research investment in India ranged from 57 to 59% since the green revolution era. This is against 35% rate of return realized for private agricultural R&D, and 45% for public agricultural extension. The growth in agricultural TFP is estimated to be 1.4% during 1980–2000, which is equal to that observed for the crop sector during initial phase of the green revolution.

However, TFP decelerated growth for crops in the Indo-Gangetic Plains during the mid-1990s. This is certainly an undesirable trend, but it would be premature to entertain the deceleration hypothesis based on the data for few years. Moreover, there is no clear indication whether this deceleration is because of slow improvement in the technical efficiency—an important factor for growth in TFP—or technological regression. Thus, there is no clear evidence of decline in socio-economic impact of public agricultural research in the country. In fact, deceleration in the agricultural growth since the mid-nineties underscores the need for acceleration of technology flow to farmers, requiring higher investment in R&D.

**Internal rates of return (%) to agricultural research investment in India**

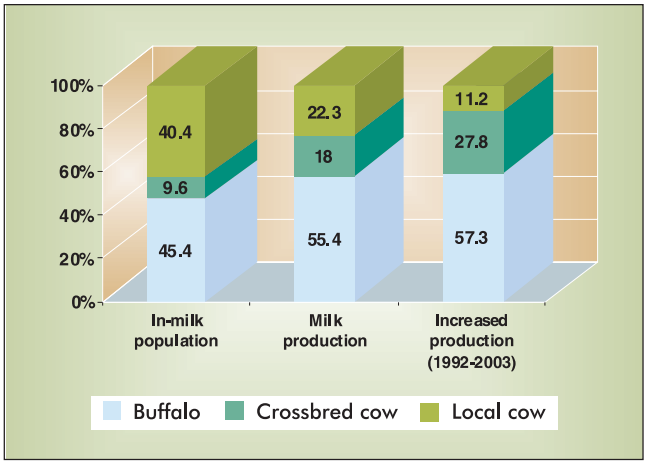
| Particulars | India (All studies) | Global estimates |
|---|---|---|
| Mean | 71.8 | 79.6 |
| Mode | 50.0 | 26.0 |
| Median | 57.5 | 49.0 |
| Minimum | 6.0 | -7.4 |
| Maximum | 218.2 | 910 |

***Benefits to smallholders:*** Has agricultural research in India also benefitted smallholders and dryland areas? Since the green revolution technologies were neutral to scale, the growth benefits were also shared by small producers, and urban poor benefited through reduction in food prices. The high-yielding varieties also spread rapidly to dry and semi-arid regions of the central and peninsular India and covered more than 74% of area under sorghum and pearl millet, which is higher than that of paddy. Lately modern varieties rapidly spread in the eastern India, contributing to most of the increase in the national foodgrain production during the 1990s. A study, revealed that technological change has been pervasive even in the rainfed areas, and crops like coarse grains, pulses, oilseeds, fibres, and vegetables have also registered a positive growth in the total factor productivity. However, the impact has been rather limited in a few states, viz. Bihar, Madhya Pradesh, and Karnataka, partly because of incremental nature of technological advancements (unlike oneshot jump in irrigated areas), which are often eroded by erratic weather conditions. Barring these few limitations, the research system has been able to address the objective of sustainable agricultural development with social justice, and economic policy environment has helped in achieving this objective. International research community, mainly the CGIAR system, has been a useful ally in this endeavour, but, technology spillovers from the CGIAR system would not have been realized in the absence of the strong national system.

Significant changes were observed in the Indian seed system in the last decade or so, and the most significant development was the emergence of private seed sector. This has improved access of farmers to commercial seed. Study on cotton (Maharashtra), groundnut (AP), vegetables (HP), paddy (Haryana) and potato (HP and UP) indicate that a significant proportion of

hybrid seed was purchased from the commercial sources (more than 90% of the cotton and tomato seed was procured from the commercial source by the farmers) but at the same time only 20 to 35% of the potato and groundnut seed was procured from the commercial sources indicating restricted participation of the private sector in the seed system of 'orphan' crops because of high investment, low profit margins and voluminous nature of seeds of such crops. A significant proportion of farmers, irrespective of their farm size, purchase seed from commercial sources for quality considerations. Majority of the farmers get to know about a new variety from the fellow farmers indicating the inefficiency in the public extension or seed system. For self-pollinated and vegetatively propagated crops, the public varieties still dominate. However, there are some instances of multiplication and supply of foreign variety seeds of potato, especially for the processing sector. Thus, there is an increasing trend towards privatization in the Indian seed industry. The public seed system is facing several resource and institutional constraints. In particular, there is a need for technological backstopping, developing partnerships with private and civil society organizations, and developing capacity at local level. There are significant changes in terms of seed regulations, management of genetically modified (GM) crops and protection of intellectual property. Since all these regulations are mutually enforcing, there is a need for developing institutional capacity for their enforcement, as well as flexibility to learn from the experience for future adaptations.

Considerable efforts have been made to improve the genetic potential of dairy cows and poultry over the last 3 decades. NCAP has attempted to quantify the contribution of crossbred cows and improved layers to their output growth for 1992–93 to 2003–04. In 2002/04 crossbred cows comprised 10% of the in-milk animals and contributed 18% to the total milk production. Their share in in-milk bovines and in milk production almost doubled since early 1990s.



Contribution of crossbreding technogy in dairying

Between 1992/94 and 2002/04 total milk production in the country increased by 26 million tonnes, and 37% of this was because of increase in animal productivity. Crossbred cows contributed to 28% to the incremental milk production, and about 18% of this came from increase in productivity. On the other hand, indigenous cows contributed 11% to the incremental output, and most of it came from enhanced productivity. Buffaloes account for most the incremental production (61%) and yield improvements accounted for 37% of this.

These results imply that future growth in milk production should come largely from (i) a replacement of low-yielding indigenous cows with crossbreds and buffaloes, (ii) improvements in their yields as their potential is yet to be exploited—the potential yield of a crossbred cow is about 3,000 kg/annum and that of buffalo about 2,000 kg/annum, and (iii) better management of good milk yielding indigenous cows.

**Losses in livestock production in India, 2002/03 (Rs billion)**

| Species | Losses due to | | | | | Output | | |
|---|---|---|---|---|---|---|---|---|
| | Breeding problems | Diseases | Feed scarcity | Inefficient management | Total losses | Actual output | Attainable output | Attainable output lost (%) |
| Cattle | 50.8 | 100.1 | 71.2 | 34.4 | 256.5 | 595.1 | 851.7 | 30.1 |
| Buffalo | 22.5 | 20.8 | 79.0 | 9.7 | 132.0 | 670.1 | 802.1 | 16.5 |
| Sheep | 6.6 | 4.5 | 4.7 | 0.3 | 16.1 | 24.5 | 40.6 | 39.7 |
| Goat | 3.4 | 3.4 | 3.4 | 1.7 | 11.9 | 62.7 | 74.6 | 16.0 |
| Pig | 0.0 | 4.3 | 1.4 | 0.0 | 5.7 | 13.3 | 19.1 | 30.1 |
| Poultry | 0.0 | 5.1 | 2.5 | 2.2 | 9.9 | 120.2 | 130.0 | 7.6 |
| All | 83.3 | 138.3 | 162.3 | 48.3 | 432.1 | 1485.9 | 1918.0 | 22.5 |
| % of total | 19.3 | 32.0 | 37.6 | 11.2 | 100.0 | | | |

**Economic losses in livestock production in India**

Livestock production faces a number of constraints related to health, breeding, nutrition and management. Livestock output worth Rs 432 billion (at 2002/03 prices) is annually lost due to inadequate feeding and nutrition, diseases, breeding problems and inappropriate management. This comprised 23% of the attainable output from the sector in 2002/03.

Feed and fodder scarcity is the main limiting factor to improving production and productivity. Output worth Rs 162 billion a year is lost due to inadequate supply of feed and fodders. Diseases cause an annual loss of Rs 132 billion, and breeding problems add another Rs 83 million to it. The magnitude of losses however varies across species. Nearly 30% of the attainable output of cattle and pig, 16–17% of buffalo and goat and 40% of sheep is lost due to different constrains.

Serious concern has been raised recently on the long run sustainability of the productivity effects of Green Revolution technologies in the light of decelerating trend in the yield growth of rice since the mid 1980s under irrigated ecosystem. However, the changes in physical yield are not true measures of productivity from efficiency perspective. Total factor productivity (TFP) is a true measure of economic efficiency of any technology impact. The study addresses this crucial issue empirically by analyzing TFP.

TFP grew at average rate of 1.2–1.3% per annum during Green Revolution (GR) period in the irrigated areas of Andhra Pradesh and Punjab. But, the TFP growth declined rapidly between early and late GR periods in Punjab and Karnataka. On the contrary, TFP growth picked up in the rainfed areas as modern variety (MV) adoption increased after 1980s.

Results suggest that various modern technologies (such as MVs) adopted by the farmers over the period have continuously affected rice productivity growth as reflected in the increasing trend of TFP growth. However, rate of increase in TFP growth decelerated under the irrigated ecosystem during the late GR period. This implies that 'level' of productivity impact of the successive generations of modern technologies (such as new MVs) has apparently been going down, which is not unusual to experience plateau or deceleration in TFP growth in the progressive areas (irrigated ecosystem) because TFP levels can not be increased at the same rate during the late GR period as it was during the early GR period.

It is a matter of concern that despite four-fold increase in food production, the food security in the country has raised doubts on sustainability and raising anxiety in the food production front. Rice is a choice crop of the millions of poor and small farmers not only for income but also for household food security, therefore any deficiency in production will have serious implication on the whole.

Historical analysis shows that the phenomenal pace in increase in rice production has been uneven and the regional disparity is highly pervasive among the states and across the diverse ecosystems. Clearly, the gain due to modern rice technology has been discriminatory against the resource poor areas, which is also dominated by small and marginal farmers. The rice production growth rate has been depicting a picture in the shape of an inverted bowl, which is a matter of concern.

The trend analysis of 10-yearly moving average and growth in rice production brings out the changing pattern of rice production system across the state (eg. in Punjab on one hand and Orissa on the other hand).

**Total factor productivity growth of rice in principal growing states**

(% per year)

| State | Period | Output growth | Input growth | TFP growth |
|---|---|---|---|---|
| Andhra Pradesh | Early GR | 2.85*** | 2.16** | 0.69** |
| | Late GR | 1.97** | 0.01 | 1.96** |
| | Overall GR | 2.43*** | 1.13** | 1.30** |
| Karnataka | Early GR | –0.46 | –1.51* | 1.04** |
| | Late GR | 2.44** | 2.84*** | –0.40 |
| | Overall GR | 1.28** | 1.10* | 0.18 |
| Punjab | Early GR | 4.72*** | 1.10** | 3.62*** |
| | Late GR | –0.92** | –0.12 | –0.79* |
| | Overall GR | 1.67*** | 0.44* | 1.23** |
| Uttar Pradesh | Early GR | 2.52*** | 0.05 | 2.48** |
| | Late GR | 0.72* | 0.14 | 0.58* |
| | Overall GR | 1.51** | 0.10 | 1.41** |
| Assam | Early GR | 1.30* | 0.53* | 0.76* |
| | Late GR | 0.91* | 0.24 | 0.68* |
| | Overall GR | 1.11* | 0.39 | 0.72* |
| Bihar | Early GR | 0.14 | 1.13* | –1.00* |
| | Late GR | 3.79*** | –0.57* | 4.36*** |
| | Overall GR | 1.15* | 0.66* | 0.49* |
| Madhya Pradesh | Early GR | 2.25** | 1.15* | 1.10* |
| | Late GR | 0.81* | 1.35** | –0.55* |
| | Overall GR | 1.53** | 1.25** | 0.28 |
| Orissa | Early GR | 1.18* | 0.96* | 0.22 |
| | Late GR | 2.79*** | 0.44* | 2.36** |
| | Overall GR | 1.89** | 0.73* | 1.16** |
| West Bengal | Early GR | 2.88** | 1.00* | 1.89** |
| | Late GR | 2.07** | 1.13* | 0.94* |
| | Overall GR | 2.49** | 1.06* | 1.43** |

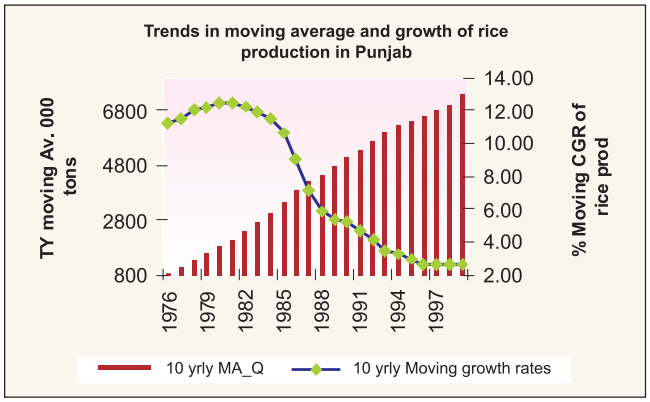
***, **and *indicate 1%, 5% and 10% probability levels of significance respectively.

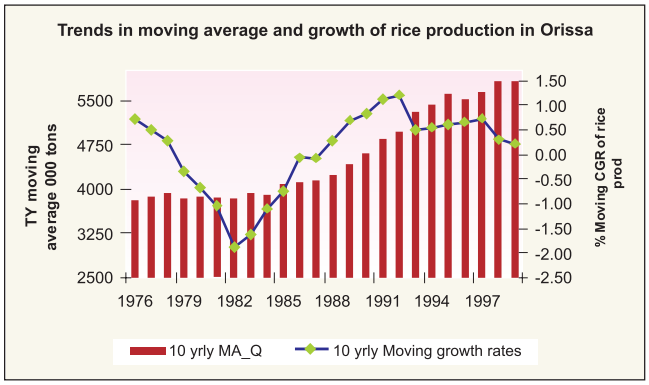
**Decadal compound growth of area, production and yield on rice in India**

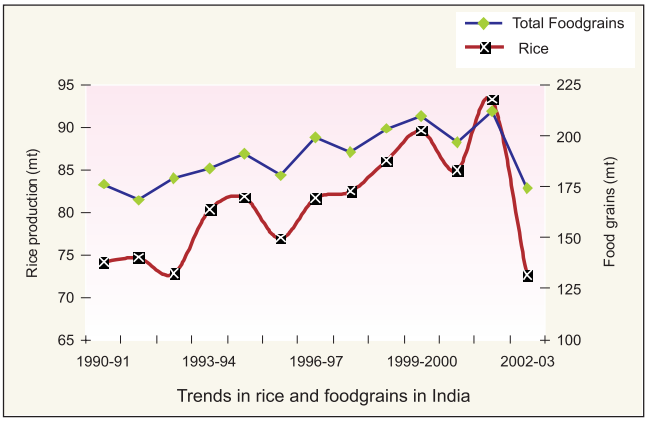
| | 1970s | 1980s | 1990s |
|---|---|---|---|
| Area | 0.87 | 0.42 | 0.35 |
| Yield | 1.05 | 3.62 | 1.32 |
| Production | 1.92 | 4.04 | 1.68 |

The regional dimension of rice production systems depicts an interesting contrasting picture. The irrigated rice in Punjab shows a highly progressive picture where the average production reached nearly 7.36 million tonnes of rice production in 1999–00, while the moving compound growth rate of production went down from more than 10% in early 1980s to a low of 2.58% in 1999–00. As against this, the same in rainfed rice in Orissa shows a diametrically opposite and unequal picture. The average production was 5.8 million tonnes in 1999–00 and the growth rate stagnating below the 1% per annum. The regional picture is also an identical picture between developed and less developed region.

Hence the green revolution bypassed the less developed rice production system in eastern India and it is now required to play more innovative role in future.




Rice seems to set trend in overall food production, where both rice production and food grain moves identically. The production of food grain decreased to 174 million tonnes in the dialectic is that while combined areas under wheat and rice is stagnating around 69 million ha (57% of area under foodgrains), at the same time, the productivity of rice in over two-third area has been hovering around 2 tonnes/ha, which affects the household food security of the millions of small and poor farmers, a phenomenon, likely to reach an un-manageable situation in future. The low productivity and vulnerability to natural calamities push a large number of the population towards abject poverty. It, therefore,

**Share of area, production and yield of rice during 1999–2000 and 2000–01 in major rice producing states**

| Zones | 1999–2000 | | | 2000–01 | | | |
|---|---|---|---|---|---|---|---|
| | Area % | Production % | Yield (t/ha) | Area % | Production % | Yield (t/ha) | Irrigation % area |
| East Zone | 66 | 55 | 1.61 | 65 | 52 | 1.36 | 36.0 |
| North Zone | 8 | 13 | 2.87 | 8 | 14 | 3.03 | 94.8 |
| South Zone | 18 | 25 | 2.72 | 18 | 27 | 2.73 | 79.0 |
| West Zone | 5 | 4 | 1.58 | 5 | 4 | 1.42 | 49.7 |
| All India | 100 | 100 | 1.99 | 100 | 100 | 1.91 | 52.3 |

Source: Govt. of India, 2003, Agriculture Statistics at a glance, Ministry of Agriculture, New Delhi

**Institutional innovations: a driver for rural prosperity**

Rural institution is a crucial instrument to carry forward innovations and policy. Because, agriculture development being a public good, the individuals can rarely performs efficiently. Lack of efficient institution at rural areas thus hinders proper implementation of projects and hence failed in the"reach out" to the stakeholders. The mode of institution formation, functioning and role played by a mega institution in Assam was studied. The FMC (Field management Committee, locally known as called PPS- *pather parichalana samiti*) is a village level institution, which normally has about 50 voluntary members, possessing land holdings in the contiguous areas facilitating collective management. A little known institution in the country has been involved in many useful rural activities. Total FMCs are about 26, 000 covering almost every village in the state. A unique aspect is that the government recognised the FMC as village intermediary for schemes like million STW (shallow tubewell schemes), SKY (Samridhi Kisan Yojana of the Government of Assam), and for several NABARD schemes. Some of them are performing extremely successfully, although majority of them are not been able show any impact publicly. On the whole, as usual the *bads* are multiplying as free-rider and *goods* are not replicated in the required pace. To understand the impact of such a mega organisation, in-depth studies are required. Because, there is hardly any study undertaken to assess performance and evaluate the FMC for future improvisation. Actually, the FMCs helped the farmers

- in capacity building
- access to information, and
- forming cohesive groups for their well being.

This has increased the crop production and enhanced adoption of modern technology including crop diversification. A typical impact of the FMC, according to the villagers is that after formation of FMC, the villagers benefited to the extent of changing the desperate situation of enabling two-meals a week from their own food production to a most successful case of two-meals a day due to FMC-led innovations in agriculture. In another case, it was found that before the formation of FMC, the farmers were unaware of the existence of a agricultural research centres in the vicinity of their village, now they participate in several forums organised by the agricultural university and government departments to get benefits from the modern innovations. Comparison of few case studies revealed an interesting contrasting picture of success stories and the failures. The study brings out useful case studies depicting both the instances of organisational excellence and as well as laggardness. The findings provide excellent lessons in relation to pathways of rural organisational excellence.

implies the need for productivity enhancement and providing more entitlement to livelihood to the rice growing population, which is a major challenge to the agricultural research and development system. More particularly, the hub of green revolution state as Punjab, resorting to pro-agriculture diversification policy, which divert rice-wheat area in favour of other crops follow this new path and Tamil Nadu and Andhra Pradesh follow the suit, it may create an unexpected vacuum in the food production frontier. The situation is particularly frightening while reckoning the historical production performance in eastern India.

The study brings out certain critical factors affecting food production, which require more policy attention.

- The enhancement of the productivity of rice and rice-based systems with special emphasis on regional priority is essential. Not only the development of modern and new technology but also imbibing the traditional base on the rice production systems need to be considered carefully.
- Effective policy advocacy for more demand-driven technology and reaching out to the target groups along with developing more resilient varieties to biotic and abiotic constraints, require due emphasis.
- The quality improvement in rice is another area requiring more careful attention to ensure a niche in rice export.
- The need for regionally differentiated research and development is advocated, and intervention strategies identified.
- Immediate attention is required on the aspect that the overall annual growth of rice production is significantly lower than that of the population growth.

The contribution of Information and Communication Technology's (ICT) to national development has been steadily increasing since early 1990s. Special efforts are made to exploit the potentials of ICT for agricultural development.

The series of revolutions led to national food security but the agricultural sector is facing the challenges of diminishing land/ natural resources, increasing biotic and abiotic stresses, indications of factor productivity decline, economic inequality etc. Further Indian agriculture has come under significant adjustment pressure from market liberalization and globalization. New information intensive extension system has to be more diversified and demand-driven. To perform this broad based role, ICT can play complimentary role, because, it has the merits in terms of more subject matter coverage, decision support, direct access to information, minimize time and distance barriers, empower rural intermediary organizations. Thus, ICT has the potential to facilitate cost-effective production, vertical integration, improve value added marketing, minimize transaction costs, improve communication efficiency, encourage competitiveness and accelerate growth.

Realizing this, National Agriculture Policy of India has

**Some innovative ICT-based initiatives in Indian agriculture**

| Project | Name of organization | Important features | Subject matter area |
|---|---|---|---|
| (a) Public Sector<br>Cyber extension project | National Institute of Agricultural Extension Management (MANAGE), Hyderabad | Village information centers, institutional support to other ICT projects | Post harvest processing, women and child welfare |
| Help-line service | Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT), Kanpur | Helpline service through telephone, researcher-farmers linkage | Cultivation practices, plant protection, new technologies |
| Gyandoot project | Grama Panchayat, Community, Dhar district, Madhya Pradesh | Soochanalayas, Portals, Partial recovery, Panchayat-community partnership | Agriculture produce, market intelligence, auction rates, land records |
| (b) Private Sector<br>E-*Choupal* | Indian Tobacco Company, Madhya Pradesh | e-*choupal*, crop specific intranet | Market price, cultivation practice, weather |
| I-kisan portal | Nagarjuna group, Andhra Pradesh | Portal in regional languages | Agricultural practices, plant protection, animal husbandry, weather |
| (c) NGOs<br>Village Knowledge Center | M S Swaminathan Research Foundation (MSSRF), Chennai | Knowledge center, pro-poor, pro-nature, pro-women, community ownership | Agronomic practices, cattle, feed, weather, schemes |
| Computer on wheels | Pingali Rajeswari-entrepreneur, Andhra Pradesh | Internet on motor bikes, portals, remote area, resource poor | Market, weather, plant protection, animal health |

**Differential features of selected ICT-based initiatives**

| Features | Public sector | Private sector | NGOs |
|---|---|---|---|
| Investment | Funds from central and state governments | Company expenditure | Funds from international organizations, state governments, etc. |
| Area of interest | Research, education, training and capacity building | Business goals with social orientation | Uplifting of remote area people |
| Salient services | Researcher-farmer linkage, call centers | Input-output marketing, technology dissemination | Agriculture and animal husbandry, social developmental work |
| Working areas | Based on the research and training needs, villages/districts | Commercial, strong marketing areas of the companies | Remote and socially under-developed areas |
| IT facilitator at the grass root level | Government officials, trained local personnel | Local trader, professional personnel | Volunteers from local areas and service-oriented personnel |
| Goals | To make a role model for agriculture and the allied development | To generate economic benefits for the people as well as company | To create awareness about socio-economic benefits of innovative technologies |

emphasized to revitalize the 'Agricultural Extension Services' using ICT for communication between researchers, extension workers and farmers The Government's supportive policy has influenced the role of emerging pluralistic extension system in India in application of ICT in agriculture also. Public sector institutions (e.g. Department of Agriculture, research institutes, State agricultural universities), NGOs, cooperatives and various private firms (farm-related input marketing firms), are actively

**Constraints experienced by the beneficiaries**

| Constraints | Organization/Percentage | | | | | |
|---|---|---|---|---|---|---|
| | E-C | IK | HL | COW | GD | MAN |
| Regional specific information-insufficient | 25 | 55 | | 40 | | 50 |
| Subject matter-inadequate | 25 | 10 | 37.5 | 62.5 | | 45 |
| Not suitable to all information | 20 | - | 30 | | | |
| Support from facilitator-inadequate | 10 | 35 | | | | 37.5 |
| Facilitator's knowledge is inadequate | 52.5 | 30 | | 25 | | 35 |
| Facilitator is required | | | 50 | | | |
| Lack of infrastructure facility | | 62.5 | | | 55 | 30 |
| Internet/phone connectivity inadequate | | 50 | 50 | | 50 | 47.5 |

E-C:E-*choupal*, IK: I-*kisan*. HL: Helpline service, COW: Computer on wheels, GD: Gyandoot, MAN: MANAGE

venturing into ICT-based initiatives for providing information on agricultural technology, production, processing, marketing and other farm-related aspects.

### *Constraints in ICT based initiatives*

The utilization of ICT in agriculture and rural development in India is facing many field problems, while translating any ICT model into reality. For instance, among the various constraints reported by the beneficiaries in different initiatives, subject matter inadequacy and lack of content in local language were prominent constraints. Facilitator's cooperation and his subject matter knowledge skills were perceived as some of the significant constraints by more than one-third of the respondents. About half of the respondents expressed irregular internet connectivity as one of the major constraints, except case of initiatives like *e-choupal* and computer on wheels. These two initiatives had used solar cell and battery back up for the regular power supply and the e-choupal had VSAT connectivity whereas COW had GPRS connectivity. Farmers faced constraint to use helpline due to very low teledensity in the rural Uttar Pradesh (0.56 phones per 100 people by March 2003.

### *Strategies and policy options*

Each initiative is a unique model in the application of ICTs to agriculture and has merits and constraints of its own. The study also helped in learning lessons from these initiatives for up scaling ICT-based initiatives. Accordingly, the following suggestions would be useful in framing appropriate strategies for greater use of ICT in agriculture sector.

- Involve local people in content development as in village knowledge centre' to assess information needs and collection of indigenous knowledge, which can be synthesized, with information from experts/institutions
- Prepare user-friendly content in the regional languages also with visuals
- In kiosks, supplement the digital information with public address system, vernacular print media, and bulletin boards for wider dissemination
- Use alternative technologies to substitute electricity (batteries and solar panel) and telephone connectivity (wireless network), use space in rural institutions (*Panchayat* office, school, temple) to overcome infrastructure barriers (e.g. Soya-choupal, Village knowledge centre)
- Appoint facilitators exclusively for information service; they should be motivated and accountable, well qualified with adequate knowledge on subject matter and computer operation
- Support these initiatives by other quality services and rural infrastructure (extension expert's advice, market access, transport service, roads, development schemes etc.) to translate knowledge-based decisions into actions without bottlenecks
- Encourage networking of institutions and public-private partnership for improving rural teledensity, information generation and delivery, capacity building of the facilitators etc
- Public sector institutions have to play a greater role in synthesizing information while private sector institutions and NGOs disseminate it through information centres

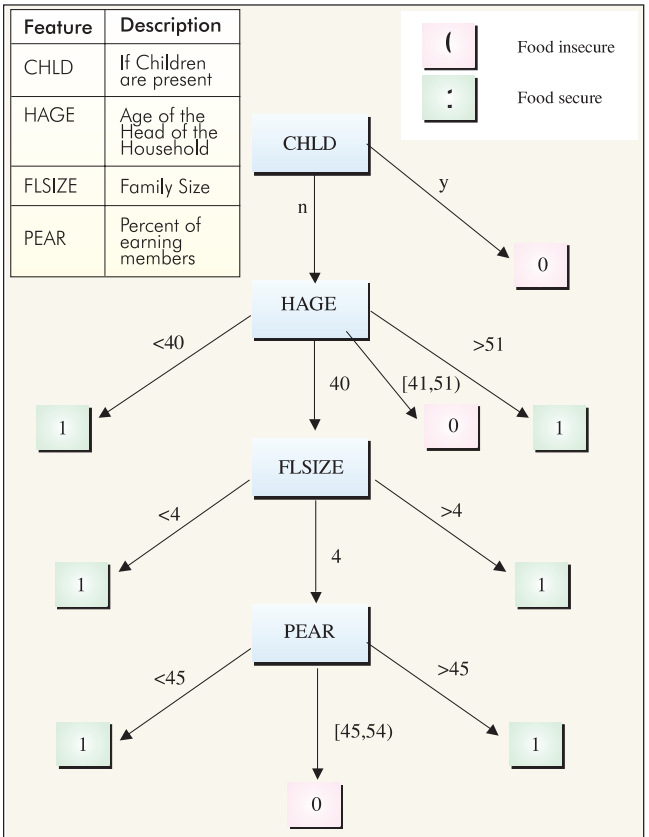
### Identifying vulnerable and food insecure households

Dynamic rough set based decision tree induction (Dynamic RDT) model was developed to extract rules and patterns which can identify vulnerable households. The produced ruleset is aimed to help in identification of the households which are vulnerable to food shortage. Nutrition dataset, a primary survey data of 180 rural households in Dharampuri district of the state of Tamil Nadu in India, is used for the demonstration. The dataset was collected for an independent study and was not manipulated for

**Comparison of dynamic RDT with linear discriminant analysis**

| Algo | Accuracy | Number of rules | Number of features |
|---|---|---|---|
| Dynamic RDT | 73.00 | 9 | 4.0 |
| Linear discriminant analysis | 71.1 | – | 8.0 |

| Feature | Description |
|---|---|
| CHLD | If Children are present |
| HAGE | Age of the Head of the Household |
| FLSIZE | Family Size |
| PEAR | Percent of earning members |




A simplified decision tree induced using the entire data of Nutrition dataset using Dynamic RDT algorithm

experiments with the proposed model.

The estimated accuracy as obtained by using linear discriminant analysis (LDA) is used as a benchmark for comparing accuracy of the proposed model called dynamic RDT. LDA approach does not provide the rule based model hence number of rules are not possible in this approach. Also number of features that are required to predict the vulnerable and food insecure households using the developed model is 50% less as compare to the LDA along with comparable accuracy and improved understandability.

Several other data mining approaches were also experimented on the dataset. The estimated performance of the proposed model is better for the dataset.

**Forecasting techniques in agricultural system**

Models based on weather indices (simple/weighted total of values of weather variables and product off weather variables taken two at a time) were developed and validated for cotton (Whitefly, pink bollworm, American bollowrm for Lam) and rice (gall midge for Cuttack). Forecasts of subsequent years, not included in model development, were close to the observed values in all the cases.

Logistic regression models were developed for qualitivative data on alternaria blight and white rust in mustard crop. The forewarnings on the basis of models using two categories were satisfactory in al the cases artificial neural network (ANN) technique has been tried for powdery mildew in mustard (S.K. Nagar). The data of four years for forecasting maximum severity, crop age at first appearance and peak severity, were used. Technique worked very well for forewarning crop age at first appearance of disease whereas for other character further refinement is needed. A flexible Central Data warehouse (CDW) of agricultural resources of the country was developed at the IASRI, new Delhi, and was probably the first attempt of data warehousing of agricultural resources in the world. This provided systematic and periodic information to research scientists, planners, decision makers and developmental agencies in the form on On-line Analytical Processing (OLAP) decision support system. This project was implemented with active collaboration and support of NBSSLUP, Nagpur (for soil resources); CRIDA, Hyderabad (for agro-meteorology); PDCSR, Modipuram (for crops and cropping systems); NBAGR, Karnal (for livestock resources); NBFGR, Lucknow (for fish resources); NBPGR, New Delhi (for plant genetic resources); CIAE, Bhopal (for agricultural implements and machinery); CPCRI, Kasaragod (for plantation crops); IISR, Calicut (for spices crops); ICAR Research Complex for Eastern Region, Patna (for water resources); NRCAF, Jhansi (for aro-forestry) and IIHR, Banglore (for horticulural crops). Subject-wise data marts were created; multidimensional data cubes developed and published on Internet/Intranet. The web site and the project is already launched (www.inaris.gen.in) and the multidimensional cubes, dynamic reports, GIS maps, adhoc-queries and information systems are already available to the users. The information of this data warehouse are available to user in the form of decision support system in which all the flexibility of the presentation of the information, its on-line analysis including graphic is inbuilt into the system. The systems also provides facility of spatial analysis of the data throuh web

using functionalities of geographic informations system (GIS). Apart from this, subject wise information systems have been developed for the general users.

**Cropping systems research**

Under AICRP on long-term fertilizer experiments conducted at Ludhiana, revealed that in the presence of residual P fertility of 82 kg/ha the reduction of P application by half under 100% NPK original treatment proved effective in sustaining the respective average yield levels of 31.85 and 48.71 q/ha of maize and wheat compared to the corresponding yields with optimal P application. With complete P omission under 100% NPK(-S) treatment the sustainable average maize and wheat yields were 28.8 and 45.10 q/ha. The depletion of available zinc from the initial level of 2.7 mg/kg to 0.62 mg/kg over the years at Pantnagar, became a yield limiting factor under the 150% NPK+S treatment. Its replenishment @ 25 kg $ZnS0_4$/ha significantly enhanced the average rice and wheat yields over the corresponding yields obtained without zinc application. The trend analysis of available phosphorus in soils under optimal and super optimal NPK treatments over the years indicated its huge build up of 169.7 kg/ha over its initial value at Palampur and at Barrackpore, indicating need of management intervention for rescheduling P application to enhance efficient fertilizer use and economic profitability of the fertilizer added to the cropping systems. On the basis of trials conducted on farmers' field adopting only the improved varieties and continuing with existing practices for rice and wheat crops, the increase in productivity was 10.89% and 10.30% respectively. In case when farmers had adopted improved varieties along with recommended dose of fertilizer, the increase in rice and wheat production was 25.71% and 28.85% respectively. The increase in productivity for rice crop owing to adoption of new varieties varied from 2.38% for Punjab to 16.61% in Maharashtra state under farmer's existing practices. In case of adoption of new varieties of rice along with recommended fertilizer doses, Punjab has shown decrease in production up to 1.07%, due to use of higher fertilizer dose 150 kg/ha of N + 40 kg/ha of P by farmers than the recommended dose of 120 kg/ha N. A database of Experiments on Long Range Effect of Continuous Cropping and Manuring on Soil Fertility and Yield Stability, for online storing and retrieving the data for different centres was prepared. Database for the project on Statistical and Algorithmic Approach for Improved Estimation of Treatments Effects in Repeated Measurements Designs, has been designed and parameters of 50 repeated measurements designs (RMDs) catalogued from literature were entered into it. Computer softwares have been developed in Visual Basic for the generation of various types of RMDs. Under design and analysis of experiments for spatially correlated observations in block design setup, the coefficient matrix of reduced normal equations for estimating treatments contrasts was obtained for a nearest neighbour correlation error structure and first order autocorrelation error structure. At Faizabad, normal method of wheat sowing provided maximum gross returns from rice-wheat sequence compared to late, transplanting and zero tillage methods.

**Experimental designs for agricultural,animal and agroforestry research**

A project entitled 'Studies on block designs for bioassays' was undertaken to obtain and catalogue optimal/efficient block designs for bioassays.

The following are some of the salient achievements.

(i) Optimality of block designs for multiple parallel line assays that allow estimation of three contrasts of major importance but do not necessarily allow the estimability of other treatment contrasts was also studied and a method to obtain such designs was developed. A catalogue of 35 A-optimal block designs for $3 \leq m \leq 8$, $8 \leq k \leq 16$, $k < 4m$, $bk \leq 100$ was prepared for one standard and three test preparations.

(ii) A-optimal block designs for asymmetric slope ratio assays were obtained. A catalogue of 61 A-efficient block designs for asymmetric slope ratio assays was prepared. Wherever, A-optimal design is not obtainable a lower bound to A-efficiency is provided.

(iii) Besides cataloguing optimal/efficient block designs obtained in the studies on block designs for biological assays, a catalogue of the designs obtainable from the methods of construction available in literature is also prepared. A-optimality aspects of these designs for parallel line assays were investigated. None of the designs in the parametric range $3 \leq m \leq 6$, $4 \leq k \leq 10$, $bk \leq 50$ were A-optimal for inferring on the contrasts of interest. Indeed it is possible that some designs with parameter combinations beyond these parameter combinations may turn out to be A-optimal.

The analysis of crop data on agro forestry experiment pertaining to various characters received from the collaborative center revealed that performance of the under storey crop was affected by the tree species and the distance of the crop from the tree base. The yield increased as the distance increased. The RBD analysis of tree data with 12 treatment combinations (4 tree species with 2 crops along with 4 sole trees, i.e. $4 \times 2 + 4$) in 2 replications indicated the treatment effects as significant. The crude protein yield was significantly different in group containing babul indicating the effect of crops on babul. Trend-free binary variance balanced block designs under homoscedastic model and heteroscedastic model (error variance proportional to some

power of block size) were obtained when there is uniform trend within the blocks. Trend-free nested balanced incomplete block designs, when the trend effect is in nested blocks, were also obtained.

**Assessment and evaluation studies**

To finalise the farm mechanization strategies in the country a study was carried out. A large scale survey, adopting stratified multi-stage random sampling design, was planned and conducted in 120 randomly selected districts through 24 Centres (21 Centres of AICRP on FIM; GAU, Gujarat; SKUAST, Jammu; NDUAT, Faizabad) spread nation-wide. The analysis of data for all the states was carried out and the mechanization strategy draft for different agro climatic zones/states was submitted.

To develop a user friendly software for the imputation of missing data based on neural network based imputation concept along with other alternative methods of imputation, requirement analysis was done.

**Production and area estimation**

For studying the methodology of estimation of wool production a pilot study was taken up. The estimates of sheep number, average wool yield and total wool production for Kolar and Bikaner districts were prepared and finalised. The difference in estimates obtained by using different estimators was also tested.

From the study, "On efficient block level estimators of yield rates of important crops", the accuracy comparison of crop cut estimates and the farmers' estimates were made with actual production values. The crop cut estimates by and large were close to the actual production figures for crops harvested in multiple pickings, cotton, etc. The percentage standard errors of the estimates were obtained through crop cut approach.

**Cost of production studies**

Sampling methodology was developed for estimation of cost of production of coconut in Kerala. It revealed that technologies such as basin opening and application of organic manures were the most commonly adopted practices; plant protection, spacing for optimum plant density and cultivation of hybrid/high yielding varieties showed low level of adoption; applications of chemical fertilizers, irrigation, intercultural operations, inter/mixed cropping and mixed farming was having medium level of adoption.

Under the project 'On development of methodology for productivity of important flowers' estimated production of loose flowers on the basis of market arrival from Delhi as well as outside Delhi was studied. Percentage standard errors of the estimates of different kind of flowers traded in three flower *mandis* of Delhi clearly indicated the applicability of sampling methodology adopted.

**Technological change, risk and uncertainty in agriculture**

An econometric study of technological dualism in egg production was based on primary survey data of selected poultry farms in two districts Mansa and Ludhiana of Punjab state. Major factors influencing egg production are feed, labour, medicines and electricity costs. On cage system and deep litter types of farms most of the input variables except for feed cost were not properly utilized. If the poultry farms using deep litter system shifts over to cage system of technology there may be a substantial saving in the input resources. The existence of technological dualism in egg production revealed that inputs were not being efficiently used on deep litter farms. Factor share analysis in district Mansa revealed that the share of labour factor remained about 4 %, the share of poultry feed which is a proxy variable for capital, was maximum of about 62 % on both types of farms.

The study on 'Technical efficiency analysis of rice-wheat system in Punjab', revealed an ardent economic viewpoint that the majority of farmers in Punjab did not appear very far from frontier but there existed possibilities of increasing rice and wheat output with better use of technical skills at least in deployment of factors of production under farm control efficiently.

**Modeling for agricultural marketing**

The host wise details of brood lac in Jharkhand state were obtained. The annual average income of different host trees from lac cultivation were — in ber host income on small farms was Rs 545, on medium farms Rs 272, and on large farms Rs 224. Income from *palas* host on small farms was Rs 319, on medium farms Rs 405 and on large farms Rs 537. In *kusum* host income on small farms was Rs 641, on medium farms Rs 1,073 and on large farms Rs 868.

**Food security and poverty alleviation**

The study was based on primary data collected for base year, 2001 and the year 2004 on household food and nutritional security for tribal, backward and hilly areas under 'Jai-vigyan national science and technology mission project'. Technology intervention improved the benefits from sheep husbandry resulting in food security and poverty alleviation in the studied areas.

Under the study 'Determinants of performance of self-help groups (SHG) in rural micro-finance', the divergences between Andhra Pradesh and Uttar Pradesh states in terms of agro climatic and socio-economic parameters was examined. SHG progress was very fast in Andhra Pradesh compared to Uttar Pradesh. This scenario rejected the hypothesis that there should be a higher positive correlation between female population and number of SHGs.

**Software development**

Statistical package on Agricultural Research (SPAR 2.0) was

developed. The package consists of the following eight modules, which have sub-modules for various type of data analysis:

- Data management—(i) Editing of data (ii) Transformatin of data
- Descriptive Statistics—(i) Measures of Central Tendency, (ii) Measures of Dispersion, (iii) Generation of Moments, (iv) measures and Coefficients of Skewness, (v) measures and Coefficents of Kurtosis (vi) Measures of Partition Values
- Estimatino of Breeding Values—Generations Means (Six Parameter Model, Five Parameter Model, Three Parameter Model) and scaling and Joint Scaling Tests
- Correlation and Regression Analysis—Estimates of the Regression Coefficients, Analysis of Variance of Regression, and Regression Equations (linear regression or multiple), Simple Correlation, Partial and multiple Correlations, Validity of Test of Significance and Path Analaysis.
- Variance and Covariance Components Estimation—Computation from ANOVA, Components of Variances such as Phenotypic Coefficient of Variation and heritability (borad sense), Standard Error and Critical Differences, Bivariate Analysis of Variance and Covariance Components such as Phenotypic Covariance, Genotypic Covariance
- Stability Analysis—(i) Eberhart and Russell's, (ii) Perkins and Jinks' (iii) Freeman and Perkins' Models
- Multivariate Analysis—(i) Cluster Analysis, (ii) Discriminent Analysis (iii) Principal component Analysis
- marting Design Analysis—(i) Complete Diallel, (ii) Partial Diallel, (iii) Line × Tester (with parents), (iv) Line × Tester (without parents), (v) Three Way Cros, (vi) Double Cross (vii) North Carolina Designs Analaysis.

**Training programmes**

Several training programmes were conducted at the IASRI, New Delhi.

1. Senior Certificate Course in Agricultural Statistics and Computing was organized for the benefit of research workers engaged in handling statistical data collection, processing, interpretation and employed in research Institutes of the Council, State Agricultural Universities and State Government Department, etc. and foreign countries including SAARC countries. The main objective of the course was to train the participants in the use of latest statistical techniques as well as use of computers and software packages.
2. Winter School on 'Sample Survey Techniques in Agricultural Research'.
3. Recent Advances in Biometrics under Centre of Advancd Studies in Agricultural Statistics and Computer Application.
4. Advances in Designing and Analysis of Agricultural Experiments.
5. Sampling Techniques, Sample Surveys and Methodological Aspects relating to Cost of Cultivation Studies.
6. Statistical tools for data analysis.
7. Working with INARIS data warehouse.
8. Exposure and usage of Personal Management Information System
9. Large Sample Survey.

# Technology Assessment, Refinement and Transfer

Krishi Vigyan Kendra (KVK) is a major project of the Council for technology assessment, refinement and transfer. At present, there are 500 KVKs in State Agricultural Universities, ICAR Institutes, NGOs, State Governments and other institutions.

- KVKs conducted on-farm trials on 1,318 technologies to identify the location specificity under different farming systems.
- ZTSD on rice-wheat system not only increased yield but also lower the cost of land preparation.
- Puddling in paddy with soil pulverizing roller saved 90 cm of water per hectare with an increase in yield of 2.4% over conventional method of puddling.
- Adoption of IPM gave 32% increase in yield over control with an average yield of 2.05 tonnes/ha in pigeonpea.

The major activities of KVK are enumerated here.

**On-farm Trials**

A total of 1,318 technologies were taken up for on-farm trials by the KVKs in order to evaluate and assess their impact on location-specific basis in different farming systems including varietal/feed evaluation (562), nutrient feed management (293), cropping system (97), resource conservation (35), weed management (62) and insect/disease management (269).

***Performance of zero-till seed-cum-fertilizer drill (ZTSD):*** Zero-tillage trials were conducted by 16 KVKs (7 of Haryana and 9 of Punjab) to make the farmers aware of the use of zero-till drill for sowing of wheat. The wheat sown by zero-tillage gave more yield by 6.7% in Haryana and 4.1% in Punjab than conventional method of sowing

***Leaf Colour Chart (LCC) based nitrogen management in paddy in Haryana:*** In Faridabad district, paddy is transplanted with a basal dose of 20 kg urea/acre. On-farm trials were conducted on LCC based nitrogen management in paddy (cv HKR 126) during *kharif* 2005. The application of nitrogen based on LCC with recommended plant population gave the highest

Sowing of wheat by zero-tillage at KVK, Chitrakoot, Uttar Pradesh

**On-farm trials by KVKs**

| Crops | Varietal/feed evaluation | Nutrient/feed management | Cropping system | Resource conservation* | Weed management | Insect/disease management | Total |
|---|---|---|---|---|---|---|---|
| Cereals | 230 | 75 | 34 | 11 | 30 | 57 | 437 |
| Oilseeds | 62 | 32 | 20 | | 4 | 29 | 147 |
| Pulses | 52 | 9 | 10 | 8 | 5 | 28 | 112 |
| Commercial crops | 28 | 16 | 8 | 1 | 0 | 33 | 86 |
| Vegetables, fruits and flowers | 135 | 85 | 25 | 15 | 13 | 102 | 375 |
| Animal Science | 55 | 76 | 0 | 0 | 10 | 20 | 161 |
| Total | 562 | 293 | 97 | 35 | 62 | 269 | 1,318 |

*Resource conservation technologies include zero-tillage, bed planting and LCC based nitrogen management

**Zero-tillage in wheat in Haryana and Punjab**

| District/KVK | Year | No. of farmers | Area (ha) | Average yield (tonnes/ha) | | % Increase over conventional tillage |
|---|---|---|---|---|---|---|
| | | | | Zero-tillage | Con-ventional tillage | |
| HARYANA | | | | | | |
| Kurukshetra | 1998–05 | 271 | 132.6 | 4.78 | 4.44 | 7.7 |
| Kaithal | 1997–05 | 123 | 121.3 | 4.39 | 4.12 | 6.6 |
| Panipat | 1999–05 | 153 | 70.5 | 4.80 | 4.57 | 5.0 |
| Faridabad | 2001–05 | 92 | 132.0 | 4.28 | 4.01 | 6.7 |
| Rohtak | 2002–03 | 18 | 56.0 | 4.72 | 4.67 | 1.1 |
| Sonipat | 2002–04 | 16 | 22.0 | 4.67 | 4.51 | 3.5 |
| Gurgaon | 2004–05 | 5 | 2.0 | 4.77 | 4.68 | 1.9 |
| Total/Average | | 678 | 536.4 | 4.56 | 4.31 | 5.8 |
| PUNJAB | | | | | | |
| Bathinda | 2002–05 | 56 | 111.4 | 4.52 | 4.39 | 3.0 |
| Faridkot | 2002–05 | 55 | 87.0 | 4.53 | 4.35 | 4.1 |
| Ferozepur | 2000–03 | 41 | 108.4 | 4.54 | 4.51 | 0.7 |
| Gurdaspur | 2000–03 | 52 | 47.7 | 4.60 | 4.58 | 0.4 |
| Kapurthala | 1999–04 | 57 | 179.7 | 4.99 | 4.83 | 3.3 |
| Nawanshahar | 2001–03 | 38 | 59.6 | 4.58 | 4.45 | 2.9 |
| Patiala | 1999–05 | 92 | 299.8 | 4.61 | 4.56 | 1.1 |
| Sangrur | 2002–05 | 201 | 154.8 | 5.27 | 5.17 | 1.9 |
| Hoshiarpur | 2003–04 | 10 | 20.0 | 5.05 | 5.03 | 0.4 |
| Total/Average | | 602 | 1,068.4 | 4.77 | 4.67 | 2.1 |

yield of 5.7 tonnes/ha with an improvement in yield of 2.2% over application of recommended dose of nitrogenous fertilizer. In Kaithal district, the application of nitrogen based on leaf colour chart basis with recommended plant population gave the highest yield of 6.35 tonnes/ha, with an improvement in yield of 2.1% over application of recommended dose of nitrogen fertilizer.

***Performance of soil-pulverizing roller and conventional method of puddling on paddy***: Puddling in paddy (cv PR 114) with soil pulverizing roller saved 90 cm of water per hectare with an increase in yield of 2.4% over conventional method of puddling in Patiala district of Punjab.

***Effect of pruning and mulching on yield and quality in Santa Rosa plum:*** On-farm trial was conducted on yield and quality in Santa Rosa plum in Solan district of Himachal Pradesh. The highest fruit yield (21.68 tonnes/ha) and maximum fruit weight (47.50 g) were recorded with 25–30% thinning of shoots along with $^1/_3$—$^1/_2$ heading back of shoots. The treatment also recorded the highest Benefit : Cost ratio of 3.95.

**Effect of pruning and mulching on yield and quality in Santa Rosa Plum**

| Treatments | Fruit size (mm) | | Fruit weight (g) | Yield (kg/) tree | Yield (tonnes /ha) | TSS (%) | Acidity (%) | Increase in yield over FP (%) |
|---|---|---|---|---|---|---|---|---|
| | Length | Breadth | | | | | | |
| FP | 36.4 | 33.2 | 34.4 | 48.5 | 13.43 | 11.10 | 0.60 | - |
| $T_1$ | 39.3 | 38.2 | 38.3 | 58.8 | 16.28 | 11.70 | 0.65 | 21.80 |
| $T_2$ | 40.2 | 39.4 | 44.2 | 67.0 | 18.55 | 11.50 | 0.52 | 38.12 |
| $T_3$ | 43.3 | 41.8 | 47.5 | 78.0 | 21.689 | 12.30 | 0.40 | 61.49 |

Sale Rate: Rs 8/kg

FP: No orchard management practices; $T_1$: 25–30% thinning of shoots; $T_2$: $T_1$ + $^1/_3$–½ heading back of shoots and $T_3$: $T_2$+ grass mulch

***Performance of groundnut varieties***: KVK in Kaimur district, Bihar conducted an on-farm trial with 5 varieties of groundnut. Among the varieties, TG 22 gave the highest average yield of 2.2 tonnes/ha followed by Birsa Bold (1.76 tonnes/ha). Among the short duration varieties (105 to 112 days duration), ICGS 1 gave higher yield of 1.48 tonnes/ha followed by 1.37 tonnes/ha and 1.14 tonnes/ha from ICGS 37 and BR 12 respectively.

***Performance of turmeric varieties***: The KVK in Bankura district of West Bengal conducted an on-farm trial for identification of suitable turmeric variety for red lateritic soil conditions. Out of 8 varieties, TCP 2 gave the highest yield of 92.5 tonnes/ha, followed by TCP 11 (87 tonnes/ha) and Kasturi (79.2 tonnes/ha).

**Performance of turmeric varieties in West Bengal**

| Variety | Yield (tonnes/ha) |
|---|---|
| R.Sonia | 50.2 |
| Nagaland local | 59.0 |
| RH 5 | 55.0 |
| Pct 13 | 59.0 |
| TCP 11 | 87.0 |
| Kasturi | 79.2 |
| TCP 2 | 92.5 |
| TCP 1 | 72.0 |

***Management of* Helicoverpa *and wilt in Chickpea***: The KVK in Basti district, Uttar Pradesh conducted an on-farm trial to identify suitable control measures for *Helicoverpa* and wilt disease in chickpea through IPM. Application of IPM module (HYV PUSA 256 + Trichoderma 4g/kg seed + spraying of 5% neem kernel extract + NPV 250 L.E./ha) gave 42% increase in yield.

**Management of *Helicoverpa* and wilt in chickpea in Uttar Pradesh**

| Treatments | Yield (tonnes/ha) | Increase in yield (%) |
|---|---|---|
| $T_1$– Use of variety Radhey | 1.22 | - |
| $T_2$– HYV Pusa 256 + Trichoderma 4 g/kg seed | 1.48 | 21 |
| $T_3$– $T_2$ + Spraying of 5% neem kernel extract | 1.61 | 32 |
| $T_4$– $T_3$ + NPV 250 L.E./ha | 1.73 | 42 |

***Management of population density and feed regulations in fishponds***: To increase the fish production through polyculture, optimum density of fingerlings and supplementary feeding (rice bran + mustard cake 1 : 1 @5 kg/day for first 3 months, 8 kg/day for next 3 months and 12 kg/day for next 3 months/ha) was suggested. The KVK in Basti district conducted an on-farm trial with 3 treatments. Using proper ratio of Indian and exotic fingerlings alone could increase the fish yield by 28%. This treatment in combination with use of supplementary feed gave 52% increase in yield.

In treatment $T_1$ (farmers' practice), the net income was Rs 39,000/ha by investing Rs 24,000/ha. In $T_2$, with an initial investment of Rs 23,000/ha, the net income was Rs 57,000/ha. Similarly by investing Rs 29,000/ha in $T_3$, the net income was Rs 75,000/ha.

***Increasing milk yield through mineral supplement for buffalo***: The KVK in Etah, Uttar Pradesh, conducted a trial with 3 treatments. The use of mineral supplement (Ostovet 100 ml/day) gave an average milk yield of 9.2 litres/day, which is 15% more than without the supplement.

**Feed management for buffaloes in Uttar Pradesh**

| Treatments | Milk production (litres/day) | Increase in yield (%) |
|---|---|---|
| $T_1$–Farmers' practice without mineral mixture | 8.0 | - |
| $T_2$–Mineral supplement (untimely 40g/day) | 8.6 | 6.97 |
| $T_3$–Mineral supplement (ostovet 100 ml/day) | 9.2 | 15 |

***Nutrient management in wheat***: The KVK in Satara, Maharashtra, conducted an on-farm trial on nutrient management to improve the low yield of wheat due to poor tillering and grain filling. The application of 120 kg N, 60 kg $P_2O_5$ and 60 kg $K_2O$ per ha along with spray grade of N,P and K at the time of tillering (19 : 19 : 19), flowering (0 : 52 : 34) and grain filling stage (0 : 50)

**Nutrient management in wheat with spray grade fertilizer**

| Treatments | Yield (tonnes/ha) | Increase in yield (%) |
|---|---|---|
| $T_1$–Imbalance use of fertilizers | 2.87 | |
| $T_2$–Application of 120 kg N, 60 kg $P_2O_5$ and 60 kg $K_2O$/ha | 3.24 | 12.94 |
| $T_3$–Application of 120 kg N, 60 kg $P_2O_5$ and 60 kg $K_2O$/ha plus spray grade 19:19:19 at the time of tillering, 00:52:34 at the timeof flowering and 0:0:50 NPK at the time of grain filling stage | 3.45 | 20.10 |

increased the yield by 20% over the farmers practice (2.87 tonnes/ha).

***Nutrient management in wheat based on soil test results in Pune, Maharashtra:*** The KVK in Pune district of Maharashtra conducted an on-farm trial with 3 treatments. The highest yield of 3.77 tonnes/ha was obtained with the application of 120 : 60 : 60 NPK kg/ha as per soil testing, which was about 23% more than yield under the farmers' practice (2.79 tonnes/ha).

**Nutrient management of wheat in Pune, Maharashtra**

| Treatments | Yield (tonnes/ha) | Increase in yield (%) |
|---|---|---|
| $T_1$–Farmers' Practice: Urea, SSP and MOP @10:26:26. | 2.79 | |
| $T_2$–Recommended dose of fertilizers 120:60:60 NPK Kg/ha as per soil test results | 3.42 | 22.27 |
| $T_3$–Recommended dose of fertilizers and use of spray grade multi-nutrient fertilizer @ 9% N, 9% $P_2O_5$ 9% $K_2O$, 2% Fe, 2% Mn, 2% Zn—5 litres/acre at 60, 90 days after sowing | 3.77 | 34.79 |

***Nutrient management of niger in Orissa:*** An on-farm trial was conducted by the KVK in Keonjhar district, Orissa, to increase the yield of niger through proper nutrient management with 4 treatments. Application of recommended dose of fertilizer (40 : 40 : 0 kg NPK per ha) gave 133% more yield than farmers practice (no fertilizer). Application of 50% recommended dose of fertilizer along with application of *Azatobactor* and PSB also gave 113% more yield than farmers' practice.

***Nutrient management of onion in Maharashtra:*** To improve the bulb formation and thereby the yield of onion through proper nutrient management, the KVK in Ahmedagar district, Maharashtra, conducted an on-farm trial with 3 treatments. It was found that application of 150 : 50 : 70 NPK kg/ha along with foliar application of P and K and vermiwash gave yield of 23.5 tonnes/ha which was 24% more than the yield under farmer's practice.

***Nutrient management of pomegranate in Maharashtra:*** To reduce the flower drop for obtaining higher yield of pomegranate, the KVK in Pune, Maharashtra, conducted an on-farm trial with 3 treatments including Planofix spray and balanced fertilizer application. Application of 625 : 250 :250 g NPK per plant and 2 sprays of Planofix @ 20 ppm gave 18% more yield than farmers practice.

***Management of white wooly aphid in sugarcane***: The KVK in Ahmednagar, Maharashtra conducted a trial with 3 treatments to identify suitable control measures for white wooly aphids attack in sugarcane. The practice of collecting and burning infested leaves, seed treatment with Malathion, paired row planting, release of bioagents, application of verticilium @ 2 kg/acre followed by neem oil spray @ 2 litre/acre gave yield of 8.79 tonnes/ha compared to that of pesticide spray alone (9.89 tonnes/ha) with 50% reduction in cost of plant protection.

***Integrated pest management for pod borer in pigeonpea:***To test the efficacy of integrated pest management on control of pod borer in pigeonpea, on-farm trial was conducted by the KVK in Bhopal district, Madhya Pradesh, with 3 treatments including farmers practice. Adoption of IPM gave 32% increase in yield over control with an average yield of 2.05 tonnes/ha.

**Management of white wooly aphid attack in sugarcane**

| Treatments | Yield (tonnes/ha) |
|---|---|
| $T_1$–Farmers practice: Spraying Methyl demeton @2ml/litre | 9.89 |
| $T_2$–Cutting and burning of infested leaves, seed treatment with Malathion, bio-agents-Conobathara/ Chrysoperla and need based Chemical sprays (Methyl demeton/dimethoate @2ml/litre) | 9.49 |
| $T_3$–Cutting and burning of infested leaves, seed treatment with Malathion, paired row planting, release of bio-agents Conobathara/Chrysoperla, application of Verticilium @2kg/acre followed by Neem oil spray @2 litre/acre | 8.79 |

**Integrated pest management for pod borer in pigeonpea**

| Treatments | Yield (tonnes/ha) | Increase in yield (%) |
|---|---|---|
| $T_1$– Farmers' practice (one and two spray of endosulfan) | 1.55 | |
| $T_2$– Polythin 40 + Chloropyriphos | 1.88 | 21.3 |
| $T_3$– IPM (SDP + Seed treatment + Nimbicidine + Pheromone trap +bird perches) | 2.05 | 32.2 |

**Integrated wilt management in chickpea**

| Treatments | Wilt incidence (%) | Yield (tonnes/ha) | Increase in yield (%) |
|---|---|---|---|
| $T_1$– Farmers' practice – use of seeds of available variety and no seed treatment | 20.5 | 1.28 | - |
| $T_2$– Use of farmers seeds + seed treatment with *Trichoderma viridae* | 6.2 | 1.52 | 18.75 |
| $T_3$– Use of seed of resistant variety of chickpea (JG 130) +seed treatment with *Trichoderma viridae* | 3.6 | 1.91 | 49.2 |

***Integrated wilt management in chickpea:*** The KVK in Bhopal, Madhya Pradesh, conducted an on-farm trial on chickpea with 3 treatments. Adoption of IPM including the use of resistant variety and seed treatment with *Trichoderma viridae* gave 49% more yield as compared to farmers practice and the wilt incidence was 20% in locally adopted variety (U 21).

**Frontline Demonstrations**

During the year, 35,064 demonstrations were organized on various aspects of crop production and fishery covering an area of 11,938.8 ha.

***Oilseeds:*** During the year, 15,787 demonstrations were conducted covering 5,918.4 ha on 13 oilseed crops. The increase

**Frontline demonstrations on oilseeds**

| Crop | No. of farmers | Area (ha) | Yield (tonnes/ha) | | Increase (%) |
|---|---|---|---|---|---|
| | | | Demonstration | Local | |
| Castor | 678 | 325.5 | 1.47 | 1.13 | 39.9 |
| Gobi Sarson | 511 | 113.3 | 1.15 | 0.86 | 42.6 |
| Groundnut (*kharif*) | 2,887 | 1,039.6 | 1.82 | 1.31 | 43.0 |
| Groundnut (*rabi*) | 905 | 418.0 | 2.14 | 1.55 | 37.9 |
| Linseed | 453 | 134.6 | 0.94 | 0.65 | 48.5 |
| Mustard | 3,992 | 1,374.1 | 1.31 | 0.95 | 43.1 |
| Niger | 598 | 168.0 | 0.38 | 0.24 | 66.0 |
| Raya | 559 | 254.0 | 1.44 | 1.06 | 39.3 |
| Safflower | 231 | 106.6 | 0.92 | 0.74 | 24.4 |
| Sesame | 1,463 | 616.0 | 0.65 | 0.84 | 46.3 |
| Soybean | 1,572 | 617.3 | 1.60 | 1.18 | 39.0 |
| Sunflower | 963 | 466.6 | 1.45 | 1.13 | 31.9 |
| Toria | 975 | 284.9 | 0.95 | 0.67 | 52.0 |
| Total/Wt.Average | 15,787 | 5,918.4 | 1.38 | 1.05 | 31.4 |

Frontline demonstration on GCH 6 variety of castor at KVK, Jamnagar, Gujarat

Frontline demonstration on mustard variety Kaushal at KVK, Barmer, Rajasthan

**Frontline demonstrations on pulses**

| Crop | No. of farmers | Area (ha) | Yield (tonnes/ha) | | Increase (%) |
|---|---|---|---|---|---|
| | | | Demonstration | Local | |
| Bengalgram | 1,911 | 643.8 | 1.36 | 0.97 | 42.9 |
| Blackgram | 1,263 | 378.3 | 0.82 | 0.60 | 40.6 |
| Field Pea | 429 | 81.8 | 2.09 | 1.65 | 32.8 |
| Greengram | 1,111 | 416.3 | 0.80 | 0.55 | 47.8 |
| Lentil | 629 | 159.9 | 1.19 | 0.85 | 42.9 |
| Moth bean | 69 | 31.2 | 0.77 | 0.52 | 50.3 |
| Rajmash | 244 | 41.2 | 1.06 | 0.91 | 21.9 |
| Red gram | 1,626 | 583.1 | 1.33 | 0.89 | 52.1 |
| Total/Wt.Average | 7,282 | 2,335.6 | 1.17 | 0.82 | 42.7 |

in yield varied from 24.4 in safflower to 66% in niger and on an average oilseed crops under demonstration gave 31.4% more yield than farmers practice.

***Pulses:*** During the year, 7,282 demonstrations were conducted covering 2,335.6 ha. The increase in yield varied from 21.9 in rajmash to 52.1% in moth bean and on an average pulse crops under demonstration gave 42.7% more yield than farmers practice.

***Cotton:*** During the year, 1,122 demonstrations covering an area of 618.9 ha were conducted. A total of 33 high yielding and pest-tolerant varieties and hybrids, INM and IPM technologies were demonstrated to show the production potentials on the farmer's fields. Training programmes (164) covering 5,544 farmers and 31 training programmes for 725 extension functionaries were organized besides 49 field days with 5,571 participants. In addition, 173 other extension activities (1,813 participants) were undertaken, besides, radio/TV talk and newspaper coverage.

- KVKs organized 35,064 demonstrations on various aspects of crop production and fishery covering an area of 11,938.8 ha.
- Yield increased in oilseeds, pulses, cotton, cereals, horticultural and commercial crops and different enterprises through frontline demonstrations. Number of livestock also increased.

Frontline demonstration on gladiolus at KVK, Muzaffarnagar, Uttar Pradesh

**Frontline demonstrations on other crops and enterprises**

| Crop/Enterprise | No of demonstrations | Area (ha) |
|---|---|---|
| Cereals | 6,657 | 2,559.9 |
| Millets | 20 | 10.0 |
| Cash crops | 884 | 444.6 |
| Fodder crops | 671 | 142.5 |
| Fruit crops | 76 | 16.9 |
| Vegetable crops | 1,764 | 316.5 |
| Plantation crops | 30 | 12.0 |
| Spices and condiments | 125 | 23.7 |
| Flowers and ornamental crops | 139 | 13.2 |
| Medicinal and aromatic plants | 83 | 30.6 |
| Fishery | 78 | 114.9 |
| Total | 10,527 | 3,684.8 |
| | | Units (No) |
| Dairy | 15 | 20 |
| Sheep and goat | 58 | 370 |
| Poultry | 183 | 1,260 |
| Piggery | 10 | 6 |
| Rabbi try | 17 | 12 |
| Apiculture | 13 | 13 |
| Mushroom units | 50 | 210 |
| Total | 346 | 1,891 |
| Grand Total | 10,873 | |

***Other crops:*** During the year, 10,873 demonstrations were conducted covering 3,684.8 ha on cereals, horticultural and commercial crops, and 1,891 different enterprises like dairy, sheep and goat, poultry, piggery, rabbitry, apiculture and mushroom production.

**Training programmes for farmers and farmwomen**

| Areas of training | No. of courses | No. of participants | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| Crop production | 6,650 | 139,952 | 40,085 | 180,037 |
| Horticulture | 4,060 | 84,753 | 22,956 | 107,709 |
| Group dynamics | 1,097 | 23,420 | 7,839 | 31,259 |
| Agricultural engineering | 1,177 | 25,350 | 6,213 | 31,563 |
| Home science | 3,914 | 9,132 | 79,083 | 88,215 |
| Livestock production/management | 2,739 | 47,435 | 22,967 | 70,402 |
| Plant protection | 3,866 | 88,304 | 16,399 | 104,703 |
| Fishery | 410 | 7,994 | 1,614 | 9,608 |
| Seed production | 106 | 2,999 | 295 | 3,294 |
| Apiculture | 41 | 561 | 274 | 835 |
| Mushroom production | 130 | 1,303 | 1,997 | 3,300 |
| Soil fertility management | 1,062 | 22,509 | 7,050 | 29,559 |
| Agroforestry | 354 | 6,381 | 1,236 | 7,617 |
| Others | 363 | 8,201 | 3,913 | 12,114 |
| Total | 25,969 | 468,294 | 211,921 | 680,215 |

**Training for rural youth**

| Areas of training | No. of courses | No. of participants | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| Agricultural engineering | 387 | 5,511 | 801 | 6,312 |
| Agricultural extension | 282 | 5,773 | 2,008 | 7,781 |
| Agroforestry | 212 | 1,501 | 359 | 1,860 |
| Apiculture | 77 | 1,559 | 462 | 2,021 |
| Crop production | 1,150 | 18,642 | 4,058 | 22,700 |
| Fishery | 172 | 2,847 | 879 | 3,726 |
| Home science | 1,587 | 2,898 | 29,518 | 32,416 |
| Horticulture | 1,350 | 19,396 | 7,003 | 26,399 |
| Livestock production/management | 1,076 | 13,605 | 5,796 | 19,401 |
| Mushroom production | 136 | 1,607 | 1,555 | 3,162 |
| Plant protection | 974 | 14,239 | 3,198 | 17,437 |
| Seed production | 35 | 618 | 17 | 635 |
| Soil fertility management | 195 | 3,588 | 1,232 | 4,820 |
| Others | 610 | 6,761 | 7,508 | 14,269 |
| Total | 8,243 | 98,545 | 64,394 | 162,939 |

- KVKs organized 25,969 training programmes for farmers, 8, 243 skill-oriented training programmes for rural youth and 3,751 training programmes for in-service personnel. Out of these 1,584 training programmes were sponsored by various organizations.

## Training Programme

***Farmers' training:*** A total of 25,969 training programmes were organized benefiting 0.68 million farmers and farmwomen in crop production, livestock production and management, group dynamics, use of improved tools and implements, agroforestry, fisheries, biotechnology, horticulture, plant protection, soil fertility management, home science and others.

Training course for farmers on proper use and maintenance of farm machinery at KVK, Bhatinda, Punjab

**Training for in-service extension personnel**

| Areas of training | No. of courses | No. of participants | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| Crop production | 867 | 18,920 | 2,292 | 21,212 |
| Horticulture | 786 | 10,473 | 1,877 | 12,350 |
| Agricultural extension | 368 | 7,029 | 1,559 | 8,588 |
| Agricultural engineering | 202 | 3,857 | 896 | 4,753 |
| Home science | 345 | 1,720 | 7,698 | 9,418 |
| Livestock production/management | 269 | 5,258 | 1,144 | 6,402 |
| Plant protection | 538 | 11,624 | 1,760 | 13,384 |
| Fishery | 37 | 491 | 84 | 575 |
| Seed production | 17 | 620 | 77 | 697 |
| Soil fertility management | 147 | 3,424 | 449 | 3,873 |
| Agroforestry | 46 | 979 | 152 | 1,131 |
| Others | 129 | 1,810 | 732 | 2,542 |
| Total | 3,751 | 66,205 | 18,720 | 84,925 |

**Sponsored training programmes**

| Areas of training | No. of courses | No. of participants | | |
|---|---|---|---|---|
| | | Male | Female | Total |
| Crop production | 515 | 21,908 | 6,676 | 28,584 |
| Horticulture | 200 | 8,672 | 1,367 | 10,039 |
| Livestock production/management | 191 | 5,717 | 3,952 | 9,669 |
| Home science | 254 | 2,676 | 10,351 | 13,027 |
| Agricultural engineering | 24 | 785 | 66 | 851 |
| Plant protection | 138 | 5,689 | 1,949 | 7,638 |
| Fisheries | 10 | 625 | 225 | 850 |
| Agricultural extension | 100 | 4,423 | 1,591 | 6,014 |
| Agroforestry | 3 | 120 | 0 | 120 |
| Soil fertility management | 44 | 1,226 | 151 | 1,377 |
| Rural crafts | 26 | 545 | 50 | 595 |
| Apiary | 1 | 20 | 14 | 34 |
| Sericulture | 1 | 14 | 7 | 21 |
| Vermicompost | 1 | 15 | 0 | 15 |
| Others | 76 | 4,177 | 677 | 4,854 |
| Total | 1,584 | 56,612 | 27,076 | 83,688 |

***Training for rural youth:*** The training programmes for the rural youth were organized on use of farm power and machinery, group mobilization, agroforestry, biotechnology, crop production, fishery, horticulture, hybrid seed production, livestock production and management, cultivation of medicinal plants, plant protection, post harvest technology, soil fertility management, home science and other income generating activities. A total of 8,243 skill-training programmes were organized for 0.16 million rural youth.

***Training for in-service extension personnel:*** A total of 3,751 training programmes were conducted covering 84,925 participants.

***Sponsored training programmes:*** Out of a total 37,963 training programmes (9.28 lakh participants) conducted by the KVKs for the farmers and farm women, rural youth and inservice

- KVKs organized 55,355 extension activities to accelerate dissemination of technologies.
- KVKs produced 53,22.5 tonnes of seeds of cereals, oilseeds, pulses and vegetables, in addition to 5.22 million sapling/ of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species. KVKs also produced 23,321,176 livestock strains.
- KVKs (129) started publication of quarterly newsletters in local languages as well as in English and Hindi.

extension personnel, 1,584 training programmes were sponsored by various organizations covering 83,688 participants. The organizations which sponsored such training programmes include NABARD, DRDA, CAPART, ATMA, DBT, DST, State Department of Animal Husbandry, Agriculture, Women and Child welfare and Horticulture.

**Extension Activities**

The KVKs organized 55,355 extension activities covering 2.43 million farmers to accelerate dissemination of technologies. The activities included field days, kisan mela, kisan gosthies, exhibitions, ex-trainees sammelan, advisory service, film shows, diagnostic services, clinic centres, farm science clubs and formation of self-help groups (SHGs).

**Extension activities**

| Activities | Number | No. of beneficiaries |
|---|---|---|
| Advisory services | 32,841 | 127,594 |
| Diagnostic visits | 4,654 | 30,962 |
| Ex-trainee sammelan | 112 | 7,109 |
| Exhibitions | 521 | 1,281,973 |
| Field days | 1,916 | 120,643 |
| Film shows | 1,022 | 57,293 |
| Group discussions | 546 | 12,346 |
| Help line services | 11,267 | 4,079 |
| Kisan gosthies | 1,457 | 124,058 |
| Kisan melas | 397 | 625,138 |
| Seminars | 195 | 14,879 |
| Self-help group meeting | 376 | 20,998 |
| Workshops | 51 | 3,298 |
| Total | 55,355 | 2,430,370 |

In addition 4,910 newspaper coverage, publication of 1,785 popular articles and 1,281 extension literatures, 63 bulletins and 3,030 radio and TV talks were taken up by the KVKs.

**Production of seeds by the KVKs**

| Crop | Seed (tonnes) |
|---|---|
| Cereals | 3,459.15 |
| Oilseeds | 643.91 |
| Pulses | 630.10 |
| Vegetables | 132.47 |
| Spices | 38.94 |
| Flowers | 9.55 |
| Potato (Tubers) | 9.09 |
| Commercial crops | 27.11 |
| Fodder | 31.52 |
| Greenmanure | 12.80 |
| Medicinal | 4.99 |
| Other | 322.84 |
| Total | 5,322.54 |

**Publications**

129 KVKs have started publication of quarterly newsletters in local languages as well as in English and Hindi 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 science, agricultural engineering, etc. The newsletters also carry the schedule of training programmes of the KVK in the ensuing three months and are widely circulated to the farmers, Gram Panchayats and line departments.

**Production of Seed/Planting Material**

The KVKs produced 5,322.5 tonnes of seeds of cereals, oilseeds, pulses and vegetables. In addition, 5.22 million saplings/seedlings of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species were produced. Besides, 23,321,176 livestock strains were also produced for availability to the farmers.

**Monitoring Mechanism**

During the year, Zonal Workshops (10) were organized with the participation of all the KVKs to review the work done during the year and formulation of action plan for the next year. Similarly, 42 State level workshops were organized in order to review the frontline demonstrations on oilseeds and pulses. Workshop (6) were organized under HRD programmes for KVKs staff.

**Interface at District Level**

To strengthen research-extension linkages the KVKs organized

**Production of planting materials by the KVKs**

| Categories | Seedlings/saplings/livestock strains (No) |
|---|---|
| Cereals | 282,000 |
| Commercial crops | 155,000 |
| Vegetables | 1,797,736 |
| Fruits | 780,532 |
| Ornamentals | 218,161 |
| Spices | 432,511 |
| Fodder | 112,527 |
| Plantation | 88,649 |
| Forest tree | 958,123 |
| Medicinal | 2,705 |
| Biofuel | 370,236 |
| Others | 26,702 |
| Total | 5,224,882 |
| Livestock strain | 25,231 |
| Fishery (Fingerlings) | 23,295,945 |
| Total | 23,321,176 |
| Grand Total | 2,846,058 |

222-interface meetings involving the scientist and development officials at district level.

Literature Developed/Published:The KVKs published 8,269 literatures.

### Stem Application—A Cost Effective Technology in Cotton

In Andhra Pradesh, cotton is grown in an area of 0.8 million ha during *kharif*. Cotton accounts for more than 50% of the total amount of pesticides used in agriculture. The KVKs in Guntur and Khammam districts have demonstrated the effectiveness of stem application of pesticides in cotton. This reduces the pesticide usage in cotton to control sucking pests (ahpids, jassids, thrips and whitefly) especially during the initial stages. The technology has been adopted by 1,935 farmers in Guntur district alone, covering an area of 1,400 ha, resulting in overall saving of Rs 1.26 million to the farmers. It has also been adopted by 230 farmers in Pinapaka village in Khammam district of Andhra Pradesh with a saving of Rs 2,250/ha.

Demonstration of stem application technique in cotton at KVK, Khamman, Andhra Pradesh

- Stem application of pesticides in cotton reduced pesticide usage by controlling sucking pests.
- KVK, Ahmednagar provided the facilities for leaf/petiole analysis for the first time in the district for proper nutrient management, especially for cash crops. The fertigation and foliar nutrients management technology has diffused among the farming community with KVK's need based intervention.
- Kisan clubs (9) in different villages maintained a continuous interaction with the farmers.

#### Kisan Club

The KVK in Hoshiarpur district of Punjab formed 9 Kisan Clubs in different villages with 229 farmers to maintain a continuous interaction with the farmers. A yearly action plan is prepared in consultation with the Chief Volunteers of Kisan Clubs, Chief General Manager and Assistant General Manager of NABARD and Managers of the concerned banks. NABARD provided a financial assistance of Rs 3,000 per club per annum. Besides regular interaction with the club members and the KVK staff in bimonthly review meetings, the KVK also organized training programmes, demonstrations, seed replacement campaigns, educational tours and animal welfare camps, providing necessary literature to disseminate improved technologies.

### Tissue Analysis Based on Nutrient Management

Nutrient management is an important aspect for quality production of grape and pomegranate at Ahmednagar district and its export. The KVK provided the facilities for leaf/petiole analysis for the first time in the district especially for cash crops. Tissue analysis along with foliar feeding and fertigation through drip has become a common practice and KVK became the focal point for commercial fruit growers. The soluble fertigation grades and the spray grades are made available to the farmers at the KVK. Annually about 1,000 to 1,200 farmers especially grape and pomegranate growers of about 500 ha from 7 tehsils of Ahmednagar district and 3 intensive grape growing tehsils of Nasik district are benefited. The farmers from these areas adopted the plant tissues based nutrients management package and produces the export quality fruits.

Tissue analysis in the laboratory at KVK, Ahmednagar, Maharashtra

Farmers' clubs played a key role in spreading the technology among the grape and pomegranate farmers. Initially soluble and spray grades were available with the KVK only but with the increase in their demand, most of the agro-service centres are providing these inputs.

About 70–75% grape and pomegranate growers of Ahmednagar and adjoining districts now follow the soil and tissue analysis based nutrient management to get higher yield and better quality. Tissue analysis based nutrient management is also being adopted in other crops like vegetables and sugarcane.

### Women Self-help Group

A number of KVKs have tried the concept of disseminating

appropriate need based technologies through Self-help groups (SHGs). KVKs (4) in Andhra Pradesh (Chittoor, Karimnagar, East Godawari and Srikakulam), 7 in Maharashtra (Ahemdnagar, Amaravathi (Durgapura), Jalna, Satara, Solapur, Thane and Pune) and 2 KVKs in Assam (Sonitpur and Golaghat) formed a total number of 1,584 self-help groups with a membership of 16,826 covering 409 villages.

The activities of most of the SHGs include establishment of various rural enterprises like dairy, backyard poultry, goatry, production and sale of vermicompost, tailoring, rural crafts, food processing and production and sale of vegetables. Among all the enterprises dairying was found to be highly promising. The average annual earning of a SHG beneficiary from dairying was found to be Rs 23,000 (Srikakulam, Karimnagar and Pune) to Rs 30,000 (Chittoor and Ahmennagar). Landless women belonging to SHGs of KVK, Chittoor derived maximum income i.e., 73% income from dairy. There was 70% increase in participation of landless women in dairying due to formation of such groups by KVK, Pune. Small scale food processing and value addition was also found to be one of the major activities of the SHGs. Food preservation and processing generated income of Rs 17,000/year to most of the women belonging to SHGs of Jammikunta and nearby villages in Karimnagar district of Andhra Pradesh. The average annual income from tailoring and garment making enterprise was Rs 13,000 (Ahemdnagar and Karimnagar)

With the technical assistance of the KVK, SHGs have established various rural enterprises like dairy (15 groups), backyard poultry (56 groups), goatry (49 groups), vermicompost unit (32 groups), tailoring and fabric designing (15 groups), and food processing and value addition (8 groups).

The KVK has been focusing on the problems of health and malnutrition of women and children of 2 drought prone villages (Kadegaon and Warudi) of Jalna, Maharashtra. The KVK has conducted 33 training programmes on various technologies, viz. post harvest value addition (anola, mango, sapota, grapes, tomato, soybean and fingermillet), kitchen gardening, seed treatment, IPM, INM, vermicomposting, watershed management, grading of fruits and vegetables, backyard poultry, dairy and hand embroidery. Some of the packed items such as fruit candy (anola and sapota), powdered sapota, raisin grapes, tomato ketchup, jams and jellies, anola supari, cereal and pulse based papads and soybean products made out of village surplus are in great demand in local markets of Jalna and nearby areas.

The tribal women belonging to Dhanu and nearby villages of Thane district of Maharashtra formed 10 SHGs and established 10 vermicompost units under the guidance of KVK, Thane and with financial assistance of ITDP, Dhanu. There was substantial cost reduction due to usage of forest-based raw material for running the units. The average bimonthly income of each unit was found to be Rs 8,500.

**Leader Driven Transfer of Technology**

KVK, Gadag (Karnataka) identified representatives of selected self-help groups and progressive farmers who were closely associated with different programmes of KVK. Farmers/farmwomen (50) were selected and special trainings were imparted to them in their area of expertise and in technology leader concept. These leaders serve as resource persons for the KVK training programmes as well as for their self-help groups and fellow farmers of the village. The advisory services and material provided by these technology leaders resulted in establishment of 474 units in 72 villages, with an annual production of 3,700 tonnes of vermicompost. Because of vermi compost application in 9,000 ha the farmers could save Rs 800–1,400/ha on fertilizer. The floriculture leaders influenced 10 farmers in 3 villages to cultivate improved varieties and adopt scientific methods of post harvest handling and marketing. Now the area under floriculture has increased to 13 ha in four villages, providing an additional income of Rs 10,000–15,000/ha.

***'aAqua'*—A Dynamic and Interactive IT Portal**

KVK in Pune district of Maharashtra and IIT, Mumbai, developed a web based interactive portal called *'aAqua'* (almost all questions answered) for the benefit of the farmers, which can be accessed and viewed on http://aaqua.persistent.co.in/aaqua/forum/index. The main features are bi-lingual (both English and Marathi),

- With the assistance of the KVK, SHGs have established various rural enterprises like dairy (15 groups), backyard poultry (56 groups), goatry (49 groups), vermicompost unit (32 groups), training and fabric designing (15 groups), and food processing an value addition (8 groups).
- A web based interactive portal called 'aAqua' was developed by KVK in Pune district of Maharashtra and IIT, Mumbai
- KVK, Pune, Maharashtra in collaboration with Vidya Partisthan Institute of Information Technology at Baramati started FM community radio dedicated to agriculture.

**Vermicomposting**

It is emerging as an important source in supplementing chemical fertilizers in agriculture. In 2002, KVK in Bharuch district (Gujarat) provided worms to 13 farmers to start their vermicompost units. There was a constant follow up by the KVK for proper adoption of the technology by the farmers. It was observed that by 2004 all the farmers in village Chikolta started vermicompost production by 2004. The efforts of KVK Kangra (Himachal Pradesh) to promote vermicomposting resulted in establishment of 4 units with improved race of Red American worms in 2003 and the technology was extended to 115 FIGs and WIGs (Farmer interest and Woman interest groups).

- KVK, Ahmednagar, Maharashtra standardized the technology for production of commercial products of Spirulina like Vaseline and face pack.
- KVK, Mandubar, developed audio-visual material (CD) in tribal dialect.
- Farmers' field school are being conducted since 1994–95 or paddy, groundnut and cotton.

question and answer archives, and decision support by plant pathologist to identify crop diseases and crop-wise recommendations by State Agricultural Universities of Maharashtra. So far, the portal has answered 2,737 queries covering 1,145 topics and at present there are 714 registered users. It has received Gold award of Digital Foundation Empowerment, New Delhi for best e-content development for the year 2005.

**FM Community Radio Dedicated to Agriculture**

The KVK, Pune in collaboration with Vidya Pratishthan Institute of Information Technology at Baramati, started FM (Frequency Modulation) community radio dedicated to agriculture on 29 March, 2005. The major aspects are market information, day-to-day field operation of important crops and major enterprises, information on daily weather, daily serial reading of a book on agriculture, answering farmers questions by subject-matter specialists, farmers school on radio, i.e. a serial on a crop or enterprise, disease forecasting, interviewing a progressive farmer, a slot for subject matter specialist of State Agricultural University or other research institute. KVK is shouldering the responsibility of content generation, while Vidya Pratishthan's Institute of Information Technology is responsible for the transmission.

**'Own Your Seed'—An Intervention by KVK, Guntur**

The KVK, Guntur, initiated seed production activity including the latest and high yielding varieties of major crops like rice, blackgram, greengram and groundnut in its instructional farm since 1992–93. KVK promoted the concept of 'Own your Seed' and 'Farmer to Farmer' net work by conducting 15 training programmes and 35 demonstrations which has benefited 612 farmers since 1993–94. Due to sustained efforts by KVK, the total seed production at KVK farm was 865 tonnes, which include rice (687.10), blackgram (116.9), greengram (39.4), groundnut (13.6), and other crops. The intense activity of KVK also resulted in a total production of 298 tonnes of quality seed of rice (196.97), blackgram (40.8) and groundnut (60.6) by 150 farmers. KVK has established a seed-processing unit at its campus with financial assistance of ICAR for the benefit of the farmers in Guntur district.

**Spirulina for Balance Diet and Employment Generation**

Spirulina, blue green algae, is a good protein supplement with medicinal value. It took 3 years for KVK, Ahmednagar, Maharashtra to standardize its production technology. It has also standardized the procedure for production of commercial products of spirulina like spirulina vaseline (used for wound healing, cuts, sore feet and dry lips) and spirulina face pack (used for smooth skin, to remove black spots and for anti aging property). After successful development of technology, KVK started a demonstration unit for rural/family based spirulina production unit and commercial raceway tank. The benefits of spirulina were publicised through newspaper, magazine, television, etc. which helped in creating its awareness among both the rural and urban population. Mass media also helped in developing market linkages. Based on the encouraging feedback KVK is now planning to enrich different food items and health drinks with spirulina besides helping to establish more spirulina units.

**Farmers' Field School (FFS)**

The schools are being conducted by the Department of Agriculture, Government of Pondicherry, since 1994–95 for paddy, groundnut and cotton. During 1994–95 to 2003–04, 158 Farmers Field Schools were conducted on various crops for 4,740 farmers of Pondicherry region.

As a result of FFSs, 3,420 paddy farmers used 3,725 cc of *T.Japonicum* against paddy stem borer, 11,528 cc of *T.chilonis* to control paddy leaf folder and 13,285 kg of *P.flourescens* against paddy blast, sheath blight, sheath rot and bacterial leaf blight. Continuous use of biocontrol agents and biopesticides helped not only to protect the crop from the targeted pests but also to conserve the natural enemies of these pests, which led to reduced occurrence of pests and diseases (sheath rot and bacterial blight incidence reduced from 25% in 1998 to only 5% in 2003). With the adoption of IPM, paddy farmers are now able to earn a net income of Rs 16,875/ha, which is Rs 5,688 more than their income before they adopted the IPM package. Pesticides consumption in Pondicherry has come down significantly from 135 tonnes in 1994–95 to 46.95 tonnes in 2003–04, accounting for more than 65% reduction. The reduced demand for pesticides, led to closure of about 30% of pesticide outlets in the district (209 in 1996–97 to 130 in 2003–04).

**Educational Material in Tribal Dialect**

To enhance the control of the hairy caterpillar in groundnut by the tribal farmers, the KVK developed audio-visual educational material (CD) in tribal dialect, which evoked good response from both farmers and the agricultural department personnel.

Spirulina production for employment generation (rectangular family based production) at KVK, Ahmednagar, Maharashtra

# Gender Issues for Technological Empowerment of Women in Agriculture

The National Research Centre for Women in Agriculture has made various efforts to identify gender issues and test the appropriateness of available farm-technologies/programmes/policies with women perspectives for promoting gender mainstreaming in research and extension for empowerment of farmwomen, and capacity building of scientists, planners and policy makers to respond to the needs of the farm women.

The project on **Database on Gender** was taken up to generate gender-disaggregated data in crop, animal husbandry, fisheries, forestry and agro-processing. A woman was engaged on an average for 138 days in a year in crop-related activities including post-harvest as against only 98 days for a man. In crop related activities, a clear cut division of labour was observed along gender lines with some common activities for both men and women. Men were at an advantageous position so far as access to agricultural implements were concerned. Poor access of households

- Database on Gender revealed farm women are in disadvantageous position from knowledge gaining and credit availing points of view
- Self-help Group served as a source of credit for individual women
- Women's access to productive farm resources and services should be increased
- Agricultural farm women labourers are unorganized leading to poor wages and nearly no participation in development process
- SWOT analysis of self-help group was made
- Low-cost and locally available feed material based weaning mix prepared
- Farm women were given training on improved implements and farm operations
- Aquaculture training helped in overall development of farm families

Participation in Self-help Group programmes gave woman decision making capacity and confidence

### Aquaculture for rural women

Aquaculture projects Involving Rural Women in Aquaculture—A Step towards Ensuring Economic and Nutritional Security, Family based Economic Security of Backward Communities through Ornamental and Integrated Fish Farming, and Studies on Sustainable Aquaculture—A Practice' for Empowering Women in Rural Aquaculture, have been operating in different villages to test and disseminate aquaculture technologies to rural women for increasing the productivity of rural ponds, to empower the backward communities through integrated aquaculture systems and to standardize a sustainable aquaculture package for rural women. Under the project following activities were taken up:

- Training on fry production as an income generating activity for the women in their small backyard ponds
- Increasing the pond productivity by scientific management
- Promoting integrated fish farming and evaluating the income from fish-cum-duck integration in rural set up
- Introducing ornamental fish production as a small enterprise for rural women

The significant achievements of the projects are as follows:

- Establishment of fry production as an income generation activity for women in the villages
- Fry production units were (8) established in different villages, to ensure availability of quality fry in the locality
- The findings of the project revealed that the integration of fish-cum-duck farming could be an effective technology for resource poor farmers as they can generate income for building economic and nutritional security. In a pond of 1,500 $m^2$ women earned Rs 1,200 from sale of male ducks, Rs 4,875 from sale of duck eggs, Rs 665 from sale of vegetables, and Rs 12,500 from sale of fish within 1 year
- Average yield of fish from the project has gone up to 2.73 t/ha from pre-project average of 0.125 t/ha, which contributed to the economic and nutritional security of women and their families. As a result per family fish consumption increased by 44.4 kg and average cash income by Rs 2,763. Fish-cum-duck integration has gained popularity because of its additional economic gain
- The project has successfully demonstrated the aquaculture potential of derelict water bodies to the local people.

Fish harvest from backyard pond

**Impact on the community**

- Skill training of farmwomen in fish fry production and nursery rearing in a pond of 0.02ha could yield an income of Rs 9,000 in 2 months taking 2 successive crops of nursery.
- Experiment with nursery technology has contributed to awareness building on nursery rearing technology and enhanced confidence with requisite knowledge and skill
- Enhanced availability of good quality fry at reasonable cost has increased area under aquaculture by over 10 ha, which increased fish production

to extension and training was clearly discernible. Women were quite aware of the health workers and benefited from them but not of agriculture extension agents. Men were quite aware of the institutional sources of credit, and 30% of men have availed institutional credit facilities. For individual woman, it was the self-help-groups that mostly serve as a source of credit.

**Project entitled Approaches to Engendering Agricultural Research and Extension in 3 states – On Networking Mode** focused on many gender related parameters for making gender mainstreaming more efficient. The study revealed that there is a need to give utmost attention for technological empowerment of the women who are mostly middle aged, educationally backward, malnourished and belonging to the schedule caste, schedule tribe and backward community. For time use efficiency the women in Kerala and Orissa need to be empowered in the technologies related to farm diversification activities. Poor farm mechanization in Orissa is very common, which need urgent attention of scientists and extension functionaries. The policy and programme interventions are commonly needed to increase women's access to productive farm resources and services from development programme.

The study on **Efficient Resource Management of Women Agricultural Labourers** in Orissa and Andhra Pradesh was taken up in both irrigated and non-irrigated farming system. In the study area women agricultural labourers were mostly from the backward caste and illiterate and landless. Their part time activities in Andhra Pradesh were collection of fodder for the livestock and fuel, and in Orissa mainly fuel and collection for par boiling of rice, winnowing of milled rice, rearing animals, preparation of cow dung cake, calf rearing and cleaning of cowshed. Almost all the woman agricultural labourers live in *kutcha* houses in Orissa, whereas in Andhra Pradesh they lived in better houses (36% living

Participants on the ocassion of Kisan mela


Training to tribal woman on balanced diet

**Krishi Vigyan Kendra (KVK)**

The KVKs organized training programme on crop production, horticulture, home science, livestock production/management, etc., in which nearly 2.12 lakh farm women, and 64,394 rural girls were trained.

In addition, 27,076 farmwomen and rural girls were also trained through sponsored training programmes on several frontier areas of agriculture. NABARD, DRDA, CAPART, ATMA, DBT, DST, State Department of Animal Husbandry, Agriculture, Women and Child Welfare and Horticulture, sponsored such training programmes.

in *pucca* houses). The wage disparity between male and female labourers was more in Andhra Pradesh compared to Orissa. In these states the labourers get plenty of work during peak farming operations, with no rest even during the lean period as they have to travel long distances in search of off-farm works. Their hard physical work in farm for 8–9 hr/day in rain, heat and cold, caused various health problems including common cold, fever and throat infections. They have no interaction with any government/ private organizations and were unorganized, which resulted in very poor participation of women in developmental programmes.

The project on **Development of Modules for Mobilization of Rural Women for Sustainable Livelihood through Women Self Help Groups** was taken up to analyze the entrepreneurial activities undertaken by women SHGs related to different production systems. The SWOT analysis of the successful groups was made in the first phase of the project. The rural woman perceived the woman self help groups advantageous in terms of co-operation, self confidence and special recognition.

The project on **Popularization of Eco-friendly Pest Management Technologies for Vegetables among Farm Women in Homestead Lands** was initiated to validate the available eco-friendly pest management technologies. Eco-friendly pest management technologies and ITKs related to vegetables farming were documented. It was found that nearly 74–95% women lacked knowledge in bio-pesticides, seed treatment and botanical pesticides.

Proper weaning practices are not followed in different localities, hence standardization of a low cost weaning mix was initiated for the children utilizing the locally available food materials under the project **Standardization of Weaning Mix Using Different Proportions of Sweet Potato**. The low cost and abundant local food materials are rice, moong, gram, til, groundnut, ragi, green leafy vegetables, banana, papaya, yam, sweet potato, potato etc. Dehydrated material of sweet potato, green leaves and potato were prepared and kept in airtight containers and polythene bags for evaluating the shelf life. Broad based food materials rice, moong, gram and til, were selected based on the criteria of palatability for mixing with sweet potato powder at different proportions.

Assessment of extent of deterioration in quality of the seeds saved by the farm families and collection of various invigoration techniques available and determination of potentiality of its

Practical training for participants on use of improved farm equipment

Processing of Aonla

Training on fruit preservation

application by farmwomen were taken up in project on **Refinement of Invigoration Techniques as Suitable to Farmwomen for Enhancing Planting Value of Finger Millet (*Eluesine coracana*) seeds.** Invigoration process as followed by the local people for cucurbits and paddy seeds was recorded for bringing improvement in the techniques. Locally available materials were used to make this process effective.

Under the project on **Empowerment of Women in Agriculture** the women beneficiaries acquired knowledge for using improved implements and performing farm operations. Custom hiring of the improved implements was on demand among the farmwomen. The impact of the project was assessed through various indicators of drudgery reduction. The ergonomic assessment of the technologies indicated that technologies had contributed in reducing the physiological cost of work by reducing heart rate and energy expenditure during the agricultural operations and increasing output and reducing the postural discomfort. Organizing Self-help Group followed by skill development trainings helped the farm women to set-up different enterprises in aquaculture, floriculture, vegetable cultivation, mushroom cultivation, agro-processing, coir rope, yarn and doormat making.

Family nutrition, confidence and decision-making ability, improved along with their social empowerment among members of the project and members of SHGs through technological

**Ergonomical evaluation of manually operated equipment**

The project Ergonomical Evaluation of Manually Operated Cleaner Grader, Seed Drill, Fertilizer Broadcaster and Ridger with Women Workers, was undertaken to assess the drudgery in manually operated cleaner grader, seed drill, fertilizer broadcaster and ridger with women workers. Seed treatment drum, naveen dibbler, wheel hoe, improved sickle, tubular maize sheller, sitting type groundnut decorticator, hanging type cleaner, fertilizer broadcaster, CIAE seed-cum-fertilizer drill, PAU seed drill and hand ridger were suitable for women. There was a need of rubber grip over mild steel handle of the equipment to avoid blisters on farmwomen's palm during the farm operation.

The drudgery in manually operated equipment was studied

**SUCCESS STORY**

### Dissemination of beekeeping technology through lead farmwoman

Ms Gian Kaur of village Makha in district Mansa, Punjab, adopted scientific beekeeping through the concerted guidance of KVK, Bhatinda. After getting 1 week's training in bee keeping, the KVK helped her in getting loan of Rs 54,000 from Mansa Co-operative Development Bank to start the enterprise. She started with 12 bee colonies and added subsequently another 15 colonies within 1 month, which increased to 54 in a year. Though her main interest was sale of honeybees by bee breeding rather than sale of honey, she sold 1 q of honey in 5 months. She had also sold 49 framers with honeybees till March 2004. The strength of her apiary rose to 90 by September 2004. The economics of bee keeping by Ms Gian Kaur is given below:

**Economics of beekeping**

| | |
|---|---|
| *Details of expenditure:* | |
| (i) Cost of 27 bee colonies (@ Rs 800/unit) | Rs 21,600 |
| (ii) Cost of bee accessories (bee veil, gloves, hive tool, smoker, queen cage) | Rs 1,000 |
| (iii) Cost of artificial diet (40 kg sugar @ Rs 16/kg) | Rs 640 |
| (iv) Cost incurred for raising the strength of bee colonies to 90: | |
| Cost of 30 kg foundation sheets of wax | Rs 9,000 |
| Cost of 60 wooden boxes | Rs 24,000 |
| Miscellaneous expenditure | Rs 500 |
| Total | Rs 56,740 |
| *Details of income* | |
| Sale of 100 kg of honey | Rs 10,000 |
| Sale of 94 frames with honeybees | Rs 37,600 |
| Sale of 60 bee colonies | Rs 1,20,000 |
| Gross Income | Rs 1,67,600 |
| Net profit | Rs 1,10,860 |
| Profit/colony/year | Rs 2,771 |

She has been now imparting training to other women in bee keeping.

empowerment. The feedback received from the SHG indicated that 4 SHGs have started availing the micro credit facilities from the banks and they have been sanctioned a loan of Rs 2.50 lakh for expanding their enterprises.

Under the project **Empowerment of Farmwomen in Post-harvest Handling of Vegetables**, the performance of the zero energy cool chamber (ZECC) and bamboo iceless refrigerator (BIR) was tested in 4 villages. Quality of the tomato could be maintained for 3 weeks at low temperature as compared to 3–4 days at ambient conditions.

**SUCCESS STORY**

### Success of Self-help Groups

The KVK, Srikakulam, Andhra Pradesh conducted training programme on dairying for 11 members of a Self Help Group called Santhoshimatha. These SHG women were basically fruit vendors with a monthly income of Rs 300-450. The KVK conducted a 7-day training programme on improved dairy practices for the women, under finance of ABIRD (Andhra Bank Institute of Rural Development) besides method demonstrations (fat and SNF estimation, and chopping of fodder) and exposure visits to instill confidence in the trainees to take up dairying. The SHG group established crossbred units (2 crossbred cows/ unit) at Uppinivalasa village of Burja mandal with finance from IOM (International Organization for Migration) through ARTS. The KVK scientists visited these units at regular intervals to solve their problems and conducted various programmes on animal health, vaccination and deworming and provided fodder seed during monsoon season.

Dairying through SHG has also been taken up by several other KVKs for the women farmers. Besides, most of the SHGs also started establishment of other enterprises like backyard poultry, goatry, production and sale of vermicompost, tailoring, rural crafts, food processing, and production and sale of vegetables.

Vermicomposting on income generating entreprise

**Drudgery reduction**

Involvement of farm women in agricultural activities, types of tools/equipment/machine used by them, their working pattern and drudgery status were studied through the project on **Involvement of Farm Women in Agriculture and Allied Activities in the Madhya Pradesh**. It revealed maximum involvement of farmwomen in drying and storage (77.3%) followed by inter culture (73%) and harvesting operation (72.1%). Nearly 19% households were having wheel hoes and 15% farmwomen operated the wheel hoe. About 53% of the farmwomen were interested in composite training on agriculture, whereas only 19.3% women visited agricultural fair. The farmwomen were utilizing 5.3 hr/day in agricultural activities. The utilization of

time in agriculture varied from 3.5 to 7.3 hr during lean to active seasons. The farmwomen perceived maximum drudgery in harvesting and paddy transplanting operations.

**Training programmes for women in-service personnel**

A large number of training programmes were organized by the KVK for upgrading the knowledge and skill of women in-service extension personnel. These training programmes were organized mainly for extension functionaries working in government and non-government organizations related directly or indirectly with the development of agriculture.

***Extension activities:*** The KVKs have organized several extension programmes including *Kisan Melas*, Field Days, *Kisan Goshties*, Exhibitions, Advisory services, etc., in which 5.75 lakh farm women participated.

# 3. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through the Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, the ICAR Research Complex for North-Eastern Hills Region, Umiam, Meghalaya, and the Central Agricultural Research Institute (CARI), Port Blair, evolves technologies to meet the needs of tribal and hill farmers.

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.

- Released 2 hybrids and 1 composite of maize for cultivation
- Identified varieties (4 in wheat, 2 in tomato, 1 each in maize, finger millet, field pea, lentil, soybean, horsegram, *toria* and vegetable pea) for their release
- Popularization of polyhouses in Uttaranchal opened possibility of year-round cultivation of high-value vegetables
- Designed and developed light weight, rust-proof, pedal-operated paddy thresher-cum-pearler
- Identified crop varieties suitable for organic farming
- A newly identified bacterium *Paenibacillus koreensis* possesses vast bicontrol potential for white grubs management in hill region

**Crop Improvement**

Two hybrids and one composite of maize have been released for cultivation. Besides, four varieties in rice, two varieties in tomato and one variety each in maize, finger millet, field pea, lentil, soybean, horsegram, *toria* and vegetable pea have been identified for release in different parts of country.

**New varieties of maize released**

| Variety | Adaptation region/agro-ecology | Yield (tonnes/ha) | Duration | Other salient features |
|---|---|---|---|---|
| Vivek Maize Hybrid 15 | Zone I (Himalayan Region) | 6.5 | Extra early duration (85-90 days) | It is fairly tolerant to *turcicum* leaf blight, and showed good response at lower doses of nitrogen |
| Vivek Maize Hybrid 17 | Zone III (Eastern Uttar Pradesh and Eastern States of the country), Zone IV (Peninsular India) and Zone V (Central and Western India) | 3.9 in Zone III, 5.9 in Zone IV and 3.6 in Zone V | Extra early duration (85–90 days) | It possesses moderate degree of tolerance against most prevalent diseases in zones III, IV and V |
| VL Baby Corn 1 | For commercial cultivation across the country | 1.2 | First extra early babycorn | Prolific, baby corn composite Besides better baby corn yield, it gives 13.5% more green fodder than the check, VL Makka 42 |

Vivek maize Hybrid 15

Vivek Maize Hybrid 17

VL baby corn 1

## Seed Production

During the year, 13.8 tonnes breeder seed of 43 released varieties and inbred lines, 1.22 tonnes nucleus seed of 38 released varieties and 7.63 tonnes truthfully-labelled seed were produced. Around 11.4 tonnes breeder seed was supplied to meet the demand of various organizations for production of foundation and certified seed. About 7.20 tonnes truthfully labelled seed was supplied to farmers.

## Protected Cultivation of Vegetables

Popularization of polyhouses in Uttaranchal has opened up possibilities of year round cultivation of high-value vegetables. Three cropping sequences, viz. capsicum-tomato-spinach, squash-French bean-tomato and cucumber-French bean- French bean-spinach, suitable for growing vegetable round the year inside polyhouse, have been identified for the mid-hill conditions. These sequences gave net profit of Rs 515,000, 810,000 and 325,000/ha respectively.

## Varieties identified suitable for organic farming condition

A number of varieties of rice, finger millet, soybean, garden pea and wheat were identified suitable for organic farming condition. Of the varieties screened, VL 184 of rice, VL 149 of finger millet, VLS 21 of soybean, VL 802 of wheat and VL 3 and VL 6 of garden pea gave the highest yield with the application of farmyard manure.

### LDPE Film lined Tank – A Supplemental Irrigation Source

In Uttaranchal, only 10% cultivated area is irrigated. The water requirement of the vegetables, which fetches more money, can be fulfilled by using low-density polyethylene film-lined tanks, developed by this Institute. This tank is being popular among hill farmers of the region for limited irrigation facilities. The farmers of an adopted village are harvesting water from low discharge springs in these tanks and using for cultivation of vegetables like, tomato, capsicum, cabbage, cauliflower, French bean etc.

## Biological control

***Soil-borne plant pathogens:*** For biological control of soil-borne plant pathogens, a total of 60 isolates of *Trichoderma* spp., representing 45 locations in NW Himalayas, could be isolated from rhizosphere and non-rhizosphere soils of various crops grown in the hills. These were screened for their antagonistic potential against *Rhizoctonia solani*, *Sclerotinia sclerotiorum*,

**Genotypes of different crops found promising against diseases/insect-pests**

| Disease/insect | Genotype |
|---|---|
| **Rice** | |
| Blast disease | BG 367-7, Diwani, E 890715, E 890744, IR 4547-3-3-6, Milyang 47, Suweon 303, VL 88-971, VL 89-1193, VL 91-1190 |
| Stem-borer and leaf folder | VL 4930, VL 30218, VL 4637, VL 4455, VL 7072, VL 779, VL 7220, VL 7314 |
| **Wheat** | |
| Rusts and leaf blight | VL 867, VL 868 |
| Powdery mildew | VL 824,VL 858, VW 0204, VW 0207, VW 0208 and VW 0472 |
| Leaf blight | VL 829, VW 0401, VW 0417, VW 0418, and VW 0419 |
| Loose smut | VL 614, VL 636, VL 639, and VL 646, |
| Hill bunt | VL 798, VW 0254, VW 0270, VW 0321, VW 0374, and VW 0375 |
| Aphid | VL 829 |
| **Barley** | |
| Stripe and leaf rust | VLB 91,VLB 93, VLB 97 |
| **Maize** | |
| Turcicum blight | FH 3245, FH 3248, FH 3288, FH 3294, CM 129, V 336, V 338, V 340, V 354, and V356 |
| **Finger millet** | |
| Leaf, neck and finger blast | VR 299, VR 301, VR 302, VR 169 |
| **Barnyard millet** | |
| Grain smut | VB 287, GECH 71, VB 360, VB 366 |
| **Soybean** | |
| Frog eye leaf spot | JS 75-46, PK 262, NRC 37, VLS 59, US 31, JS 98-63, MACS 985, PS 1392 |
| **Lentil** | |
| Wilt | VL 120, VL 2115, IPL 208, PL 4, L 4597, VL 126, |
| ***Rajmash*/French bean** | |
| Fuscous blight | MFB 4, VLB 8, VLFB 2002, VLFB 9908 |
| **Garden pea** | |
| Powdery mildew | DPP 9411, JP 15, JP 585, VP 8901, VP 9211, NDVP 250 |

### Design and Development of Pedal-operated Paddy Thresher-cum-Pearler

Engineering plastics (polycarbonate sheet) were utilized in development of pedal-operated paddy thresher-cum-pearler. The machine was basically designed and developed for hilly region where the weight of the machine is the major concern. Total weight of the machine is 40 kg and is rust-proof. The machine appears to be less noise producing during operation as compared to the machine of metal body. The probability of injury hazards is less during operation and transportation. The machine having, capacity 80-100 kg/hr and efficiency 98%, is operated by single man.

*Sclerotium rolfsii* and *Fusarium* spp. The *Trichoderma* isolates provided 48–70% growth inhibition against different soil-borne plant pathogens. Two isolates of *Trichoderma*, viz. *T. harzianum* and *T. viride*, also showed enhancement in seedling emergence and vigour index of tomato plants in nursery and checked damping-off incidence.

***White grubs and other insect-pests:*** Out of 40 species of white grubs, *Anomala dimidiata*, *Holotrichia seticollis*, and *H. longipennis* are the major pests of upland rice, millets and many vegetables in Uttaranchal region. Of the 27 indigenous isolates of entomopathogenic bacteria tested against white grubs, an isolate, WGPSB 2, identified as *Paenibacillus koreensis* was found very effective against white grubs. A talc-based formulation of this bacterium caused mortality up to 90% of *A. dimidiata* grubs under laboratory as well as micro-plot field condition. This bacterium has vast biocontrol potential for managing white grubs in this region.

***Toxicity of* Bacillus thuringiensis *strains against lepidopterous insects:*** *Bacillus thuringiensis* (Bt) strains were evaluated for the management of *Helicoverpa armigera*, causing extensive damage to chickpea and tomato, and of *Spodoptera litura*, *Plutella xylostella*, *Pieris brassicae*, *Spilartia obliqua* and *Trichoplusia ni* severe defoliators of cole vegetables. Most toxic Bt strain has been identified for each insect species for use in IPM. Four Bt strains have been isolated from diseased insects and were highly toxic against these insect species.

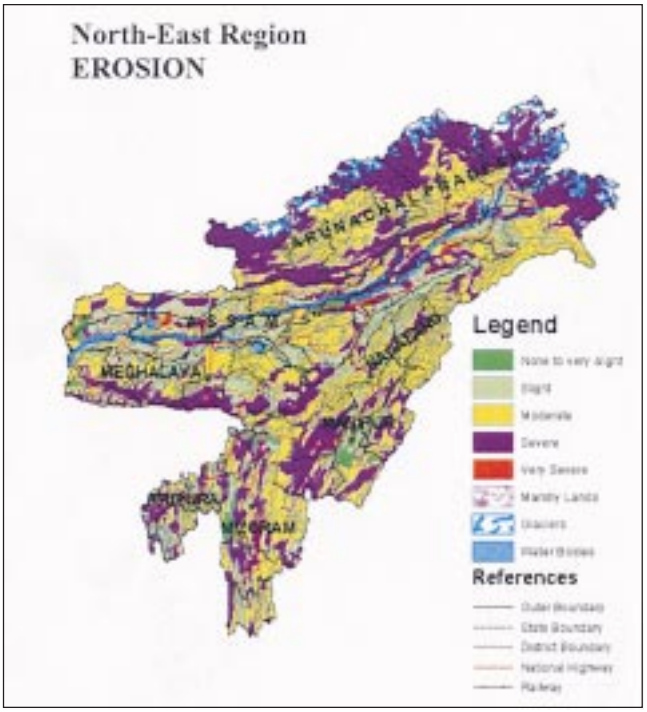
### Fodder Production from Sloping Wastelands

Growing improved grasses on the sloping degraded lands in hills is an important conservation measure for stabilizing these lands as well as for providing additional green forage. In view of fodder scarcity in hills, attempts were made to grow hybrid Napier on these lands to overcome the fodder scarcity as well as to help in soil conservation. Hybrid Napier produced the highest green forage 5-8 tonnes/ha during initial year and 30-50 tonnes/ha in the second year. Five to eights cuts can be taken during the growing season (May to mid-November).

## Soil Resource Characterization

Soil erosion map for NEH region has been generated. The map is useful for planning of suitable soil-conservation measures in the region.

- Developed protocol for *in-vitro* conservation and cryopreservation of wild rice
- Standardized soft wood grafting in Khasi mandarin
- Managed thrips in gladiolus
- Established hatcheries in 3 stations out of 7 to popularize Vanaraja birds in NEH region
- Developed DOT-ELISA-based diagnostic kit for identification of specific gastro-intestinal parasitic infection from serum samples of goat and cattle
- Detected and characterized pathogenic organisms from livestock and their products
- Developed cost-effective package of practice for commercial production of exotic ornamental fishes




Soil erosion map of North-eastern region

## Crop Improvement

***Protocol development for* in-vitro *conservation and cryopreservation of wild rice:*** Protocol for *in-vitro* conservation of *Oryza rufipogon* and *Oryza officinalis* was developed. Clonal shoots were produced from young seedlings in MS medium supplemented with 8.9 µM BAP and with 0.053 M Mannitol + 0.058 M sucrose + 4.4 µM BAP for its maintenance.

Similarly, protocol for cryopreservation of seed-derived calli of *O.rufipogon*, *O. officinalis* and *O. sativa* was also standardized. A common protocol worked for all the three species. N6C medium (N6 + CH + 18.1 µM 2, 4-D) gelled with Phytagel® produced calli suitable for cryopreservation. A combination of PEG, DMSO and sucrose was used as cryoprotectant.

Plant regeneration of *Oryza rufipogon* from recovered calli (*left*) and regenerated plant transferred to pot (*right*)

***Soft wood grafting in Khasi mandarin:*** Soft wood grafting in Khasi mandarin was standardized with a success rate of more than 90%. The Institute resorted to soft wood grafting because the T-budding technique of vegetative propagation gave a success rate of less than 50% only.

***Pole type French bean:*** A promising pole type French bean (RCMFB 1) with yield potential of 11 tonnes/ha was identified and is being tested in multilocations under All-India Co-ordinated Research Project.

Pole type French bean

**Crop protection**

***Isolation and bioefficacy of entomogenous fungus* Nomurea rileyi:** Bioefficacy of locally isolated *Nomurea rileyi* indicated 100% control of *Spodoptera litura* in lichi, soybean and groundnut.

***Management of thrips in gladiolus:*** Among the various botanicals and insecticides tested or tried to manage thrips in gladiolus, imidacloprid was found most effective (97%) followed by the botanicals Anonin (90%) and Karanjin (75%).

***Fruit feeders of passion fruit:*** Passion fruit production and processing in the region has revolutionized the fruit sector development. Since it is relatively a new fruit crop, no major insect pest was reported. However, the fruit has been observed to be now attacked by *Xylotrupes gideon* and *Trigonophorus hookeri* inflicting 39.7% and 27.65% damage to Kaveri and Meghalaya local varieties respectively. Biological control of the insect through mass trapping with fermented jaggery was found most effective.

**Animal Science**

***Piggery:*** Around 30 members of piggery units with the improved species at farmers' fields were established. Pig ration could be supplemented by up to 25% with broken rice without any adverse effect on growth rate (353 g/day). Experimental results indicated that up to 40% weaner pig (56 days of age) could be fed with boiled sweet potato tuber for achieving a growth rate of 235 g/day. Artificial insemination in pig was also successfully carried out in the hill states of the region.

Artificial insemination in pig in a adopted village

***Poultry:*** The Institute established hatcheries in 3 of the 7 stations to popularize the Vanaraja birds in the region for maximizing egg and chicken production. Their services were opened up to the beneficiaries who were given the 6-week-old Vanaraja birds. These also helped them in egg hatching, produced subsequently in their households. Around 300 farm families per centre have been benefited during the year. In addition to this, indigenous fowls of the region have also been collected for characterization, conservation and further use in the breeding programme.

***Rearing of rabbit:*** A comprehensive technology package for rearing broiler rabbits was developed and transferred to farming

Vanaraja breed of poultry is being popularized in NEH region

community. On an average, they are getting 16 numbers of young ones per rabbit per year, each fetching Rs 150 after 90 days.

***Parasite diagnostic kit:*** DOT-ELISA-based diagnostic kit for identification of specific gastro-intestinal parasitic infection (*Oesophagostomum* sp. and *Bunostomum* sp.) from serum samples of goat and cattle was developed particularly for the field veterinarians and master trainers for on the spot diagnosis of parasitic diseases and their subsequent control. The kit so developed is being released shortly.

DOT-ELISA based diagnostic kit developed for identification of specific gastro-intestinal parasitic infection

***Detection and molecular characterization of pathogenic organisms from livestock and their products:*** PCR-based protocols for *Listeria* sp., *Campylobacter* sp., *Salmonella* sp., *E. coli*, *Brucella*, *Bordetella bronchiseptica*, mesophilic *Aeromonas*, *Clostridium perfringens* Type A and *Pasteurella* sp., and RT-PCR for detection of Group C rotavirus were standardized. Isolation and molecular characterization of *Bordetella bronchiseptica*, a respiratory pathogen from pigs was carried out. Eight toxin genes, viz. *BvgAS*, *fhaB*, *fhaC*, *fim* 2, *fim* 3, *dnt*, *AchlyA* and *tcfA*, were detected by PCR. Molecular typing and subtyping of all the *C. perfringens* isolates by multiplex PCR using 6 toxin specific primers amplified only the primer specific for alpha toxin (*cpa*, 324 bp fragment) indicating that all the cultures belonged to the genotype A.

**Fisheries**

After successfully breeding cultivable carps, cost effective package of practice for commercial production of exotic ornamental fishes like gold fish and platty was developed to support ornamental fish rearing by local hobbyist.

Cost-effective package of practice developed for commercial production of gold fish (*left*) and platty (*right*)

**Horticulture and Forestry**

Co 3, Anand, DT 2, DVRT 2, Arka Vikas, BT 120, BT 136, Sel 7, DT 1 and MDB No. 2-3 varieties of tomato; PB 64 of brinjal and JCA 283 of chilli recorded 100, 80.5 and 100% survival against bacterial wilt respectively. CHCP 1 cowpea, Contender French bean and JSGL 55 sponge gourd gave the highest yield. Application of *Pseuodomonas fluorescens* @ 0.5% at 20 days interval from flower-bud initiation (May-June) up to final harvesting, resulted in profuse flowering simultaneously with control of anthracnose in mango. Mango fruits treated with *Pseuedomonas* (0.5%) showed the highest shelf-life with quality characters. Technology

of composting coir pith and dried leaves using *Pleurotus* and urea was standardized. Nutritional analysis of underutilized indigenous fruits was carried out. Out of 54 species conserved, 16 were identified for commercial exploitation. *Morinda citrifolia*, *M. trimera* and *Annona glabra* were identified as saline resistant. Twenty-six indigenous species of underutilized fruits were allotted IC numbers by the NBPGR, New Delhi. The optimum spacing and vase-life for gerbera was standardized as 30 cm × 20 cm for production of more quality blooms. In gladiolus, sucrose (5%) + $AgNO_3$ (100 ppm) prolonged vase-life by 5 days. In *Eulophia andamanensis*, application of IBA 2000 ppm resulted in maximum number of suckers (5) and of 1.5% urea in maximum spike length with more duration of flowering. Fifteen indigenous orchids, 10 ferns and indigenous ornamental plants were allotted IC numbers. The *Eulophia andamanensis* was also registered. The peak biomass and yield of maize was greater when the leaves were applied green in both incorporated and surface conditions. *Gliricidia* as well as *Leucaena* provided nearly equal yield in maize.

Somaclones developed from brinjal BB 66C, SM 141 and BB 60C were evaluated at $SC_5$ and $SC_6$ generations for improved agro-morphological characters. Of them, 16 promising lines were identified. Molecular characterization of three economically important endemic medicinal plant species, viz. *Alstonia macrophylla*, *Costus speciosus* and *Hernandia ovigera;* syn. *H. peltata* through RAPD analysis revealed ample genetic divergence among collections, which would be instrumental in devising sound conservation strategies.

The intercrops, *sowa* (*Anethium sowa*), kenaf (*Hibiscus sabdariffa*) and maize were found compatible with brinjal and also reduced fruit-borer damage. The crop diversity led to 8-fold increase in natural enemies. Tomato with intercrop of kenaf (4:1 rows), NPV application twice at 250 LE/ha at 15 days interval from 45 DAT led to 78% reduction in fruit damage. The NPV alone along with 2% jaggery as phagostimulant was effective in managing *Spodoptera litura* in cauliflower. Twenty-nine strains of *Pseudomonas* were collected and characterized. Local strains of *Pseudomonas* inhibited the growth of *Pythium* to varying degrees.

**Field Crop**

In the very early group (superfast) rice variety Heera produced 1.8 tonnes/ha under direct seeded condition and 2.0 tonnes/ha under transplanted condition. Scope of double cropping involving a productive very early variety in conjunction with a medium-duration variety is distinctly discernible. Al and Fe toxicity tolerant lines developed in IR 72 and C 14-8 background showed appreciable field tolerance under constrained soil conditions. Microprojectile-based genetic transformation was optimized in Basmati 370 and Taraori Basmati involving diverse physico-chemical parameters.

- Standardized the technology of composting coir pith and dried leaves using *Pleurotus* and urea
- Allotted IC numbers to 26 indigenous species of underutilized fruits, 15 orchids, 10 ferns and ornamental plants
- Collected and characterized 29 strains of *Pseudomonas*
- Developed putative transgenics in rice
- Designed and fabricated coconut dehusker for Nicobari tribals
- Achieved captive breeding of *A. ocellaris* in laboratory
- Assessed the impact of Tsunami on agricultural lands and suggested suitable technologies for rehabilitation of affected farmers in groups of islands

Putative transgenics involving *cryI* A (b), *cryI* A(c), Amsod and chitinase were developed. About 150 entries from $F_3$ population of IR 28 × Pokkali were phenotyped under artificially simulated saline soil condition and were molecularly profiled through RAPD analysis. Molecular tagging of salt-tolerant gene/s in a mapping population derived from IR 28 × Pokkali was carried out through RAPD analysis.

**Natural Resource Management**

Both runoff loss and soil loss were less under forest canopy, being 3.9–31.8 mm and 2.8–13.2 tonnes/ha, respectively, depending on rainfall and followed by arecanut and other canopies except during September and October. In furrows, high-yielding varieties of rice-ratoon-pulses/sunflower and super rice-ratoon-ratoon could be recommended to achieve high yield. Quing Livan 1 rice registered high yield in main and ratoon crops compared to other varieties. Application of 50% N through *Gliricidia* and 50% N through inorganic sources was recommended for main crop and 40 kg N/ha to ratoon crop for high yield. *Sesbania aculeata* (*dhaincha*) and *Sesbania rostrata* could be recommended for intercropping in wet seeded rice under island conditions. Combination of cultural (intercropping) and mechanical (cono weeder) weeding method was found effective in bringing down the weed density, registering high yield. A study on 'System of Rice Intensification' using Taichung-sen-Yu variety revealed that this method resulted in higher grain yield (6,222 kg/ha) than conventional method of planting (4,347 kg/ha). Newly fabricated half and full cage wheels showed better performance than existing cage wheels. Puddling field capacity for one pass of tractor cultivator was maximum (0.1188 ha/hr), followed by power tiller (0.1152 ha/hr) and animal drawn puddlers (0.0144–0.120 ha/hr). Power tiller was found the best for puddling of rice field owing to highest puddling index. Aerobic direct seeders required less time (8–20 hr/ha) than anaerobic seeder (19.55 hr/ha). Conoweeder required 50–60 man-hr/ha compared to 120–150 man-hr/ha required in traditional method of weeding. A coconut

*Dhaincha* incorporation using conoweeder in rice + *dhaincha* intercropping reduces weed density and increases rice yield

CARI coconut dehusker

Low-cost solar dryer traps solar energy and improves copra quality

dehusker was designed and fabricated for Nicobari tribals. A solar dryer was designed and developed to trap solar energy and to improve the quality of copra. With two days of bright sunshine hours, with temperature of 28–52°C, 110 nuts copra could be dried.

**Animal Sciences**

The turkey and guinea fowl birds were found well adapted to the island condition. In these islands, sera samples collected from cattle, goat, pig and poultry revealed the prevalence of brucellosis, infectious bronchitis rhinitis, leprospirosis in cattle; mycoplasmosis, brucellosis and leptospirosis in goat; and infectious bursal disease (IBD), salmonellosis and infectious bronchitis and mycopalsmosis in poultry. The parasitic diseases, humpsore, fascioliasis, strongyloides, taeniasis, trichuris and schistosomiasis were also prevalent in these islands. Detailed study on outbreak of foot-and-mouth disease was conducted and samples were examined for antibodies and it was found to be type 'O' FMDV. Efficacy of IBD vaccine was tested in poultry chicks @ 2 drops/bird through oral route and found to be safe and protective. Deficiency of mineral elements in dairy animals caused infertility at different places like Indiranagar, New Bimblitan and Namunagar, in South Andaman.

Turkey birds are well adapted to island climatic condition

**Fisheries**

Evaluation of different mixed wet feeds showed that combination of 'green mussel + lam' resulted in best growth of lobster, *Parilurus. versicolor,* and combination of 'sardine + stolephorus + common ingredients' in maximum growth of grouper, *Ephirephelus tauvina* and *Cephalopholis argus argus.* Captive breeding of *A. ocellaris* was successfully achieved under laboratory conditions. Feeding habit of clown fishes was studied. Walnes

media gave highest population growth for *Thoreckandra carteriformis*, *Chlorella pyrenoidosa* and *Phacodactylum tricornutum*.

**Social Sciences**

Post-intervention impact of project 'Development of Integrated Farming System under different resource conditions in humid tropics of Bay Island' revealed that the application of chemicals in vegetables was reduced to 30–40%. Technologies like 'IPM in paddy' and 'Insect pest and disease management in vegetables' were adopted by 100 farmers with minor refinement. Significantly higher yield and net returns were realized using these technologies, as these were socio-economically viable and ecologically compatible in these islands. Dependency of farmers on broiler farm for more income reduced with the increase in farm size. The labour utilization pattern for broiler and layer farming revealed that with increase in farm size, the number of hired labour increased and that of family labour reduced. The IBD, heat-stroke, curled toe paralysis, visceral gout and *E. coli*, were common causes of mortality for broilers, and for layers main causes of mortality were fungal toxins, mycoplasma, heat stroke, visceral gout, *E. coli*, IBD and curled toe paralysis.

**Tsunami disaster**

The CARI, Port Blair, constituted expert committees to assess the impact of Tsunami on agricultural lands. Based on the findings, the expert teams made the following recommendations for rehabilitation of affected farmers in various groups of islands such as South Andaman, Little Andaman, Car Nicobar, Nancowrie and Campbell Bay.

- Provision of adequate surface and sub-surface drainage
- Impounding and leaching of affected fields with rain water
- Construction of raised embankments along with one way sluice gates
- Biofencing through conservation of existing mangroves and planting new seedlings
- Planting of alternate trees like *Casurina*, sea mahua, *Pongamia*, *Pandanus*,*Thespesia*, *Ipomoea pes-caprae* etc. in the sea shores, if the site is not compatible for mangroves.
- Planting of trees/shrubs with higher evapotranspiration requirement, viz. *Eucalyptus* sp. and *Acacia auriculiformis* to act as a bio-pump in waterlogged areas.
- Selection and raising of salt-tolerant crops like rice, sugarcane, sorghum, watermelon, castor and forage crops like karnal grass (*Diplachne fusca*) and para grass (*Brachiaria mutica*) and green-manure crop like *Sesbania*.
- Selection of suitable crop rotations like rice-watermelon, rice-maize, rice-sorghum, rice-vegetables, rice-sugarbeet and rice-forage crops
- Adoption of broad bed and furrow system of land manipulation in the affected areas to cope up with the problem of salinity and for increased profit
- Application of higher dose of farmyard manure and its incorporation in the field to improve the drainage
- Incorporation of blue green algae and azolla in rice fields
- Adoption of 25% higher seed rate than the recommended seed rate
- Sowing the seeds in the furrows or two-thirds from the top of the ridge
- Cultivation of rice followed by *dhaincha*, sunnhemp followed by safflower, castor, sugarbeet, watermelons during dry season. Replanting of coconut and other fruits like aligator apple and tuber crops like sweet potato in the lowlying submerged areas in the next rainy season.
- For wide spaced crops like vegetables, adoption of pit system of planting by replacing the salt-affected soil with mixture of normal soil and farmyard manure
- Adoption of drip irrigation or pitcher irrigation for high-value crops
- Application of higher dose of NPK than the recommended dose
- Promotion of jatropha and *Morinda citrifolia*, which are saline-tolerant crops
- Adoption of rice-cum-brackishwater-prawn and fish culture
- Adoption of auger hole technique for planting tree species in salt-affected areas
- Distribution of poultry birds (Nicobari fowl, Vanaraja, Turkey, Guinea fowl and ducks), goat and piglets to the affected farmers
- Culture of shrimps, mud crab, milkfish, mullet and sea bass
- Tambak system of aquaculture by planting mangroves and culturing shrimp/fishes in trenches

# 4. National Agricultural Innovation Project

Activities under the National Agricultural Technology Project were completed in June 2005 and 4 months (from July to October 2005) were provided for consolidation of different reports, settlement of account, audit utilization certificate and reimbursement of claims etc.

An impact assessment study on the NATP indicates significant progress made by it in the implementation of diverse activities planned under its different components (i) Organization and Management System, (ii) Agro-ecosystem Research, and (iii) Innovation in Technology Dissemination.

**Organization and Management System**

A simple yet effective system for project-peer review and monitoring was developed through NATP. In 32 institutes (38% of the candidate institutes), Priority-setting, Monitoring and Evaluation (PME) cells were established to strengthen priority-setting, monitoring, evaluation and impact assessment works within and outside the NATP project. An Intellectual Property Rights (IPR) cell, led by an ADG, was established. Guidelines for increasing revenues were disseminated to ICAR institutes. The newly established Agricultural Technology Information Centres (ATICs) have generated Rs 99.5 million as revenue.

***Human Resource Development for Research Management:*** A total of 80 administrative personnel were trained within the country and 9 from outside. Two retreats for ICAR top management (40 participants) and one management development programme for comptrollers of SAUs were organized. In addition, training programme were conducted mostly at the NAARM for directors, administrative, finance and accounts officers of the ICAR institutes, and for comptrollers and directors of research of SAUs.

***Information Systems Development:*** In 70% of the institutes, 50-100% of scientists have now a computer. A total of 310 units in the system have local-area networks and 280 are linked to the internet very effectively, and substantial improvements in the ICAR's library system have been made; 128 libraries were strengthened, of which 39 are now fully computerized.

**Agro-Ecosystem Research**

This component had supported 4 modes of researches.

***Production Systems Research (PSR):*** These were location-specific research projects that focused on production systems improvement, rather than single commodity or discipline, reinforcing emphasis on sustainability and on an integrated approach have had a major impact on farm incomes and rural development. Two hundred and sixty-four research projects in 5 main agro-ecosystems were implemented. The impact analysis of zero tillage programme has clearly illustrated high returns. A total of 70 research projects were also implemented under Institute Village Linkage Programme.

Zero tillage in wheat, zero till drill (inset) under irrigated agro-ecosystem

***Cross-Cutting Mission Mode Research (MMR):*** In this, research activities spanned more than one agro-ecosystem and were designed to generate critical outputs needed to back-stop

Vanaraja birds at farmer's backyard

*Aerides multiflora*, an epiphytic orchid with ornamental, high vase value (15 days) and very long spikes collected from Sikkim

KBSH 44, a sunflower hybrid with 21% higher yield over national check KBSH 1 recommended for all sunflower growing states

location-specific PSR projects in more than one production system. The main objective was achieved through the implementation of 43 well-defined, multi-institutional, inter-disciplinary projects. Six improved technologies were released for commercial production, 47 scientists had received international training and 535 scientists were trained locally in thematic areas. More than 49,000 farmers received training. Two projects on "Conservation of Biodiversity" and "Household Food and Nutritional Security" were included in 21 science-and-technology missions supported by the Government of India.

**Mission Mode Research**

Notable results include: household food and nutritional security; collection, characterization and conservation of agro-biodiversity (plant, animal, fish); production of hybrids of maize, sorghum, rice, millets, sunflower, castor bean, chilli and brinjal; production of transgenic phenotypes of rice, cotton, and brassica; development of diagnostics for emerging plant and animal diseases; validation and promotion of IPM technology in different crops; improvement of watersheds; and development of prototypes of farm machines.

A prototype of indigenous chopper type sugarcane combine harvester developed to work even under adverse conditions

**Strategic Research through Teams of Excellence (TOE)**

These were created to conduct strategic and upstream research, and to provide technical assistance to PSR and HRD. The objectives were achieved through implementation of 31 projects. In addition, 218 short- to medium-term specialized trainings were conducted for 3,311 scientists. Long-term training was given to 235 scientists in priority areas like molecular diagnosis, cloning, virus identification and molecular markers. The TOE research has generated 83 promising technologies.

**Team of Excellence**

Notable achievements are: molecular characterization of major viral diseases of rice, banana and papaya; isolation of full gene sequences from banana mosaic virus; identification of very virulent pathotypes of bursal viral disease; identification of efficient rhizobacterial isolates for nitrogen fixation in rice; development of farm machinery for grading fruit, soil tillage and chemical crop spray; and establishment of 4 referral laboratories for pesticide residues, meat products, fish products and cotton textiles.

**Competitive Grants Programme (CGP)**

The objective of CGP was to improve research efficiency by promoting innovative research and also to provide an incentive for research partnerships and collaboration to maximize complementarities among research providers. The project provided

funds to mobilize the best scientific expertise in the country, including NGOs and the private sector. A total of 120 technologies were developed/ refined under the CGP, including diagnostics and vaccines, biocontrol agents, farm machinery and equipment, processed foods and products.

**Innovations in Technology Dissemination**

The goal of this component was to develop models that improve effectiveness and financial sustainability of technology dissemination system with greater accountability to, and participation by farming communities. The Agricultural Technology Management Agency (ATMA—a registered society) model was established in 28 districts to facilitate programmatic convergence of line departments and to link research and extension activities with rural-farm households within each district. Participatory Rural Appraisal (PRA) procedures were used to develop a Strategic Research and Extension Plan (SREP) for each district which provided a framework for development of annual work plans at the block and district levels in consultation and with approval of stakeholder groups. State Agricultural Management and Extension Training Institutes (SAMETIs) were established in 7 participating states to train and support implementation of the ATMA model; particularly in the 3rd and 4th phase districts. In addition, the ICAR's Division of Extension including headquarters and 8 Zonal Coordinating Units (ZCUs) were strengthened; 53 Zonal Agricultural Research Stations (ZARSs) were remandated (transformed) into KVKs to provide "farming systems research" and training capacity that could link with extension institutions and stakeholder groups. Finally, 44 ATICs were established to provide a "single window" delivery point at each of the 28 SAUs and 16 ICAR institutes.

**Lessons learnt**

The NATP has helped in accelerating sustainable agricultural growth, rural and human capital development. It has increased substantially the availability and adoption of appropriate technologies.System efficiency was enhanced through a series of organization and management reforms. The following lessons have been learnt from the NATP.

- Organization and management reforms, decentralization and devolution of powers are essential features of programme development and implementation.
- Production system research under sponsored and competitive grant modes can generate healthy competition among scientists and improve relevance to research in addressing the national goals.
- Inter-institutional and multidisciplinary programmes are essential for addressing location-specific problems and meeting needs of farmers.
- Information technology-based information system is essential for capacity-building.
- Agro-ecosystem research through sponsored and competitive programmes is a holistic approach for addressing sustainable agricultural growth and rural development. Sponsored research programmes under Rainfed, Arid, Coastal, Hill and Irrigated Ecosystems directly generated location-specific technologies. Mission Mode and Teams of Excellence strategic research systems strengthened research capacity and human capital.
- Research relevance improves by participatory approach. Multidisciplinary and multiinstitutional teams and participation of social scientists could address more effectively environmental and poverty alleviation objectives.
- Competitive grant programmes improved quality of research by wider participation of competent scientists.
- The Innovations in Technology Dissemination component helped in reducing technology vacuum and productivity gap, particularly for resource-poor farmers. This system could link the production system research with technology assessment and refinement through Institution Village Linkage Programme and the Agricultural Technology Management Agencies for a demand-driven technology dissemination system.

**Proposed National Agricultural Innovation Project (NAIP)**

The proposed National Agricultural Innovation Project (NAIP) is the next step towards attaining excellence in science, utilizing science for commerce and using science for enhancing rural livelihood security through integration of technology orientation with agricultural economy orientation. This project responds to Government of India's objectives as well as World Bank's objectives as have been expressed in their main policy documents. The project is planned for 6 years and is likely to become effective from July 2006.

# 5. Organization and Management

- The DARE has 14 Group A, 12 Group B, 16 Group C, and 6 Group D employees who are recruited centrally either through the Department of Personnel and Training or through the Department of Agricultural Cooperation, depending of the level of the post.
- Presently DARE has 8 scheduled-caste employees during the reported period.
- In Staff Welfare Fund Scheme, 42 scholarships were given to the meritorious wards of the Councils employees.
- The Competent Authority of the Council has decided to delegate powers to file patent applications to the Directors of the ICAR system under Intellectual Property Rights. These patent application will be filed at Delhi, Mumbai, Kolkata and Chennai.
- To promote the progressive use of Hindi DARE held Hindi workshops, meetings, reports and organized *Hindi Pakhwara* to encourage the employees doing their official work in Hindi.
- The ICAR also took the steps for the progressive use of Hindi and observed *Chetna Mass* from 14 September to 13 October 2005 at ICAR (Hq.). This year 10 stenographers and 9 typists who were nominated for Hindi stenography and typing respectively. Council has also given awards to 8 officials for doing maximum work in Hindi, conducted 3 workshops, and gave away *Rajarshri Tandon Rajbhasha Puruskar*.
- The Media and Information Unit coordinated the production of 44 video films which were produced by the ICAR Institutes/Project Directorates/National Research Centres working within ICAR Systems.
- During this year, 53 awards under 12 different categories have been given to honour 46 scientists, 4 farmers, 1 journalist, and 1 Co-ordinated Research Project. From next year, a few new awards for innovative farmers, scientists and research workers will be instituted.
- The Technical Coordination Unit worked for financial support to scientific societies, publication of highlights of achievements of A.P. Cess Fund Schemes, Best Annual Report Awards, ICAR International Training Programmes, Technical backstopping, Parliament Questions, VIP references and material for papers/talks/replies and preparation of technical notes, Regional Committee Meetings.
- "Touch and Explore" quizzes and "Water Cycle" for children, "Vedic Village", "Speaking Statue', "Agriculture and Solar Calendar" and "Six Pillars of Agriculture", which give information about Soil, Water, Climate, Tool, Seeds and Peasants-have been major attraction for the renowned and eminent personalities who visited at National Agricultural Science Museum.

**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 1 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 Additional Secretary (DARE) functions as Secretary (ICAR). The Financial Advisor of the DARE is the Financial Advisor of the ICAR. Generally single-file system is followed between DARE and ICAR.

The DARE has 14 Group A, 12 Group B, 16 Group C, and 6 Group D employees. The recruitment to the post in the Group 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-Caste, Scheduled-Tribe, and Other Backward Class. Presently, DARE has a 8 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 2004–2005) respectively. The detailed break up of these financial figures is given in Appendix III of DARE.

**ICAR**

The Indian Council of Agricultural Research is an apex organization at the national level for promoting of Science and Technology Programmes in agricultural research and education.

The ICAR was set up on 16 July 1929 as the Registered Society under the Societies Registered Act 1860, on the recommendations of the Royal Commission of Agriculture. It was reorganized twice, in 1965 and 1973. The headquarters of the ICAR is located at the Krishi Bhavan, New Delhi, and its other buildings are Krishi Anusandhan Bhavans I and II, and NASC, New Delhi.

The Minister for Agriculture is the President of the ICAR and the State Minister for Agriculture is the Vice-President. The Principal


Sitting on the dais are (from *left* to *right*): Ms Shashi Misra, Additional Secretary, DARE and Secretary, ICAR, Dr Mangala Rai, Secretary, DARE and Director-General, ICAR, Shri Sharad Pawar, Union Agriculture Minister, Shri M V Rajasekharan, Minister of State for Planning and Dr Rita Sharma, Financial Adviser, ICAR and Additional Secretary, DARE

Dr Mangala Rai, Director-General, ICAR and Secretary, DARE presenting some of the salient features of the progress and achievements made by the Council in agricultural research, education and extension during the year

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, Central/State Governments representatives of India, represent it as Head. The members for this are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of the various state governments, representatives of Parliament, industries, educational 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, Accredition Board, Regional Committees, Policy and Planning Committee, several Scientific Panels, and Publications Committee. In the scientific matters, the Director-General is assisted by the 8 Deputy Directors-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 for Standing Finance Committee are Director-General (ICAR), Secretary (Ministry Agriculture), Scientists, Senior Officers, Farmers, and Members of Parliament (Appendix 3). The senior officers posted at the ICAR (Hq) 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 one publication on every third day. Besides it is also creating Public Awareness by dissemination of Information globally through print media as well as electronic media in interest of students, farmers, progressive farmers etc.

The Research set-up of the ICAR includes 48 Institutes (Appendix 5), 5 National Bureaux (Appendix 6), 12 Project Directorates (Appendix 7), 32 National Research Centres (Appendix 8), and 62 All-India Co-ordinated Research Projects that are also in operation (Appendix 9).

The ICAR promotes research, education and extension education in 39 State Agricultural Universities, 5 Deemed Universities, 1 Central Agricultural University for the North-Eastern Hills Region and 4 Central Universities by giving financial assistance in different

Shri Sharad Pawar, Union Agriculture Minister, releasing the *Handbook of Agriculture* brought out by the DIPA on the occasion of Public, Private Partnership, ICAR–Industry Meet held in New Delhi. Dr Rita Sharma, Financial Adviser, ICAR and Additional Secretary, DARE is on his right

forms (Appendix 10).

For effective communication of research findings among farmers, the ICAR maintains an effective network of Krishi Vigyan Kendras, and Trainers' and 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-caste, scheduled-tribe and other backward class, is given in Appendix 11.

Thus with an extensive network of research infrastructure, backed by the excellent team 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.

## Filling up of vacant posts

A good number of vacant posts like Deputy-Secretaries, Under-Secretaries, Senior Administrative Officers, Senior Finance and Accounts Officers, Finance and Accounts Officers/Sections Officers/ Private Secretaries/Assistants/Personal Assistant/UDCs, and Group 'D' posts were filled up.

## Financial upgradation granted under ACP scheme

As per the Government of India instructions Financial Upgradation was granted to many eligible employees in various grades during this period viz., Section Officers/Assistants/Personal Assistants/UDCs and Group 'D' employees.

## Probation/Confirmation

Probation of Personal Assistants/Assistants/Administrative. Officers/Financial and Account Officers were cleared in a meeting.

## Staff Welfare Fund Scheme

- Abide by recommendations of the Managing Committee of the ICAR (Hq) financial assistance of Rs 25,000 was extended to each family of 4 deceased employees of the ICAR (Hq) from

**Total number of employees and number of scheduled castes, scheduled tribes and other backward classes at ICAR Hqrs**

| Posts | Scale of Pay (Rs) | Sanctioned posts | Filled posts | No. of SCs | Percentage to total employees | No. of STs | Percentage to total employees | Total OBCs | Percentage to total employees |
|---|---|---|---|---|---|---|---|---|---|
| Director (P) | 14300–400–18300 | 01 | 01 | – | – | – | – | – | – |
| Director (F) | 14300–400–18300 | 01 | 01 | – | – | – | – | – | – |
| Director (OL) | 12000–375–16500 | 01 | 01 | – | – | – | – | – | – |
| Dy. Secretary | 12000–375–16500 | 09 | 09 | – | – | 01 | 11.11 | – | – |
| Dy. Director (F) | 12000–375–16500 | 02 | 02 | – | – | – | – | – | – |
| Dy. Director (OL) | 10000–325–15200 | 01 | – | – | – | – | – | – | – |
| Under-Secretary | 10000–325–15200 | 13 | 13 | 01 | 7.69 | 01 | 7.69 | – | – |
| SA to Chairman, ASRB | 10000–325–15200 | 01 | 01 | – | – | – | – | – | – |
| Sr. Finance and Accounts Officer | 10000–325–15200 | 02 | 01 | – | – | – | – | – | – |
| Legal Adviser | 10000–325–15200 | 01 | 01 | – | – | – | – | – | – |
| Law Officer | 8000–275–13500 | 01 | 01 | – | – | – | – | – | – |
| Finance and Accounts Officer | 8000–275–13500 | 06 | 06 | – | – | – | – | – | – |
| Assistant Legal Adviser | 6500–200–10500 | 01 | – | – | – | – | – | – | – |
| Assistant Director (OL) | 6500–200–10500 | 02 | 02 | – | – | – | – | – | – |
| Junior Analyst | 6500–200–10500 +Spl. Allowances | 02 | 02 | – | – | – | – | – | – |
| Desk Officer | 6500–200–10500 | 06 | 06 | 01 | 16.66 | – | – | – | – |
| Protocol Officer | 6500–200–10500 | 01 | 01 | 01 | 100 | – | – | – | – |
| Assistant Finance and Accounts Officer | 6500–200–10500 | 05 | 04 | – | – | – | – | – | – |
| Section Officer | 6500–200–10500 | 78 | 63 | 10 | 15.87 | 06 | 9.52 | 01 | 1.58 |
| Private Secretary | 6500–200–10500 | 30 | 30 | 04 | 13.33 | – | – | – | – |

**Total number of employees and number of scheduled castes, scheduled tribes and other backward classes at ICAR (Hqrs)**

| Posts | Scale of pay (Rupees) | Sanctioned posts | Total no. of employees in position | No. of SCs | Percentage of total employees | No. of STs | Percentage of total employees | No. of OBCs | Percentage of total employees |
|---|---|---|---|---|---|---|---|---|---|
| Assistant | 5500–9000 | 164 | 147 | 25 | 17 | 11 | 7.48 | 05 | 3.4 |
| PA (Gr II) | 5500–9000 | 55 | 48 | 06 | 12.77 | 01 | 2.13 | 03 | 6.38 |
| Steno Gr. III | 4000–6000 | 47 | 37 | 06 | 16.2 | 01 | 2.7 | – | – |
| UDC | 4000–6000 | 188 | 186 | 37 | 19.9 | 09 | 4.8 | – | – |
| Junior Accounts Officer | 2550–3200 | 01 | – | – | – | – | – | – | – |
| Senior Sales Assistant | 5000–8000 | 04 | 03 | – | – | – | – | – | – |
| **Group C and Group D** | | | | | | | | | |
| LDC | 3050–4590 | 116 | 77 | 19 | 24.6 | 04 | 5.19 | 08 | 11.6 |
| Group-C (non-ministerial and Group-D) | 3050–4590 2550–3200 | 187 | 163 | 48 | 29.4 | 09 | 5.52 | 16 | 9.8 |
| Supporting staff (*Safaiwala*) | 2550–3200 | 14 | 12 | 12 | 100 | – | – | – | – |

Welfare Fund. Further Rs 20,000 was also given to Shri Shiv Prasad, *Mali*, as financial assistance for his treatment.

- Scholarship (42) were awarded to the meritorious wards of the Council's employees under Staff Welfare Fund Scheme.

The planning and policy that was adopted during the reported period is given here.

**Intellectual Property Rights**

The new patent applications (40) were filed at ICAR (Hq), New Delhi. Thus a total of 175 applicatons for patent were put up to December 2005. National Phase application of the property Co-operation Treaty (PCT) application of CICR Nagpur was protection in China, South Korea, South Africa and Uzbekistan.

- First examination reports (70) of the patent applications were received and examined in the Council and replies thereof submitted to the Patent Office within the stipulated time.
- Formal Scrutiny Reports (26) were received in Patent Office, New Delhi within stipulated time.
- A 3-day conference on the IPR and Management of Agriculture was organized from 27 to 29 August 2005 at NAS Complex, New Delhi. Recommendations of the conference were circulated to all the ICAR Research Institutes/National Research Centres/ Project Directorates/Bureaux.

In accordance with the recommendations made by the Government of India, DARE and ICAR are exploring work in Hindi and also providing initiatives.

**DARE**

The Department of Agricultural Research and Education's an Official Language Section— for the compliance and implementation of the Official (DARE) Language Policy of the Government of India—consists of 1 post each of Assistant Director (Official Language), Junior Hindi Translator, and Hindi Typist. Besides the Hindi translation of the Budget, compilation and preparation of the Annual Report of the Department etc. also took place. The

**The following institutes were awarded for doing maximum work in Hindi during 2004–2005**

| Name of Institutions | Category of Institutions | Prizes |
|---|---|---|
| Indian Agricultural Research Institute, New Delhi | Big Institute | First |
| Central Institute for Fisheries Education, Mumbai | Big Institute | Second |
| Central Institute for Cotton Research, Nagpur | A and B Region | First |
| Central Sub-Tropical Horticulture Institute Lucknow | A and B Region | Second |
| Central Sub-Tropical Horticulture Institute, Lucknow | C Region | First |
| Sugarcane Breeding Institute, Coimbatore | C Region | Second |

functioning of this section also included holding Hindi workshops, meetings, reports, organizing *Hindi Pakhwada* to encourage the employees for doing their official work in Hindi.

**ICAR**

- During the reported period 2 Institutes/Centres of the Council were notified in the Gazzette of the Government of India, thus raising the total number of notified Institution to 96 under rule 10(4) of the Official Language Rule 1976.
- Joint Official Language Implementation Committee of the DARE and the ICAR working, under the Chairperson, Additional Secretary (DARE) and Secretary (ICAR), met twice during the reported period. Similarly, Official Language Implementation Committees constituted at 96 Institutes/Centres convened its meetings.
- Proceedings of the Official Language Implementation Committee meetings held by the Institutes etc. as well as the quarterly progress reports regarding the use of Official Language Hindi received from various institutes at the ICAR (Hq) were reviewed and proper measures were suggested to overcome the shortcomings found therein.
- Rosters have been maintained for imparting training in Hindi, Hindi typing, and Hindi Stenography at ICAR (Hq) and officials were accordingly deputed for training during the year. This year, 10 stenographers, and 9 typists were nominated for Hindi Stenography and Typing respectively.
- '*Hindi Chetna Maas*' was observed from 14 September to 13 October 2005 at ICAR (Hq) and many programmes were organized for staff to promote the Progressive use of Hindi in official business. A message of Hon'ble Minister of Agriculture was issued on this occasion. The Director-General, ICAR also issued an appeal requesting the officers/staff to do their maximum official work in Hindi. Hindi Day/Week/Month was also organized at different Institutes National Research Centres of ICAR.
- Hindi Workshops(3) were also organized during the reported period for officers/staff.
- "Ganesh Shankar Vidyarthi Hindi Krishi Patrika Purskar" was launched during this year for the best Hindi House magazine being published by various Institutions of the ICAR. Under this scheme Central Institute of Fisheries Technology, Kochin; Central Institute for Cotton Research, Nagpur; and National Bureau of Soil Survey and Land Use Planning, Nagpur got the First, Second and Third prizes respectively.
- In accordance with the recommendations made by the Department of Official Language and the Parliamentary Committee on official language, to assess the progress of use of Hindi at the ICAR (Hq.) as well as its institutes during 2005, 21 officers were inspected and suggestions were given to improve the short-comings. Second Sub-Committee of the Parliamentary Official Language Committee inspected 5 Institutes. Other institutes also brought out Hindi publications.
- Most of the computers at the ICAR (Hq.) are bilingual, and on some of the computers are doing 100% work in Hindi.
- The Council and its institutes are organizing regular training programmes for farmers in Hindi and in other regional languages and remarkable progress has been made at Krishi Vigyan Kendras situated in Hindi speaking region in the use of Hindi and in the other regional languages in their day officials work.
- Besides the material regarding Parliament question-answers, Annual 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 translated and prepared bilingual. The Hon'ble Agricultural Minister, and other higher officials delivered many of their speeches in Hindi. The drafts of speeches of Hon'ble Union Agriculture Minister and other higher officials of ICAR were prepared originally in Hindi also.

The Budget Estimate (B.E.) and Revised Estimate (R.E) of DARE and ICAR (Plan and Non-Plan) for 2004–2005 was Rs 17,533.10 millions and Rs 16,750 millions respectively and Budget Estimate (B.E) for 2005–2006 (Plan and Non-Plan) is Rs 19,420 millions. The detailed break-up of these financial figures are given in Tables 1 and 2 (Appendix III).

The detail of Department of Agricultural Research and Education (DARE) in respect of B.E. and R.E. 2005–06 and B.E. for 2005–06 are given in Table 1. This excludes the payment to the ICAR.

The Media and Information Unit finalized guidelines for streamlining production of video films in a cohesive manner by the different ICAR Institutes. The Unit was instrumental in conceiving the details of the topics and final editing of 44 video films. Finally, all the films have been submitted to Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India, a nodal organization responsible for National Telecasting through *Doordarshan* TV Network.

The Media and Information Unit was primarily responsible for providing all the infrastructure that were required to organize the 'National Krishi Vigyan Kendra Conference 2005' from 28 to 29 October 2005 at the National Agricultural Science Centre, ICAR, New Delhi. Exhibition component of this event had 46 stalls showcasing technology, products and services that 25 Krishi Vigyan Kendras and 21 ICAR Institutes/State Agricultural Universities are offering to farmers in their respective area/locations of India.

**Table 1. Budget Estimate and Revised Estimate for 2004–05 and Budget Estimate 2005–06 of DARE**

(Rs in lakh)

| Items | Budget estimates 2004–2005 | | Revised estimates 2004–2005 | | Budget estimates 2005–2006 | |
|---|---|---|---|---|---|---|
| | Plan | Non-Plan | Plan | Non-Plan | Plan | Non-Plan |
| Major Head '3451' 090 Secretary | – | 125 | – | 125 | – | 145 |
| Major Head '2415' 80 General International Co-operation | – | 10 | – | 10 | – | 10 |
| (010032)- India's membership contribution to Commonwealth Agricultural Bureau | – | 342 | – | 342 | – | 355 |
| (030032) | – | – | – | – | – | – |
| Other Programme | 50 | – | 5.0 | – | 45.50* | – |
| (040032) – India's contributions to Asia Pacific Association of Agricultural Institutions | – | 5 | – | 5 | – | 5 |
| (050032) – India's contributions to NACA | – | 12 | – | 12 | – | 12 |
| (060032) – India's contribution to CGPRT | – | 5 | – | 5 | – | 5 |
| (070032) – India's contribution to Seed Testing Association | – | 1.65 | – | 1.65 | – | 2.25 |
| (080032) – ISHS | – | 0.35 | – | 0.35 | – | 0.75 |

*Including Rs 45.50 crore for National Fund for Strategic Research

Besides, the programmes of Conference Hall was managed by the Unit by guiding audio-visual services, audio and video recording and fabricated main *Pandal* and *dias*.

**Publicity and Public Relation Unit**

The efforts were made to further build-up the liaison with the print and electronic media with a view to get positive reports in print and electronic media regarding activities and achievements of ICAR and various Institutes and projects. Press Conferences and press briefings of DG, ICAR and other senior officials regularly were organized on various issues. The success stories on research from concerned institutes were collected and released to the

Dr APJ Abdul Kalam, Hon'ble President of India closely monitoring NBPGR stall of ICAR pavilion in the R&D 2005 exhibition


Dr Manmohan Singh, Prime Minister of India addressing the audience at the National Conference on KVKs 2005 held on 27 October 2005 at New Delhi

Dr M Sujatha, DOR, Hyderabad receiving the Panjabrao Deshmukh Woman Agricultural Scientist Award 2004 from the Union Agriculture Minister at the ICAR Award Ceremony 2005

Dr S Srinivasan, Director, CIRCOT (*right*) receiving the Sardar Patel Outstanding Institution Award from the Agriculture Minister at the ICAR Award Ceremony 2005

media for wider coverage. Some of these stories appeared on front page of national dailies.

This Unit coordinated publicity of Agriculture Minister who interacted with fisheries sector at Chennai for the first time; and at the inauguration of newly established NRC for Pomegranate at Solapur, Maharashtra. Several 1 hr phone-in-programmes highlighting new varieties, technologies, implements, etc. were organized and scheduled for broadcast on All India Radio and *Doordarshan*. In a new initiative press releases and selected newspaper clippings were made available on website of Council for media persons and others. Regular information about ICAR was provided to farm-related pages of various newspapers.

The Council along with institutes participated in 12 exhibitions, viz. Krishi Expo 2006 at Pragati Maidan, New Delhi; *Kisan Mela* at Agriculture College Ground, Jhabua; Pride of India Science Expo, Indian Science Congress Exhibition, Hyderabad; *KISAN* 2004 at Pune; Destination Uttaranchal 2005 at Parade Gr, Dehra Dun; India International Trade Fair at Pragati Maidan, Delhi; R&D 2005 at Vigyan Bhawan, Delhi; *Vijnana Mela*/Techno Expo from at Kochi, Kerala; 9th National Expo at Kolkata; Banana Festival and Conference at Pragati Maidan, Delhi; Infra Educa 2005 at Jaipur at Pragati Maidan, Delhi and at Chandigarh; and Bio, 2005 at Bangalore during the year to disseminate the information regarding development of technologies, new varieties, success-stories to farmers, scientists, students as well as other visitors.

For the first time, an exhibition was organized in the coach of *Vigyan Rail*. Biotechnological applications and career opportunities in agriculture are some of the key-subject displayed by the ICAR in the *Vigyan Rail*. The *Vigyan Rail* (Phase II) covered various parts of the country.

The staff of Indian Council of Agricultural Research got First Prize for best display in Banana Festival held at Pragati Maidan, New Delhi during 4–6 August 2005. ICAR along with 25 institutes participated in the Pride of India Science Expo Exhibition, held during Indian Science Congress at ANGARU Campus, Hyderabad and bagged Most Informative Pavilion Award.

**ICAR Library**

During 2005–06, 500 new technical books were added to the collection of books. About 1,200 readers visited the library for consultation. The library also extended information support for consulting the database of the Centre for Agricultural and Biosciences International. The document delivery service was extended to individuals and libraries against specific requests for supply of documents for AGRIS database. The Hindi library acquired about 300 books and subscribed to a number of magazines. The library continued to laminate the identity cards of the retiring and retired staff of ICAR.

The 'Annual ICAR Award Presentation, 2005' function was held at the NASA Complex, New Delhi on 16th July 2005. H E Shri Sharad Pawar, Union Agriculture Minister and President of ICAR, Dr Mangala Rai, Secretary, (DARE) and Director-General (ICAR), and Ms Shashi Misra, Additional Secretary, (DARE) and Secretary, (ICAR) attended the function. The Minister of Agriculture said, "these awards are an incentive to the scientists and such scientists are encouraged to work hard to achieve the targets". During this year, 53 awards under 12 different categories have been given to honour 46 scientists, 4 farmers, 1 journalist, and 1 Co-ordinated Research Project (Appendix 12). From next year, a few new awards for innovative farmers, scientists and research workers will be instituted.

The Technical Co-ordination included the work of Financial support to 65 scientific societies, 12 academie universities/institutes for publication of Journals and Highlights of achievements of A.P.

Cess Fund Schemes, and the work related to Best Annual Report Awards, ICAR International Training Programmes, for conducting seminars/symposia/conferences, Technical backstopping, Parliament Questions, VIP references and material for papers/talks/replies was also done. The preparation of technical notes, Regional Committee Meetings, and monthly summary reports on major breakthroughs of exports, imports, research and other related matters of all the Institutes/Project Directorates, were submitted to Cabinet, Government of India and other related departments.

The main attaractions of the museum are "Touch and Explore" quizzes and "Water Cycle" for children, "Vedic Village", "Speaking Statue', "Agriculture and Solar Calendar" and "Six Pillars of Agriculture" which give information about Soil, Water, Climate, Tool, Seeds and Peasants.

This museum is educating its visitors, viz. farmers, school children, agricultural scientists, Government and non-Government officials and public at large. Many important dignitaries from India and abroad have visited the museum. Among the prominent ones are Nobel Peace Prize winner Dr Norman E. Borlaug, His Excellency Hon'ble, Vice President of Philippines, Director-General,

Dr Mangala Rai, Director-General, ICAR enjoying a joke with Dr Jacques Diouf, FAO Director-General

(FAO), Deputy-Director General (IPGRI), Director General, (IRRI), Chairman, (Pakistan Agricultural Research Council), Director-General of Fisheries at Jeddah, Saudi Arabia, etc. All these dignitaries appreciated the efforts made for compiling and exhibiting very important information about Agriculture, Animal Husbandry, Poultry, Fisheries, etc.

# 6. Partnership and Linkages

The International Cooperation in ICAR/DARE has been operating through the Memoranda of Understandings/Work Plans signed with several countries/international organizations with ICAR/DARE as the Nodal Department, and through participation of ICAR/DARE in the Memoranda of Understandings (MoUs)/Work Plans signed by the Department of Agriculture and Cooperation as Nodal Department. Besides, Ministry of Science and Technology has developed Programme of Cooperation with various countries and international organizations in which ICAR/DARE is the participating agency in the field of 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 Cooperation.

The activities of the International Co-operation are mainly carried out under Memoranda of Understandings (MoUs)/ Agreements/Work Plans were signed by the several international organizations/countries etc. This Division organizes visits of foreign national under "*Ad hoc* categories" and receives proposals for customized training courses of foreign national.

- Memorandum of Understanding between ICAR and Brazilian Agricultural Research Corporation, Brazil was signed on 6 July, 2005.

Dr Mangala Rai, Director-General, ICAR (in the centre) signing the Joint Declaration with USDA in New Delhi in the presence of Shri Sharad Pawar, Union Agriculture Minister

- DARE/ICAR has single file system and has got signed mainly 3 Memoranda of Understandings with Brazilian Agricultural Research Co-operation, Brazil; Government of Republic of Afghanistan; and United States Department of Agriculture.
- During the reported period Indo-Collaborative Projects (18) were signed with France, USA, UK, German, European Union, Switzerland etc.
- The 36 proposals of deputation relating to collaborative projects activities of foreign countries were approved during the reported period.
- During 2005 Indian scientists (102) were approved to go on deputation.
- The Secretary (DARE) and DG, ICAR visited Israel as a part of Minister of Agriculture delegation from 13 to 16 November 2005 to attend Xth Commemorative anniversary of the assassination of the (late) Prime Minister, Yitzhak Rabin and also to participate in the bilateral meetings with Israeli Agriculture Minister and others on Dairy Farms and Horticultural Projects.
- Fourteen VIP visited India under VIP delegations. Among them President of Walloon Parliament at Nimur in Belgium, Vice Minister of Education of Ethiopia etc. visited India.
- The Minister of Rural Rehabilitation and Development, Afghanistan; and Minister of Agriculture, Water and Forestry, Namibia also led their corresponding delegations.
- The Directors-General of International Rice Research Institute, Manilla; Food and Agricultural Organization, Rome; International Food Policy Research Institute (IFPRI), USA; and Ex-Director-General of IFPRI, USA also visited at DARE/ICAR.
- Indian scientists also visited to foreign countries, viz. Russia, Brazil, Egypt, Myanmar, Nepal etc. for attending conferences, higher studies, workshops etc.
- DARE/ICAR has also hosted (6) delegations from Russia, Nepal, Uzebekistan, etc.
- DARE/ICAR deputed 26 Indian scientists abroad for participation in workshop, conferences, trainings, symposium, etc. in Indonesia, Thailand, Austria, China, Swetzerland, Iran, Bangkok etc.
- DARE/ICAR has deputed 35 scientists/technical officials/ officers abroad for attending trainings/research work/ overseas associatesship/post doctoral fellowship/higher studies/availing scholarship etc.
- During 2005 DARE has approved 102 scientists to go on deputation.

- Memorandum of Understanding between the Government of the Republic of India and the Government of the Republic of Afghanistan in the agricultural research and education was signed during the visit of Prime Minister to Afghanistan from 28 to 29 August, 2005.
- Joint Declaration of the Ministry of Agriculture, Government of India, and the United States Department of Agriculture regarding support for a India-United States Knowledge Initiative on Agricultural Education, Research, Service and Commercial Linkages was signed on 12 November, 2005.

During the reported period 18 foreign aided collaborative projects were received. However, following projects were approved for implementation by the various Institutes of the ICAR.

**International Development Research Council Project**

The project, 'Evaluation Capacity Building in Rural Resource Management, a pilot Action Research on Programme Evaluation', was launched for 15 months w.e.f. 1st October,2005. The project is being implemented by IARI, New Delhi. The aim of the project is to build programme evaluation capacity among rural resource management programme staff in the South-Asian Region through development of cadre of evaluators who will be willing to and able to conduct evaluation of educational and/or development programmes through the trained approach. The total cost of the project is Canadian $26,500 and is being funded by International Development Research Council.

**Indo-French Collaborative Project**

Use of DNA Markers (AFLP) for genetically improving the Productivity, Palatability, Storability and Dry-matter content of Tubers of Greater Yam is launched for 3 years w.e.f. 1 August 2005 and is being funded by Indo-French Centre for the Promotion of Advanced Research (IFCPAR), a joint organization of Government of India and France. The participating Institute of India is Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala, and from France, the collaborating Institute is CIRAD. The project aims at genetic improvement of vegetatively propagated greater yam through the integrated techniques of biotechnology and conventional breeding recently developed by the institutes, viz. CIRAD and CTCRI. The Central Tuber Crops Research Institute is to get Rs. 2.168 million for implementing the project.

**International Atomic Energy Agency (IAEA) Research Project**

The Project "Identification and pyramiding of genes for improving salt tolerance and seed yield in Indian mustard (*Brassica juncea* L.) under salinity stress is on progress. It was launched for 5 years w e f December 2004and is being renewed by IAEA on year to year basis. The Central Soil Salinity Research Institute, Karnal is implementing the Project. The overall objective of the project is the development of high-yielding, salt-tolerant cultivars of Indian mustard (*Brassica juncea* L.) by combination of conventional breeding, induced mutation and marker assisted breeding approaches. The funding by IAEA is Rs 329,796 million.

**Indo-German Projects**

- The project "Application of Molecular Markers to Broaden the Genetic Base of Tomato for Improved Tropical Adaptation and Durable Disease Resistance" is being funded by German Government under the umbrella network of South-Asian Vegetable Research Network, and is being executed through Asian Vegetable Research and Development Centre (AVRDC), Taiwan for 3 years w.e.f. 1 March, 2004. The collaborative institute of India is Indian Institute of Horticultural Research (IIHR), Bangalore. The total cost of the project is Euro 1,200,000 and India will be getting 93000 Euro. The project aims to improve heat tolerance, yield and multiple disease resistance of tropical tomato cultivars through application of molecular marker technique that permits effective exploitation of wild species and to make material available for use of National Agricultural Research System and private sector and adaptation by vegetable farmers.
- The Agency for Technical Cooperation in German language *Gasellschaft für Technique Ausammenarbeit* (GTZ) project 'Development of locally adapted, multiple disease resistant, high-yielding chili (*Capsicum annum* L.) cultivars for targeted countries in Asia' is in the second phase and is for 3 years w.e.f. 1 April, 2005. The Indian Institute of Horticultural Research, Bangalore is implementing this project, which is being funded by German Government under the South-Asian Vegetable Research Network and is being executed through Asian Vegetable Research and Development Centre (AVRDC). The budget meant for the Institute is 61,100 Euro. The project is to focus on the development of locally adopted multiple disease resistant chilly varieties in countries where the chili crop is economically important.

**Indo-European Project**

The project "Molecular, Environmental and Nutritional Evaluation of Bambara Groundnut for Food Production in Semi-Arid Africa and India" is being funded by European Union under their 6th Framework Programme (F P 6) on Research in all 8 countries, viz. UK, Denmark, German, Botswana, Ghana, Namibia, Tanzania and India for 48 months. From India, the collaborating institutes are National Research Centre on Groundnut, Junagarh,

Gujarat; University of Agricultural Sciences, Bangalore; and Central Arid Zone Research Institute, Jodhpur. Total funding, to be received by the 3 Indian collaborating centres, is to the tune of 305,628 Euro. The objective of the research at NRC on Groundnut is (*i*) to identify the traits associated with WUE and or drought tolerance and analysis of QTLs; (*ii*) to improve WUE under field situations in relation to crop canopy architecture and RUE, and to study the mechanism of cross tolerance i.e. drought and heat stress.

**CFC/DFID/APCC/FAO Projects**

- The 'Coconut Integrated Pest Management' project aims at developing packages of Integrated Pest Management (IPM) techniques using easily obtainable materials which can conveniently applied by coconut small holders. Nine countries including India are participating in the project. The total cost of the project is US $1,467,500 and financing by the CFC is US $ 801,050 and co-financing from Department For International Development (DFID) Crop Protective Programme is to the tune of the US$225,000 The contribution of India is US $ 86,500 which is in kind. India will be provided US $ 86,550 from the project funds for implementing the project. The project is being implemented by Central Plantation Crops Research Institute, Kasaragod, Kerala.

Mr Jacques Diouf, Director-General, FAO is in discussion with Dr Mangala Rai, DG, ICAR in a metting held in New Delhi. Ms Sushama Nath, Secretary, ICAR also attended the meeting

**Indo-Swiss Collaborations**

- The Directorate of Wheat Research, Karnal, and Institute of Plant Biology, University of Zurich, Switzerland are participating in the Biotechnology Project on "Enhancing genetic resistance against stripe and leaf rust using molecular markers in wheat adopted to the moisture stress raising". The nodal agency for funding this Swiss counterpart is SDC, Government of Switzerland. The Department of Biotechnology is funding Indian counterpart. The total cost of the project of Directorate of Wheat Research, Karnal is Rs.2.394 million and the project is for 3 years w.e.f. December 2004. The objectives of the project areas (*i*) broadening resistance base against leaf and stripe rusts, using molecular markers linked to effective resistance genes (Lr34, Lr37, Yr10 and Yr15) in genotypes adapted to the rainfed areas; and (*ii*) study on the genomic region around Lr34 in selected Indian wheat lines to rapidly identify a marker (in collaboration with University of Zurich.

**Collaborative Reserch Programme**

Dr Lal Krishna, [(ADG, (Animal Health), ICAR)] and Dr D. Swarup, (Head, Division of Medicine, IVRI, Izatnagar) were deputed to South Africa to discuss collaborative research programme on "Safety, testing of Diclofenac and Alternative NSAID *vis-à-vis* decline in vulture population".

**Global Environment Facility Project**

Dr J.S. Samra, [(DDG (NRM), ICAR)] was deputed to participate in the Final Project presentation of the Global Environment Facility (GEF) Project on "Assessment of Soil Organic Carbon Stocks and Change at National Scale" held at UNEP (headquarters), Nairobi, Kenya from 23 to 27 May, 2005.

**GTZ Funded Project**

Dr S.D. Shikhamany, (Director, IIHR,, Bangalore) and scientist (5) were deputed for participation in the Phase II Planning Workshop of the GTZ funded project on "Development of locally adapted, multiple disease-resistant, high- yielding chili (*Capsicum annum* L.) Cultivars for targeted countries in Asia' was held in China from 16 to 21 May, 2005.

**Watershed Modelling Project**

Dr V.N. Sharda, (Director) and Dr.P.R. Ojasvi, (Senior Scientist), both from CSWCR&TI, Dehra Dun were deputed to McGill University, Canada to work on Watershed Modeling Project under the Shashtri Applied Research Project (SHARP), on "Environmental Impact Assessment of community Based Water Resources Management Projects in Uttranchal" from 29 July to 12 August, 2005.

DARE/ICAR also look after foreign delegations to India, delegations hosted, Indians to foreign delegations, and Indian Scientists to foreign countries.

**Foreign delegations to India**

- His Excellency Dr Teshome Yizengaw, Vice Minister of Education

of Ethiopia and Prof. (Dr) Belay Kassa, President of Alemaya University, Ethiopia, met Dr Mangala Rai, Secretary (DARE) and Director-General (ICAR), and other senior officers on 19 May 2005.

- Mr Jose Happart, President of the Walloon Parliament at Nimur in Belgium met Dr Mangala Rai, Secretary (DARE) and Director-General (ICAR), and other senior officers on 24 May 2005.
- Dr. R. Ziglet, Director-General, International Rice Research Institute, Manila, Philippines met Dr Mangala Rai, Secretary (DARE) and Director General (ICAR), on 22 June 2005.
- His Excellency Dr Abdolmahdi Bakshandeh, Deputy Minister of Agriculture, Planning and Finance, Government of the Islamic Republic of Iran, and accompanied delegation visited ICAR (Hq), and Indian Agricultural Research Institute, New Delhi on 12 August 2005

Dr Abdolmahdi Bakshandeh, Dy. Minister of Agriculture, Planning and Finance, Govt. of Iran meeting with Dr Mangala Rai, Secretary (DARE) and DG, ICAR

- Dr Jacques Diouf, Director-General, Food and Agriculture Organization, Rome, visited Indian Agricultural Research Institute/ National Research Centre on Plant Biotechnology/National Bureau of Plant Genetic Resources, National Agricultural Science Museum, and ICAR (Hq), New Delhi on 5 September 2005.
- His Excellency Mr Arturo Barrera, Deputy Minister of Agriculture, Chile, accompanied by 4-member delegation visited Indian Agricultural Research Institute (IARI), and National Bureau of Plant Genetic Resources, New Delhi on 12 September 2005.
- His Excellency Dr Nil Okai Hammond, Deputy Minister of Food and Agriculture, Ghana visited Central Tuber Crops Research Institute, Thiruvananthapuram on 13 September 2005.
- His Excellency Mr Haneef Atmar, Minister for Rural Rehabilitation and Development, Afghanistan, visited IARI, New Delhi from 3 to 5 October 2005.
- His Excellency Mr Han Chang On, Ambassador E and P, Embassy of the Democratic Peoples' Republic of Korea and accompanied officials visited to IARI, New Delhi on 30 September 2005.
- Dr Joachim VonBraun, Director-General, International Food Policy Research Institute, USA met Dr Mangala Rai, Secretary (DARE) and Director-General (ICAR), on 20 October 2005.
- Dr Geoff Hawtin, Ex-Director-General, International Food Policy Research Institute, USA met Dr Mangala Rai, Secretary (DARE) and Director-General (ICAR), on 20 October 2005.
- Dr J.B. Penn, Under-Secretary for Farm and Foreign Programs, United States Department of Agriculture (USDA), USA, visited to a village organized by IARI, New Delhi on 13 November, 2005, and at ICAR (Hq) on 12 November 2005.
- His Excellency Mr Carlos Agostinho Do Rosario, High Commissioner of the Republic of Mozambique, New Delhi visited Water Technology Centre, Indian Agricultural Research Institute, New Delhi on 28 November 2005, and Central Research Institute for Dryland Agriculture, Hyderabad from 2 to 3 December 2005.
- His Excellency Dr Nickey Iyambo, Minister of Agriculture, Water and Forestry of Namibia accompanied by delegates (3) visited Indian Agricultural Research Institute, National Bureau of Plant Genetic Resources, and National Agricultural Science Museum, all in New Delhi on 5 December 2005.

**Delegations hosted**

- Dr Korinets Valentin, Director, (All-Russia Research Institute of Irrigating Vegetable Growing and Melon Production, Astrakhan, Russia) visited Central Institute for Post-harvest Engineering and Technology, Ludhiana from 26 April to 1 May 2005, for study in the field of "Research on power saving processing technology of vegetable and melon crops" under ICAR-RAAS Work Plan for 2004–2005.

Dr Jacques Diouf, FAO Director-General visiting the hall of Institutes of Veterinary Science. Dr S Ayyappan, DDG (Fisheries) has also accompanied the dignitary

- Shri Govinda P.Koirala, Shri Dhrub P.Subedi, Shri Bashant K.Pondeya, Shri Dev Raj Dhakal and Shri Sanjib K.Lamichhine (from Nepal Agricultural Research Council, Nepal) visited National Academy of Agricultural Research Management, Hyderabad from 12 to 16 September, 2005 for training in the field of "Administration/Finance Management" under ICAR-NARC Work Plan 2003–04 (extended upto 31.12.2005).
- Dr Nasikov Vladimir Vyacheslavovich, (Principal Scientist, All-Russia D.N. Pryanishnikov Scientific Research Institute of Agrochemistry, Moscow, Russia) visited Indian Institute of Soil Science, Bhopal from 13 to 22 September 2005, for study in the field of "Development of ecologically safe fertilizers for long-term activity on a base of agropolymers" under ICAR-RAAS Work Plan for 2004–2005.
- Dr Nomozov Shodmon Eregashevich, (Senior Research Fellow, Uzbek Scientific and Research of Cotton Selection and Seed Farming, Uzbekistan) visited National Bureau of Plant Genetic Resources, New Delhi, and Central Institute for Cotton Research, Nagpur from 22 to 27 November 2005, for study in the field of "Cotton Genetic and Growing" under the Work Plan for 2004 extended up to 31 December 2005.
- Dr Mirzaev Mirmaksud Makhmudovich, (Director-General, Scientific and Production Corporation of Horticulture and Wine Making), Dr Avakov Valeriy Sergeevich, (Director, Experimental Winery No. 2 under Scientific and Production Corporation of Horticulture and Wine Making), and Dr Saiddjaliev Bekzad Rashidovich, (Director, Sharob Scientific Research and Production Enterprize under Scientific and Production Corporation of Horticulture and Wine Making, Uzbekistan) visited Indian Institute of Horticultural Research, Bangalore, and National Research Centre for Grapes, Pune from 7 to 16 December 2005, for study in the field of "Cotton Genetic and Growing" under the Work Plan for 2004 extended up to 31 December, 2005.
- Dr Yusupov Suratbek, (Director, Uzbek Scientific and Research Institute of Astrakhan Breeding and Desert Ecology, Uzbekistan) visited Central Sheep and Wool Research Institute, Avikanagar and Central Institute for Research on Goats, Makhdoom from 13 to 17 December 2005, for study in the field of "Cotton Genetic and Growing" under the Work Plan for 2004 extended up to 31 December 2005.

**Indians to foreign delegations**

- Dr Ashwani Kumar [Project Coordinator (APA), Central Institute for Post- Harvest Engineering and Technology, Ludhiana] visited All-Russia Research Institute of Plant-Protection, St. Petersburg, Russia from 18 to 27 April 2005, for study in the field of "Protected Cultivation" under ICAR-RAAS Work Plan for 2004–2005.
- Dr Nitin Virmani, [Scientist (Sr. Scale), National Research Centre for Equines, Hisar], and Dr. S. Nagarajan, (Scientist, High Security Animal Diseases Laboratory, Bhopal) visited All-Russia Research Institute of Veterinary Virology and Microbiology, Pokrov, Russia, from 25 April to 1 May 2005, for study "Epizootology Diagnostics and Vaccines for exotic animal diseases" under ICAR-RAAS Work Plan for 2004–2005.
- Dr R.K. Sethi, (Principal Scientist and Incharge, Network Project on Buffaloes, Central Institute for Research on Buffaloes, Hisar) and Dr. Avtar Singh, (Senior Scientist, National Dairy Research Institute, Karnal) visited Agricultural Research Centre, Egypt for 4 weeks from 23 May to 20 June 2005, for training in the field of "Buffalo Breeding and Husbandry" under Indo-Egyptian Work Plan for 2004–2005.
- Dr M.P. Sharma, (Principal Scientist, Indian Institute of Sugarcane Research, Lucknow) visited Cuba from 30 May to 13 June 2005, to study the latest technology in the field of sugarcane by-products development and utilization.
- Dr R.K. Sethi, (Principal Scientist, Central Institute for Research on Buffaloes, Hisar) visited Brazil from 5 to 8 July, 2005, as a member of the delegation led by Hon'ble Agriculture Minister.
- Dr P.G. Adsule, (Director, National Research Centre for Grapes, Pune) visited All-Russia Scientific Research Institute of Brewery, Non-alcoholic and Wine-Making Industry, Moscow, from 20 to 27 July 2005, for study in the field of "Technologies in Sparkling Wine-making" under ICAR-RAAS Work Plan for 2004–2005.
- Dr Ranbir Chhabra, (Principal Scientist, Central Soil Salinity Research Institute, Karnal) visited All-Russia A.N. Kostyakov Scientific Research Institute of Hydrotechnique and Melioration, Moscow, Russia from 21 to 30 July 2005, for study in the field of "Bio-amelioration for saline and alkaline soil" under ICAR-RAAS Work Plan for 2004–2005.
- Dr S. Ayyappan, [DDG (Fisheries)], and Dr R.K. Mittal, [(Principal Scientist, TC), both from ICAR (Hq), New Delhi] visited Myanmar for participation in ASEAN - India Consultation on Agriculture held at Mandalay, Myanmar on 27 July, 2005.
- Dr K.S. Khokhar, [ADG (PIM), ICAR (Hq), New Delhi] visited Argentina from 28 to 30 July 2005 as a member of the delegation led by Minister of State (Agriculture).
- Dr M. Madhu [(Sr. Scientist), Central Soil and Water Conservation Research and Training Institute, Research Centre, Udhagamandalam] visited Nepal from 7 to 16 August 2005, for study in the field of "Sloppy Land Management under ICAR-NARC Work Plan for 2003–2004.
- Dr D.G. Dhandar, (Director) and Dr O.P. Awasthi, [(Senior Scientist, Horticulture), Central Institute for Arid Horticulture,

Bikaner] visited R.R. Shredder Uzbek Scientific and Research Institute of Horticulture, Viticulture and Wine-making, Uzbekistan, from 11 to 17 August 2005, for study in the field of "Horticulture (Fruits) in arid region - Variety Study/ Horticulture (Fruits) Management" under Work Plan for 2004 extended up to 31 December, 2005.

- Dr Desh Beer Singh [(Sr. Scientist), Central Institute of Post-harvest Engineering and Technology, Regional Station Abohar] and Dr I.N.D. Gowda, [(Sr. Scientist Post-harvest technology), Indian Institute of Horticultural Research, Bangalore,] visited All-Russia Selection and Technological Institute of Horticulture and Plant Nursery, Moscow, Russia from 10 to 19 September 2005, for study in the field of "Post- harvest Management of Horticulture Produce" under ICAR-RAAS Work Plan for 2004–2005.
- Dr T.S. Aghora, [(Senior Scientist, Vegetable Crops), Indian Institute of Horticultural Research, Bangalore] visited All-Russia Scientific Research Institute of Breeding and Seed Production of Vegetable Crops, Moscow and All-Russia Scientific Research Institute of Vegetable Production, Moscow, Russia from 10 to 19 September 2005, for study in the field of "Resistance/heterosis breeding in vegetable crops" under ICAR-RAAS Work Plan for 2004–2005.
- Dr Suresh Kumar Tandon, [ADG (Agricultural Engineering, ICAR (Hq), New Delhi] visited Uzbekistan from 25 September to 1 October 2005, for study in the field of "Agricultural Machinery - Test of Cotton Sowing and Cotton Picking Machines" under Work Plan for 2004 extended up to 31st December, 2005.
- Dr S. Rajan, [(Senior Scientist), Central Institute of Sub-tropical Horticulture, Lucknow] visited Nepal Agricultural Research Council, Nepal for study in "Production and Management of Fruits and Vegetables" under ICAR-NARC Work Plan for 2003–04.(extended upto 31 December 2005) from 02 to 06 October, 2005.
- Dr L.K.Sinha, [(Senior Scientist), Central Institute of Agricultural Engineering, Bhopal] visited Agricultural Research Centre, Egypt from 1 to 14 October, 2005, for study "Soybean Procoessing and diet food production" under Indo-Egypt Work Plan for 2004–05.
- Dr B.Rai [(Senior Scientist), Central Institute of Research on Goats, Makhdoom, Mathura] visited Nepal Agricultural Research Council, Nepal for study in the field of Goat Management under ICAR-NARC Work Plan for 2003–04(extended up to 31 December 2005) from 14 to 18 November 2005.
- Dr Prem Kumar, (Scientist) and Shri R.S.Haldar, [(Farm Manager(T–5), National Research Centre on Coldwater Fisheries, Bhimtal] visited Nepal Agricultural Research Council, Nepal for study in the field of "Trout Farming" under ICAR-NARC Work Plan for 2003–04 from 12 to 16 December, 2005.
- Dr J.S. Samra, [DDG (NRM), ICAR,(Hq), New Delhi] and Dr R.S. Mertia, [(Head), CAZRI Regional Research Station, Jaisalmer, Rajasthan] visited Iran for finalization of collaborative research programme sand dune stabilization and upgradation/ improvement of range lands and degraded lands under the Work Plan for 2004–2005 from 10 to 18 November 2005.
- Dr Mangala Rai, [Secretary, (DARE) and Director-General (ICAR)] visited Israel as part of Minister of Agriculture's delegation from 13 to 16 November 2005 to attend the 10th Commemorative anniversary of the assassination of (Late) Prime Minister, Yitzhak Rabin, and also to participate in the bilateral meetings with the Israeli Agriculture Minister and other officials and to visit important Agriculture Research Centres, Dairy Farms and Horticultural Projects.
- Dr H.S. Nainawatee, [(ADG (HRD-II), ICAR (Hq), New Delhi)] visited Rome to participate in the 33rd Session of the Food and Agriculture Organization Conference from 21 to 23 November, 2005.
- Dr Mangala Rai [Secretary (DARE) and Director-General (ICAR)], accompanied by Dr S.L. Bhat [Joint-Secretary (Seeds, Crops and TMOP), DAC]; Ms Gaitri I. Kumar, [Director (AMS), MEA]; Dr P.L. Gautam [Vice-Chancellor, GBPUA&T, Pantnnagar]; Dr S.D. Sundar Singh, (Vice-Chancellor, TNAU, Coimbatore), and Dr M.P. Yadav [Director, IVRI, Izatnagar], visited New York/Washington, USA for participation in the 1st Board Meeting of the Knowledge Initiative Board for Agriculture and to visit relevant Agricultural Business Units/Research Centres/Universities from 12 to16 December 2005.

**Indian Scientists to foreign countries**

- Dr S Ayyappan, [DDG (Fisheries), ICAR] visited from 10 to 13 May, 2005 for participation in the "World Aquacultures, 2005 Conference and Exposition" at Bali, Indonesia
- Dr P S Minhas, (Director, CSSRI, Karnal) visited from 18 to 21 April 2005 participation in the FVAO mid-term Workshop on "Integrated Management for Sustainable Use of Low fertility and Salt Affected Soils in Rainfed Agriculture including Salt Affected Soils Coastal Areas" at Thailand.
- Dr A.K.Garg, (Principal Scientist, NRL, IARI, New Delhi), visited from 9 to 13 May, 2005 for participation in the International Conference entitled "FAO/IAEA International Conference on Area-wide Control of Insect Pests Integrating the Sterile Insect and Related Nuclelar and Other Techniques" at Austria.
- Dr K V Prabhu, (Scientist, IARI, New Delhi) visited to Swaziland in Africa for 3 weeks as an FAO expert w.e.f. 11 May 2005; (Expenditure by IAEA).

- Dr Suresh Chandra (T–5) and Dr Bibhudatta Mishra (T–2) from Central Institute for Freshwater Aquaculture, Bhubaneshwar, visited China from 15 May to 13 August, 2005 for participation in the Training Course on 'Integrated Fish Farming in China'.
- Dr Anjani Kumar, (Scientist (SS), NCAP, New Delhi) visited to International Livestock Rsearch Institute(ILRI), Regional Office, New Delhi for 2 years on deputation basis as Agricultural Economist.
- Dr Abraham Verghese, (Principal Scientist, IIHR, Bangalore) visited Switzerland from 12 to 16 September 2005 for participation in the "2nd International Symposium on Biological Control of Arthropods " at Pavos, Switzerland
- Dr I D Garg (Head, Plant-Protection, CPRI, Shimla) visited Scotland, UK, from 12 to 16 September 2005 as a member of Expert Working Group of FAO- Exp by European Plant Protection Organization (EPPO)
- Dr R G Agarwal (Senior Scientist, NBPGR, New Delhi) visited from 29 August to 2 September 2005 to attend a Workshop on "*In situ* Conservation" and a training Course on GLS in the FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.
- Dr N Sarangi, (Director, CIFA, Bhubaneswar) visited Iran from 27 September to 3 October, 2005 for participation in the "Eight Technical Advisory Committee meeting of NACA", and the "FAO/NACA Regional Workshop to Synthesize the NASC",and develop an prospective analysis of the future Aquaculture Development in Asia in Iran.
- Dr R J Rabindra (Project Director, Project Directorate of Biological Control, Bangalore), visited UK from 22 to 23 September for participation in the Pathways out of Poverty Conference in United Kingdom entitled "Biological Control of *Mikinia micrantha* with *Puccinia spegazzini* at Project Directorate on Biological Control, Bangalore (Expenses by ICAR-CABI collaboration).
- Dr A K Jain, (ADG, ARIS), visited Thailand from 18 to 20 October, 2005 for participation in the Workshop on "Ltegrating Agricultural Information Systems", Bangkok, Thailand.
- Dr B P Neema, (Principal Scientist, CIAE, Bhopal) visited China, for participation in the "International on Biological Technology for Reduction and Sustinable at China" from 18 to 20 October 2005,
- Dr J L Karihaloo (Director, NBPGR, New Delhi) visited Rome from 26 to 28 October, 2005 for participation in the Third Session of the Inter-governmental Technical Working Group on "Plant Genetic Resources for Food and Agriculture" at Rome, Italy.
- Dr P Sreeramakumar (Senior Scientist, Project Directorate of Biological Control, Bangalore) visited Britain from 22 to 23 September 2005, for participation in the "Biological control of *Mikinia micrantha* with *Puccinia spegazzini* at Project Directorate on Biological Control, Bangalore"
- Dr G Kalloo, [(DDG (Horticulture and Additional Charge of DDG, Crop Science)] visited Bangkok from 7 to 10 November 2005, for participation in the High Level Policy Dialogue on "Biotechnology for Food Security and Poverty Alleviation and APAARI Annual Meeting".
- Dr (Mrs) Gurinder Jit Randhawa, (Senior Scientist, NBPGR, New Delhi) visited to participate in the High Level Policy Dialogue on "Biotechnology for Food Security and Poverty Alleviation and APAARI Annual Meeting" at Bangkok from 7 to 10 November, 2005.
- Dr Ramesh Chand (Acting Director, NCAP, New Delhi), visited Dhaka from 8 to 9 November, 2005 to attend the Programme Committee Meeting of the SAARC at Dhaka (Expenditure of Rs 29,200 was given by DARE).
- Dr J P Mishra [ADG (ESM), ICAR (Hq)], Dr R P Singh (Head, Division of Agricultural Economics, IARI, New Delhi), Dr N P Singh, and Dr Ranjit Kumar [Scientists (IARI, New Delhi)] visited Bogor from 6 to 9 December 2005, for participation in the Regional Workshop on "Rural Prosperity and Secondary Crops" towards Applied *Pro*-poor Research Policies in Asia and Pacific in Bogor.
- Dr B Mishra (Director, Directorate of Wheat Research, Karnal), and Dr M Prashar (Senior Scientist, Regional Research Station, Shimla) visited Rome from 15 to 16 December 2005, for participation as Wheat Rust Experts in the Expert Workshop on "Breeding and Disease Manpower Strategies for the Prevention and Control of the new Virulent Rae of the Wheat black stem rust" at Rome.
- Dr R C Bhattacharya [(Scientist, (SS), NRC on Plant Biotechnology, IARI, New Delhi)] visited USA for availing 'Biotechnology Overseas Associateship (long-term) award at the Institute of Biological Chemistry, Washington State University, USA for 12 months w.e.f. 1 March 2005 His entire deputation cost including air fare was given by the Department of Biotechnology, New Delhi.
- Dr Ajoy Mandal [(Scientist (SS), NDRI, Karnal)] visited France for availing Post-doctoral Fellowship Position at INRA, France for 12 months w.e.f. 14 March 05. His entire deputation cost including international level was given by Organizer of the Programme.
- Dr A K Mohanty [Scientist (SS), NDRI, Karnal] visited USA for availing Biotechnology Overseas Associateship (Long-term) Award, University of California, USA for 12 months w.e.f. March, 2005. His entire deputation cost including air-fare was given by the Department of Biotechnology, New Delhi.
- Dr P Venkatarami Reddy (Sr.Scientist, IIHR, Bangalore) visited Japan for availing UNU Kirin Fellowship for carrying research

in Biochemical and molecular basis of resistance to collosobruchimchirensissbeans, cowpea and piea germplasm at IFRI, Trukuba, Japan for 12 months w.e.f. April, 2005. His entire deputation cost including air-fare was given by the Department of Biotechnology, New Delhi.

- Dr (Mrs.) Amika Baldev Gaikwad, (Scientist, NBPGR, New Delhi) visited USA for availing Department of Science and Technology's "BOYCAST fellowship for training in the areas of Plant Genetic Resources Characterization" at University of Arizona, USA for 12 months w.e.f. from second half of March, 2005. Her entire deputation cost including international travel was given by the Department of Science and Technology, New Delhi.
- Shri Sandip Gangil (Scientist, Central Institute of Agricultural Engineering, Bhopal) visited Japan for higher studies leading to the award of Ph.D. Programme at Shizuoka University, Japan for 3 years w.e.f. 1 April 2005. His entire deputation cost including international travel will be borne by the Organizer of Course.
- Dr J K Jena, (National Fellow, CIFA, Bhubaneshwar) visited to attend an international course on 'Aquaculture Production and Management', in Israel from 16 May to 19 June 2005. His local living cost was given by the Government of Israel, and International air-fare by the Project Water IMB, Bhubaneshwar.
- Dr S.L.Ahuja (Sr. Scientist, CICR, Nagapur) visited USA to attend short-term training. on new technology in "Cotton Production Research" under ICAR Research Associate Programme in Washington, USA from 9 to 18 May, 2005. His local living cost was given by the Training Organizers and international travel expenses was given by Dr Ahuja himself.
- Dr M Prabhakar (Scientist, CRIDA, Hyderabad) visited Netherlands to attend Training Course on "Integrated Pest Management and Food Safety" at IAC, Wageningen, the Netherlands from 23 May to 1 July 2005. His entire deputation cost including International air fare(bothways) was given by the Organizers of the Programme.
- Dr (Mrs.) K B R S Visarada (Sr. Scientist, NRC on Sorghum, Hyderabad) visited Netherlands to attend training course on "Design of Plant Breeding Variety protection molecular markersin Plant breeding" at IAC, Wageningen, the Netherlands from 23 May to 1 July 2005. Her entire deputation expenses including international air-fare was given by the Organizers of the Course.
- Dr Jai Gopal, (Principal Scientist, CPRI, Shimla) visited Japan to conduct 2nd spell of research at Graduate School of Agriculture, Hokkardo University, Japan for 10 months wef 5 July 2005 His entire deputation expenses including air-fair was given by the Organizers of the Course.
- Dr K S Reddy (Senior Scientist, CIAE, Bhopal) visited to attend training on "Agricultural Infrastructure Improvement in Upland Crops Area: in Japan" from 29 May to 20 August 2005. His entire deputation cost including bothway international air-fare was given by the Government of Japan.
- Dr (Ms.) Celia Chalam V (Senior Scientist, NBPGR, New Delhi) visited to attend training in operation and technical discussions on TEM equipment procured by the Bureau under NATP Project at M/s JEO Ltd., Tokyo, Japan from 3 to 10 July, 2005. Her entire deputation expenses including air-fare was given by the Organizers of the Course.
- Sh. Ashok Maurya (Technical Officer, NBPGR, New Delhi) visited to attend training in operation and technical discussions of TEM equipment procured by the Bureau under NATP Project at M/s JEO Ltd., Tokyo, Japan from 3 to 10 July, 2005. His entire deputation expenses including air-fare was given by the Organizers of the Course
- Dr P P Srivastava (Technical Officer, CIFE, Mumbai) visited for availing Biotechnology Overseas Associateship (short-term) award training in the area of "Effect of dietary fish-oil suppression on gene expression profiling in lives of rainbow trout fish" at INRA, France for 6 months w.e.f. September, 2005. His entire deputation cost including air-fair (bothways) was given by the Department of Biotechnology, New Delhi.
- Dr K Narayanan (Scientist, SRS of CSWRI, Kodaikanal, Tamil Nadu) visited for higher studies for Ph. D. programme in Animal Reproduction at Laval University Canada for a period of 3 years from w.e.f. 2 February 2005. His local living cost including tuition fees etc., was given by the concerned Institution in Canada. International air-fare cost was given by the applicant himself.
- Dr Uttam Kumar Mandal, (Scientist, CRIDA, Hyderabad) visited for availing Israel Government Scholarship at Hebrew University for 8 months w.e.f. 8 November 2005 to 8 July 2006. His local living cost including tuition fees etc., was given by the concerned Institution in Canada. International air-fare cost was given by the applicant himself.
- Dr (Ms.) Kamla Venkateswaran, (Senior Scientist, NBPGR, New Delhi) visited Thailand to attend 2 weeks training programme on "Plant Genetic Diversity Analysis and Molecular Marker Assisted Breeding" at Kasetstart University, Thailand from 20 May to 4 September, 2005. Her entire deputation cost including both ways international air-fair was given by the Generation Challange Programme (GCP) i.e. Organizer of the Course.
- Shri P Hertwin Amala Dhas, (Scientist, SRS of NDRI, Bangalore) visited for Higher studies leading to Ph.D. programme in the subject "Agricultural and Biosystems Engineering" at University of Nebraska-Lincoln, USA for 3 years w.e.f. 15 August, 2005.

His local living cost including tuition fees etc., will be borne by the concerned Institution in USA; and International air-fare cost was given by the applicant himself.

- Dr B K Das (Senior Scientist, CIFA, Bhubaneshwar) visited for availing Biotechnology Overseas Associateship (Long-term) award at Marine Laboratory, Scotland, UK for 12 months w.e.f. 16 November 2005. His entire deputation cost including both ways international air-fare was given by the Department of Biotechnology, New Delhi.
- Dr Parveen Singh [(Scientist, (SS), IVRI, Izatnagar, Uttar Pradesh)] visited for availing of JSPS Post-doctoral Fellowship at Kyushi Unversity, Japan for 24 months w.e.f. 1st week of September, 2005. His all expenses including international air-fare was given by the Fellowship Organizers.
- Dr M Sarkar [(Scientist (SS), NRC for Yak, Dirang, Arunachal Pradesh)] visited to attend training course on 'Embro Transfer Technology and Andrology' in China w.e.f. 25 August 2005 for 1 month under INSA's Bilateral Exchanges of Scientists Programme. His local living cost was given by host academy in China. International air-fare was given by the applicant himself.
- Dr K K Pal, [(Scientist, (Sr. Scale), NRC on Groundnut, Junagadh, Gujarat)] visited USA to avail Department of Biotechnology sponsored Biotechnology Overseas Associatship (long-term) Award at Ohio State University, Wooster, USA for 12 months w.e.f. 16 November 2005. His entire deputation cost including both ways international air-fare was given by the Department of Biotechnology, New Delhi.
- Dr I Prince Devadasan, (Scientist, NRC on Meat, Hyderabad) visited USA for availing Post-doctoral Fellowship in the area of Muscle biology at University of Texas Medical Branch, Galveston, Texas, USA for 2 years w.e.f. October 2005. His all expenses including air-fare was given by the Fellowship Organizers.
- Dr S Ayyappan [(Deputy-Director-General, (Fy.), ICAR, New Delhi)] visited for participation in Executive Programme entitled "Science and Technology and in fermentation Policy at Jobn G. Kennedy School of Government, Harvard University Massachusetts, USA from 27 November to 2 December 2005. His all deputation cost including air-fare met under HRD training Plan Budget of ICAR, (Hq), New Delhi.
- Dr P K Krishnakumar (Senior Scientist, CMFRI, Research Centre, Mangalore) visited for participation in the training-cum-workshop on Food Security in Hiroshima, Japan from 26 to 30 September 2005. His all deputation cost including air-fare was given by the Training Organizers.
- Dr Suresh Walia (Principal Scientist, IARI, Pusa, New Delhi) will go to attend training in UK from 20 March to 17 June 2006 under INSA's Bilateral Exchange of Scientists Programme with foreign Academies. His local living cost abroad was given by the host Academy concerned and International air-fare by the applicant.
- Dr Sunil Kumar (Senior Scientist, IGFRI, Jhansi) visited Israel to attend training on Agriculture and Environment Process and practical in soil and water at CINADCO, Israel from 8 to 29 November 2005. His local living cost was given by the Training Organizer and air-fare by the applicant.
- Dr Uma Rao (Senior Scientist, IARI, New Delhi) visited UK for availing short-term course of Department of Biotechnology, "Biotechnology Overseas Associateship award, 2004–05" at the University of Leeds, U K, from 6 January to 5 June 2006. Her entire deputation cost including air-fare was given by Department of Biotechnology.
- Dr Rajender Kumar (Senior Scientist, NRC on Equines, Hisar), visited Japan to attend training course on "Molecular Diagnosis Protozoa Diseases" at University of Agriculture and Veterinary Medicine, Obhiro, Hokkaido, Japan from 10 January to 23 February 2006. His entire deputation cost including air-fare was given by the Organizers of the programme.
- Dr B P Mohanty, [Scientist, Senior, Scale, CIFRI, Barrackpore, Kolkata (West Bengal] visited for availing Department of Biotechnology's short-term 'Biotechnology Overseas Associateship award, 2004–05' at the University of Aberdeen, U K for 6 months w.e.f. January 2006. His entire deputation cost including air-fare was given by Department of Biotechnology
- Dr S Ayyappan [(DDG (Fisheries), ICAR] and Dr H S Nainawatee, [ADG (HRD-II), ICAR] visited China from 28 March to April 2005. As a member of Indian delegation led by Hon'ble Agriculture Minister for exchanging successful experiences in agricultural development of the 2 countries and for identifying priorities for agricultural co-operation so as to contribute to the common effort in promoting the continuous development of agriculture.
- Dr Mathura Rai, (Director, IIVR, Varanasi) visited to Argentina from 2 to 14 May 2005 for participation in the "The Asia and Near-East Regional Workshop.
- Dr K C Bansal (Professor and Principal Scientist, NRC on Plant Biotechnology, IARI, New Delhi) visited to Argentina from 19 to 20 May 2005 as a member of Indian delegation of Department of Science and Technology to participate in the Indo-Argentine joint Workshop followed by visit to Research and Development institutions.
- Dr M Sujatha (Senior Scientist, DOR, Hyderabad) visited Novi Sad, Serbia and Montenegro from 17 to 22 July 2005. He was nominated to attend the FAO consultation meeting on Sunflower including visit to the wild species nurseries (Annual and Perennial species).

- Dr Beche Lal (Principal Scientist, NBPGR, New Delhi) visited Japan from 11 to 15 July 2005 as a member of an Indian delegation of Department of Agriculture and Co-operation to discuss phytosanitary issues related to the export of Indian mangoes to Japan.
- Dr Ratan Tiwari, (Senior Scientist, Directorate of Wheat Research, Karnal) was deputed at the University of Zurich, Switzerland for 2 months, from 15 September to 15 November, 2005 for research work relating to Indo- Swiss Collaboration in Bio-technology project on "Enhancing genetic resistance against stripe and leaf rust using molecular markers in wheat adopted to the moisture stress raising".
- Dr M Kochu Babu, (Director, NRC on Oilpalm, Pedavegi) visited Malaysia from 25 to 29 September 2005 for participation in the Malaysian Palm Oil Board International Palm Oil Congress (PIPOC).
- Dr R P Nachane (Principal Scientist, CIRCOT, Mumbai) visited Liverpol, U K from 25 to 29 September as a member of Indian delegation for the 64th Plenary meeting of the International Cotton Advisory Committee (ICAC) and to present a research paper.
- Dr J S Samra, [(DDG (NRM), ICAR)] visited Nairobi, Kenya from 3 to 7 October 2005 for participation in the 3rd World Congress on "Conservation Agriculture" and to bid for holding of the 4th World Congress on Conservation Agriculture in 2007 in India to showcase achievements realized in the India to steer leadership in Asia.
- Dr M S Sahani, (Director, NRC on Camel, Bikaner), visited Saudi Arabia from 22 to 24 November 2005 for participation in the International Scientific Conference on Camels.
- Dr R K Chowdhury [OSD, Directorate of Seed Research, Mau (Uttar Pradesh)], visited Shanghai, China, from 7 to 10 November 2005 for participation in the Asian Seed Congress including APSA-UPOV workshop.
- Dr C.P.R. Nair, (Head, CPCRI Regional Station, Kayangulam) was deputed for attending second Annual Review Meeting and Mid-term Review of the CFC/DFID/APCC/FAO project on 'Coconut Integrated Pest Management' held in Sri Lanka from 13 to 16 December, 2005.

# 7. Agricultural Scientists' Recruitment Board

**Direct recruitment**

The period 2005–2006 has been a year of transformation leading to major reforms in recruitment/assessment procedures and guidelines. Some of the major initiatives undertaken and achievements made are briefly described.

- The Board focussed on recruitment and adopted a more proactive and strategic approach
- Merit remained central to the recruitment strategy
- Recruitment and examination reforms initiated
- While maintaining transparency, the Board geared itself for undertaking responsiveness to the newly implemented Right to Information Act, 2005 of Govt. of India
- The Board also planned to undertake a major renovation of its physical facilities and modernization of the infrastructure

### *Introduction of revised scorecard*

The existing scorecard system was modified to bring greater objectivity and transparency in the selection process. The weightage given to past performance varies from 60% the level of Senior Scientist to only 40% at the level of Director/Deputy Director-General, with remaining marks being allocated to personal interview. Further, weightage given to academic record or publication etc. is kept higher for scientific positions, whereas institution – building activities are given higher weightage for research management positions. The revised scorecard system has been put to test in more than 200 senior positions since April 2005.

### *Revision of guidelines for career advancement (from senior scientist to principal scientist)*

A thorough revision of the exiting guidelines for assessment has been undertaken to remove the certain ambiguities in the assessment process and emphasis on different performance parameters has been made more rational.

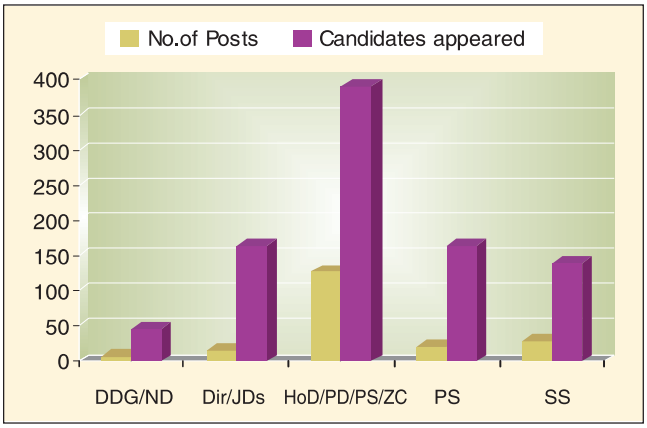
### *Simplification of application form for direct recruitment*

The existing application form has been revised to make it simple. The revised form seeks information from the candidates in tune with the revised scorecard system.

Direct recruitment by interview is made for filling up vacancies that are not covered through the regular examinations conducted by the Commission. The process of recruitment by interview starts with the receipt of a requisition from the Indian Council of Agricultural Research(ICAR). 2005–06 has also been the year during which a record number of positions, both at senior and middle levels, have been filled through direct recruitment.

**Recruitment through interview**

1. The Board completed the recruitment process for 213 posts which were advertised vide advertisement No. 1/2003, 2/2003, 3/2003, 1/2004 and 1/2005. In addition, the board also advertised 174 vacancies in three advertisements vide advertisement No. 2/2005, 3/2005 and 4/2005. Recruitment process for the 49 posts advertised vide Adv. No. 2/2005 would be completed by February 2006. Thus a record number of posts has been filled during this year.
2. There were, on an average, 9 applications per post for RMP and 4 applications for other positions for which recruitments were made during 2005–2006. From the chart given below, it is observed that the number of applicants per post is more for Research Management Positions.




Applicant to post ratio for direct rec. posts

3. The Board had to withdraw/re-advertise 39 posts due to modification in essential qualifications.

**Assessment/promotion of scientists under career advancement scheme**

The assessment process in respect of 135 Scientists for promotion from Senior Scientists to Principal Scientists was completed and the results were communicated to the ICAR.

**Examination**

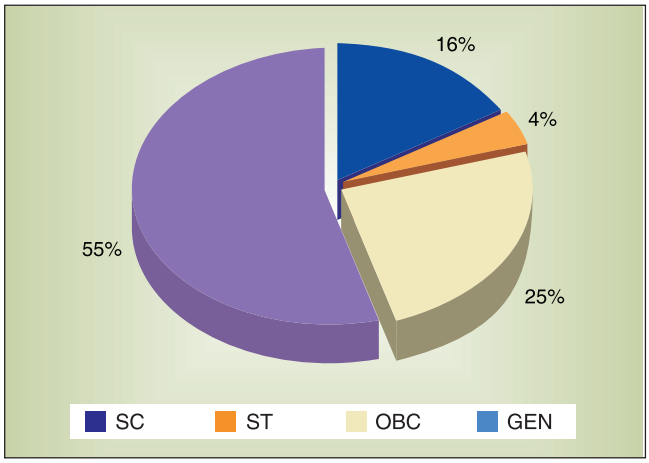
Examination reforms were initiated based on the studies on diverse aspects of process of examinations.

**Rationalization of ARS/NET**

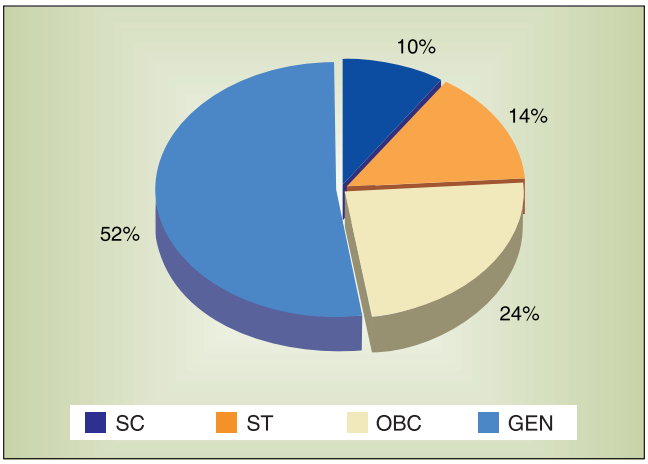
The ASRB at present conducts Agricultural Research Service (ARS)/National Eligibility Test (NET) examination in about 69 disciplines with very narrow fields of specialization, whereas the State Agricultural Universities/General Universities in most cases do not award M.Sc. degrees in those specialized fields. Further narrow fields of specialization also reduces the number of eligible candidates at entry level. Keeping this in view, a committee of eminent scientists has been constituted to deliberate on this issue and to develop appropriate recommendations.

**Recruitment by examination**

- The ARS/NET Examination 2003 was conducted by the Board in June 2004 at 32 centres across India. The total number of candidates applied for the examination were 20,676 and the total candidates appeared in the examination were 11,696. The result for appointment as Scientists in the Agricultural Research Service was declared on 17 November 2004 for 21 posts (SC 2, ST 3, OBC 5 and General 11).
- The result of NET Examination -2003 conducted by the Board in June 2004 for appointment of candidate as Assistant Professor/ Lecturer in State Agricultural Universities was declared on 23 February 2005. A total of 6,386 candidates qualified the National Eligibility Test (SC 1,048, ST 269, OBC 1,571 and General 3,498).
- The ARS/NET examination was held on 12 February 2006. The examination was conducted at 32 centres for 20,885 candidates. There are 160 vacancies in ARS.
- The Board conducted an Open Competitive Examination for recruitment of six posts of Administrative Officers at six centres of India during 27–29 December 2004. The total number of candidates applied for the examination was 3,489.
- The result of ICAR Audit and Accounts examination conducted by the Board in November 2003 was declared on 20 February 2004. 55 candidates passed the examination.




Candidates qualified for NET Exam-2003




Candidates qualified for ARS Exam-2003

- The limited Departmental Competitive Examination for recruitment of 2 posts of Stenographer Grade II at the ICAR Hqrs was conducted by the Board on 1 March 2005.Out of 28 candidates, 17 candidates appeared in the examination.

**Other activities**

- All the advertisements issued by the Commission for the posts and services were prepared and published both in Hindi and English simultaneously in the leading newspapers of the country including "Rozgar Samachar".
- The Board also prepared a bulletin to cover the various aspects of the Right to Information Act, 2005 as applicable to ASRB.

# 8. Publications and Information

The primary task of the Indian Council of Agricultural Research is to conduct research in the fields of agriculture, animal sciences, fisheries and allied subjects through a network of its Institutes National Research Centres/Project Directorates/All India Co-ordinated Research Projects which are spread all over the country. The results of research are disseminated to farmers, students, research scholars, scientists, extension workers for their benefit through the publications brought out by the Directorate of Information and Publications of Agriculture (DIPA).

The DIPA brings out various research journals, periodicals, textbooks, technical books, monographs, technical bulletins, newsletters and brochures in a lucid and popular style both in English and Hindi languages.

In addition, it also provides latest information on the title of publication, author's name, abstracts appeared in the journals, periodicals, books etc. on the ICAR website icar@org.in.

The Directorate also co-ordinates with the Heads of the Subject Matter Divisions in compilation of the manuscripts of the *DARE/ICAR Annual Report*, preparation of the brochure, viz. *ICAR – At a Glance*, *Highlights of the AP Cess Fund*, preparation of the textbooks under AHRD Programme of Education Division, National Agricultural Innovative Projects, ATIC bodies of the ICAR institutes etc.

In the era of Information Technology Revolution, DIPA's electronic connectivity provided one more channel for mass communication with a large number of ICAR Institutes, National Research Centres, State Agricultural Universities, Central Agricultural University, All India Co-ordinated Research Projects spread all over the country. In this endeavour, the DIPA has developed compact discs on on-going projects of the ICAR institutes.

Besides, the Directorate of Information and Publications of Agriculture participates in *Kisan Melas*, Book Fairs organized by the national and international agencies. This gives an opportunity to the farmers to get first hand information on the major breakthrough in agriculture/animal science/and allied subjects.

**English Editorial Unit**

During 2005-06, this unit brought out 40 publications in English. Some of the important publications were 5th revised and enlarzed edition of *Handbook of Agriculture*, *Monograph* on *Papaya*, *Cacti–Botany, Culture and Uses*, *Principles of Animal Nutrition and Nutrient Dynamics*, etc. Besides *DARE/ICAR Annual Report 2005-06*, *ICAR-At a Glance*, and a number of miscellaneous publications, viz. *Annual Plan*, *Report on NAIP*, *Highlights of AP Cess Fund*, *International Training Programme*, etc. were also brought out on time. This unit also brought out speeches of Minister of Agriculture, Secretary(DARE) and DG(ICAR), Additional Secretary(DARE) and Secretary(ICAR) as a time-bound work.

The Directorate of Information and Publications of Agriculture brought out 2 research journals, viz., *The Indian Journal of Agricultural Sciences and The Indian Journal of Animal Sciences* which have been indexed internationally (AGRIS, *Science Citation Index*, *Current Contents*). Both the journals brought out Review Research Papers on specific topics during their 75th year of publications and all the issues were on time. This unit got privilege to increase frequency of its periodical, *Indian Horticulture* from quarterly to bimonthly in the interest of progressive farmers, students, research scholars, etc. The *Indian Horticulture* brought out one dedicated issue on Sub-Tropical Fruits for Nutritional and Livelihood Security for CISH and all the issues were brought out on time.

During the reported period, the *Indian Farming*, a semi-technical monthly periodical brought out special issue on 'Agriculture and Intercultural Dialouge' on the occasion of World Food Day and one issue dedicated to Cotton Technology (CIRCOT) in February 2006, and all the issues were on time. Besides 2 quarterly periodicals, viz. *ICAR News* and *ICAR Reporter* were brought out on time. *The ICAR News*, a newsletter, covered the activities of the ICAR(headquarters) and the ICAR Research

Some of the important English books brought out by the DIPA

Institutes/Centres/SAU's etc. It disseminated information relating to promising technologies, and new crop varieties developed at the ICAR Institutes/Centres/SAU's etc. It also included profiles of the ICAR Institutes/Centres. The *ICAR Reporter*, an in-house periodical, has got a new look during the reported period, and covered reports of all important events that took place at the ICAR(headquarters) and within the ICAR system. It covered meetings, workshops, at national and international seminars, conferences etc. Under the international linkages, the Memoranda of Understandings/Work Plans signed between the ICAR and international bodies were also covered.

This Unit has got a software that has joined all the contributors of the *Indian Journal of Animal Sciences* through *icar@org.in*. As and when a contributor opens this website, he finds the names of journals/periodicals and may again click to know the present status of his research paper on the computer screen. This software is also being used in other journals and periodicals.

**Hindi Editonal Unit**

Hindi Editorial Unit plays a vital role in dissemination of agricultural information to farmers, extension workers, students and scientists by publishing regular periodicals, books, reports, etc. in Hindi. These publications are getting wide appreciation from the users for their quality and contents.

During the period under report, Hindi Editorial Unit brought out more than a dozen publications, monographs and reports in addition to its regular periodicals, viz. *Kheti* (monthly), *Phal Phool* (bimonthly), *Krishi Chayanika* (quarterly) and ICAR Reporter (quarterly). This Unit is also shouldering the responsibility of publication of Hindi version of speeches of Minister of Agriculture, State Minister of Agriculture, DG, ICAR and other dignitaries as and when required. Hindi version of documents related to AGM and GB are also prepared in the Unit.

*Kheti* and *Phal Phool* are popular magazines, which cater to the needs of farmers and students. *Kheti* publishes articles related to agriculture and allied vocations such as animal husbandry, beekeeping, agricultural engineering, forestry, etc. while *Phal Phool* publishes articles pertaining to fruits, vegetables, spices and medicinal plants. In the light of recent development and shift in the priorities, various new topics are being covered in the periodicals such as processing of crop products, value addition, marketing and use of renewable sources of energy in agriculture.

Some of the important Hindi books brought out by the DIPA

*Krishi Chayanika*, an informative agriculture digest, publishes information on the latest achievements/researches carried out in India and abroad in its columns. Latest agricultural information available on various websites of international agricultural organizations and the information for the cultivation of medicinal and aromatic plants are also included in its regular columns.

During the year, *Kheti* brought out 4 special accent numbers, viz. Fresh Water Aquaculture (April 2005); World Food Day (October 2005); Animal Husbandry (August 2005) and Cotton Technology (March 2005). It also initiated new columns for the benefit of farmers.

Due to increasing popularity of the journal *Phal Phool* (quarterly), it was decided to publish it bimonthly from January 2006 onwards. *Phal Phool* brought out accent issues on the theme of vegetable cultivation and flowers during the year.

A special issue of *Krishi Chayanika* (October–December 2005) was published on the exclusive theme of onion and garlic cultivation.

In addition to DARE/ICAR Annual Report (2005–06), the Hindi Editorial Unit brought out 6 books such as *Phal Vigyan*, *Khatta Neembu*, *Barani Shetron mein jal Prabandh*, *Machlion mein rog Prabandh*, *Lokoktiyon mein dhartiya Krishi our Pariwar*, *Vaigyanik Vidi Se Ganne ki Kheti*, among miscellaneous publications, Hindi versions of following publications were brought out. Sabbatical leave rules, Visiting scientists'/Experts' scheme, Discipline of Agricultural Research Service Examination, Consolidated instructions on forwarding of applications of employees of ICAR, Rules and Bye-laws of the ICAR Society.

**Production Unit**

The Production Unit plays a key role in the administrative planning, management and execution of the publication programme in DIPA. It is primarily responsible for management of all the aspects of printing and publishing books and journals, including time-bound publications for the headquarters of the Council.

The major activities of Production Unit focus on the management of printing of Council's publications/journals; maintaining close liaison with Editorial, Art and Business Units. The unit examines the technical aspects of paper quality and processes it for procurement. It is responsible for proper utilization of printing paper and for certification of its consumption.

All the monthly journals (3 in English and 1 in Hindi) were printed well in time maintaining the desired print quality. The

Council's prestigious quarterly newsletter *ICAR News*, *ICAR Reporter* were printed well in time using the state-of-art print technology to achieve the desired print quality, catering to the needs of national and international readership. Besides, 48 publications in English and 15 in Hindi were printed maintaining the high class print standards and holding the schedule in time.

The Unit is also assigned the responsibility of printing important annual publications of the Council such as speeches of the Union Agriculture Minister and the DG, ICAR for AGM of ICAR Society, DARE/ICAR Annual Report in English and Hindi, Agenda Notes, ICAR Budget Book, etc. The time-bound publications/certificates/ citations/invitation cards meant for the ICAR Award Ceremony and Hindi Puruskar Vitaran were also printed with desired quality within a short-time.

During the period, some of the selected important publications brought out in English were: *Handbook of Agriculture*, *Monograph*


The journals, semi-technical magazines and newsletters brought out by the DIPA during 2005–2006

*on Papaya*, *Cacti-Botany*, *Culture and Uses*, *Principles of Animal Nutrition and Nutrient Dynamics*. *Some Hindi Publications i.e. Rajbhasha Alok*, *Poster for Hindi Chetna Week* etc.. 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 course curricula and bulletins. For Hindi section of the Council, various certificates and citations were designed and produced in Hindi. The production unit also looks after the electronic production processes of DIPA. Under revenue generating scheme for DIPA, Production Unit has produced publications of State Agricultural Universities maintaining desired quality standard. The unit is consistently adopting and implementing the modern printing techniques. In this process, the unit has adopted CtP (Computer to Plate) technology for printing of the ICAR News/Reporter, a high quality publications of ICAR. The staff of the Unit was also trained for enhancing their production capabilities. The unit has provided training to the students of Polytechnic in the area of Advanced Production Techniques.

### *Art and Photography Unit*

The Art Unit prepared cover designs, Illustrations and line-drawings for text books, research journals and newsletters and other miscellaneous publications. The new masthead for *ICAR News* and *ICAR Reporter* (house-journals) were also prepared by Art Unit.

Photo Unit of DIPA covered all the important activities of the Council, viz Press Conferences of Minister of Agriculture, Minister of State for Agriculture, Secretary(DARE) and DG(ICAR); supply of photographs for press releases and supply of colour transparencies, photographs (colour and black-and-white) to various books, brought out by the ICAR in English and periodicals. Photographs


Sitting on the dias are: Smt Sushama Nath, Secretary (ICAR), Dr Mangala Rai, DG (ICAR), Shri Sharad Pawar, Union Agriculture Minister and Dr Rita Sharma, Financial Adviser

were also provided for cover pages of books, brochures brought out by the ICAR in English and Hindi. Besides, this unit covered visits of foreign dignitaries, signing of Memoranda of Understanding, Protocols, Workshops, Seminars, Convocations, Training Courses, etc. The Photo Unit provided slides and other visual support to Secretary(DARE) and DG(ICAR), DDG's and other scientists of the Council to disseminate information with visual effect in national and global seminars, meetings, etc.

### Business Unit

During the period from April 2005 to January 2006, the Business Unit earned a total revenue of more than Rs 4 million by way of sale of publications including the revenue generated by advertisements tariff in the ICAR publications. To generate revenue, new price policy was adopted in journals as well as books.

With a view to multiplying the sale of ICAR publications, new marketing strategies were adopted while putting up book display-

cum-sale counters at *Kisan Melas* and organizing book exhibitions at the State Agricultural Universities and other Book Fairs in different parts of the country. Apart from participating in routine events, the Business Unit participated in Book Fairs at the Indian International Trade Fair, from 14 to 27 November 2005, World Book Fair, New Delhi from 27 January to 4 February 2006. At the above fairs, the response for the ICAR publications was overwhelming from the public. Public-folder and new price list were also brought out which were distributed to the visitors.

Children are curiously looking at the exhibits in the animal section of the Vigyan Rail Science Exhibition in New Delhi

**Agricultural Research Information Centre and DIPA Library**

During 2005-2006, this unit collected and processed information on A P Cess Fund Schemes, Research Projects of ICAR Institutes (RPFs), All India Co-ordinated Research Projects (AICRPs), National Agricultural Research Database. Selective Dissemination of Information (SDI) and Document Delivery services were provided to about 80 scientists, research scholars and students.

This Unit has co-ordinated the activities of the development of National Agricultural Research Database of all the ICAR Institutes and SAUs working as data input centres for this database. This database covered the bibliographical details of all research information published in India in agriculture and its allied sciences. DIPA has procured information on 5,000 inputs and added this information to the NARD. The 3 issues of Abstract Journals, viz *The Indian Agricultural Science Abstracts* and *The Indian Animal Sciences Abstracts* were published from this database. Besides, this Unit has brought out *ARIS News* (Half-yearly) and Directory of Conferences, Seminars, Symposia, Workshops in Agriculture and Allied Sciences (Half-yearly) were also brought out. ARIC has compiled and co-ordinated the information for ICAR Telephone Directory 2006 for printing, and same information is made availabe in ICAR *website: www.icar.org.in*. This Unit has indexed 2000 bibliographic inputs from Indian Agricultural Periodicals and submitted to Food and Agriculture Organization for inclusion in AGRIS database.


E-publications brought out by the DIPA

ARIC scrutinized about 650 *ad-hoc* research proposals received from different subject-matter disciplines to avoid the duplication of research efforts. These proposals were checked from the database of sanctioned ad-hoc schemes available at this centre. Web page of DIPA was updated with the free text search facilities for books, journals, *ad-hoc* schemes. Full text issues of ICAR News and ICAR Reporter were also included. This unit is maintaining the Local Area Network (LAN) of Krishi Anusandhan Bhawan (KAB-I) and assisting in intenet/e-mail services to all the users of KAB-I.

**DIPA Library**

The DIPA library received about 361 books, periodicals, Annual Reports of the ICAR Institutes and State Agricultural Universities and provided reference services to the scientists, students and DIPA staff.

# 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 of 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 | 22,400 – 24,500 | 1 |
| A | Financial Adviser and Additional Secretary | 22,400 – 24,500 | 1 |
| A | Deputy Secretary | 12,000 – 16,500 | 2 |
| A | Senior Principal Private Secretary | 12,000 – 16,500 | 1 |
| A | Under Secretary | 10,000 – 15,200 | 7 |
| A | Principal Private Secretary | 10,000 – 15,200 | 1 |
| B | Assistant Director (Official Language) | 7,500 – 12,000 | 1 |
| B | Private Secretary | 6,500 – 10,500 | 1 |
| B | Section Officer | 6,500 – 10,500 | 4 |
| B | Assistant | 5,500 – 9,000 | 4 |
| B | Personal Assistant | 5,500 – 9,000 | 2 |
| C | Junior Hindi Translator | 5,500 – 9,000 | 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 | 7 |
| 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 | 2,610 – 4,000 | 1 |
| D | Peon | 2,550 – 3,200 | 5 |
| | Total | | 48 |

### Names of the Important Functionaries

| S.No. | Name | Designation |
|---|---|---|
| 1. | Dr Mangala Rai | Secretary, DARE/DG, ICAR |
| 2. | Ms Sushama Nath | Additional Secretary, DARE/Secretary, ICAR |
| 3. | Dr Rita Sharma | Additional Secretary/Financial Adviser, DARE |
| 4. | Mr Rajiv Kumar Jain | Deputy Secretary |
| 5. | Mr Ram Avtar | Deputy Secretary |
| 6. | Mr R S Bhandari | Senior Principal Private Secretary |
| 7. | Mr G Chandra Sekhar | Under-Secretary |
| 8. | Mr Roopak Chaudhuri | Under-Secretary |
| 9. | Ms Vandana Sharma | Under-Secretary |
| 10. | Mr B J Bhattacharya | Under-Secretary |
| 11. | Mr Madan Lal | Under-Secretary |
| 12. | Mr D K Chhatwal | Under-Secretary |
| 13. | Ms Geeta Nair | Principal Private Secretary |

## APPENDIX III

## ACTIVITY PROGRAMME CLASSIFICATION

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2004–2005 are Rs 1,753.31 crores and Rs 1,675.00 crores respectively and BE for 2005–2006 (Plan and Non-Plan) is Rs 1,942.00 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 2004–2005 and BE for 2005–2006 are given in Table 1. This excludes the payment to the ICAR.

**Table 1 Budget estimates and revised estimates of DARE**

(Rupees in lakhs)

| Item | Budget Estimates 2004–2005 | | Revised Estimates 2004–2005 | | Budget Estimates 2005–2006 | |
|---|---|---|---|---|---|---|
| | Plan | Non-Plan | Plan | Non-Plan | Plan | Non-Plan |
| Major Head '3451' | | | | | | |
| 090 Secretariat | | | | | | |
| Major Head '2415' | – | 125 | – | 125 | – | 145 |
| 80 -General | | | | | | |
| International Co-operation | | | | | | |
| (010032) -India's membership contribution to Commonwealth Agricultural Bureau | – | 10 | – | 10 | – | 10 |
| (020032) -India's membership contribution to Consultative Group on International Agricultural Research | – | 342 | – | 342 | – | 355 |
| (030032) -Other Programmes | 50 | – | 50 | – | *45.50 | – |
| (040032) -India's contribution to Asia Pacific Association of Agricultural Institutions | – | 5 | – | 5 | – | 5 |
| (050032) -India's contribution to NACA | – | 12 | – | 12 | – | 12 |
| (060032) -India's contribution to CGPRT | – | 5 | – | 5 | – | 5 |
| (070032) -India's contribution to Seed Seed Testing Association | – | 1.65 | – | 1.65 | – | 2.25 |
| (080032) -ISHS Belgium | – | 0.35 | – | 0.35 | – | 0.75 |

*Includes Rs 45 crore for National Fund for basic and strategic research in agriculture.

## Table 2 Details of Financial Outlay

### Demand No. 2. Department of Agricultural Research and Education

(Rupees in crores)

| | Major Head | 2004–2005 Budget | | | 2004–2005 Revised | | | 2005–2006 Budget | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Plan | Non-Plan | Total | Plan | Non-Plan | Total | Plan | Non-Plan | Total |
| A.Budget Allocation, net of recoveries | | | | | | | | | | |
| Revenue | | 1,000.00 | 753.31 | 1,753.31 | 900.00 | 775.00 | 1,675.00 | 1,150.00 | 792.00 | 1,942.00 |
| Capital | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | | 1,000.00 | 753.31 | 1,753.31 | 900.00 | 775.00 | 1,675.00 | 1,150.00 | 792.00 | 1,942.00 |
| 1. Secretariat - Economic Service Agricultural Research and Education Payments to ICAR | 3451 | 0.00 | 1.25 | 1.25 | 0.00 | 1.25 | 1.25 | 0.00 | 1.45 | 1.45 |
| 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 | | | | | | | | | | |
| 2.2.01 Crop Sciences | 2415 | 179.00 | 180.60 | 359.60 | 155.72 | 183.60 | 339.32 | 189.00 | 190.00 | 379.00 |
| 2.2.02 Horticulture | 2415 | 75.00 | 66.10 | 141.10 | 66.00 | 66.60 | 132.60 | 79.00 | 69.50 | 148.50 |
| 2.2.03 Agricultural Extension | 2415 | 160.00 | 0.60 | 160.60 | 152.46 | 0.65 | 153.11 | 230.00 | 0.75 | 230.75 |
| 2.2.04 Agricultural Education | 2415 | 106.00 | 4.25 | 110.25 | 97.00 | 4.25 | 101.25 | 177.00 | 5.20 | 182.20 |
| 2.2.05 Economics, Statistics and Management | 2415 | 5.00 | 11.75 | 16.75 | 4.00 | 11.86 | 15.86 | 4.50 | 12.50 | 17.00 |
| 2.2.06 Agricultural Engg. | 2415 | 28.00 | 22.50 | 50.50 | 24.50 | 22.55 | 47.05 | 30.00 | 23.50 | 53.50 |
| 2.2.07 ICAR Hq Admn. including ASRB and DIPA | 2415 | 5.00 | 180.00 | 185.00 | 3.00 | 189.48 | 192.48 | 3.82 | 190.00 | 193.82 |
| 2.2.08 National Agril. Technology Project | 2415 | 127.29 | 0.00 | 127.29 | 126.61 | 0.00 | 126.61 | 60.00 | 0.00 | 60.00 |
| 2.2.09 Agril. Human Res. Dev. | 2415 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.2.10 Indo-Dutch Network ORP on Drainage and Water Salinity Control in Canal commands | 2415 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.2.11 Indo-French Proj. on Seabass Breedings and Culture | 2415 | 1.21 | 0.00 | 1.21 | 1.21 | 0.00 | 1.21 | 1.18 | 0.00 | 1.18 |
| Total other Programme of Crop Husbandry | | 686.50 | 465.80 | 1,152.30 | 630.50 | 478.99 | 1,109.49 | 774.50 | 491.45 | 1,265.95 |
| Total Crop Husbandry | | 686.50 | 505.80 | 1,192.30 | 630.50 | 518.99 | 1,149.49 | 774.50 | 531.45 | 1,305.95 |
| 3. Soil and Water Conservation | | | | | | | | | | |
| 3.1 Soil and Water Conservation Institutes | 2415 | 4.50 | 10.70 | 15.20 | 4.00 | 10.70 | 14.70 | 4.50 | 11.20 | 15.70 |
| 3.2 Other NRM Instts. including Agroforestry Research | 2415 | 76.50 | 65.30 | 141.80 | 68.00 | 68.30 | 136.30 | 76.50 | 69.00 | 145.50 |
| Total- Soil &Water Conservation | | 81.00 | 76.00 | 157.00 | 72.00 | 79.00 | 151.00 | 81.00 | 80.20 | 161.20 |
| 4. Animal Husbandry | 2415 | 95.00 | 112.20 | 207.20 | 75.00 | 114.20 | 189.20 | 95.00 | 118.00 | 213.00 |
| 5. Dairy Development | 2415 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6. Fisheries | 2415 | 37.00 | 54.30 | 91.30 | 32.00 | 57.80 | 89.80 | 39.00 | 57.00 | 96.00 |
| 7. Forestry | 2415 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8. Lump-sum provision for Projects/ Schemes for the benefit of North-Eastern Region and Sikkim | 2552 | 100.00 | 0.00 | 100.00 | 90.00 | 0.00 | 90.00 | 115.00 | 0.00 | 115.00 |
| Total-Payments to ICAR | | 999.50 | 748.30 | 1,747.80 | 899.50 | 769.99 | 1,669.49 | 1,104.50 | 786.65 | 1,891.15 |
| 9. Contribution to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institutes | 2415 | 0.50 | 3.76 | 4.26 | 0.50 | 3.76 | 4.26 | 45.50 | 3.90 | 49.40 |
| 10. Total-Agricultural Research and Education | 2415 | 1,000.00 | 752.06 | 1,752.06 | 900.00 | 773.75 | 1,673.75 | 1,150.00 | 790.55 | 1,940.55 |
| Grand Total | | 1,000.00 | 753.31 | 1,753.31 | 900.00 | 775.00 | 1,675.00 | 1,150.00 | 792.00 | 1,942.00 |

| | Major Head | 2004–2005 Budget | | | 2004–2005 Revised | | | 2005–2006 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. Investments in PSEs | | | | | | | | | | |
| 1. Indian Council of Agricultural Research | 2415 | 0.00 | 42.11 | 42.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C. Plan Outlay | | | | | | | | | | |
| 1. Agricultural Research Education | 2415 | 1,000.00 | 42.11 | 1,042.11 | 900.00 | 0.00 | 900.00 | 1,035.00 | 0.00 | 1,035.00 |
| 2. North-eastern Areas | 2552 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 115.00 | 0.00 | 115.00 |
| | Total | 1,000.00 | 42.11 | 1,042.11 | 900.00 | 0.00 | 900.00 | 1,150.00 | 0.00 | 1,150.00 |
| D. Major Head-wise Total | | | | | | | | | | |
| Grand Total | | 1,000.00 | 753.31 | 1,753.31 | 900.00 | 775.00 | 1,675.00 | 1,150.00 | 792.00 | 1,942.00 |
| | 2415 | 900.00 | 752.06 | 1,652.06 | 810.00 | 773.75 | 1,583.75 | 1,035.00 | 790.55 | 1,825.55 |
| | 3451 | 0.00 | 1.25 | 1.25 | 0.00 | 1.25 | 1.25 | 0.00 | 1.45 | 1.45 |
| | 2552 | 100.00 | 0.00 | 100.00 | 90.00 | 0.00 | 90.00 | 115.00 | 0.00 | 115.00 |
| | 4552 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

## 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 Sharad Pawar
   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 (Agriculture)
   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 P Chidambaram
   Minister of Finance, Government of India
   North Block, New Delhi 110 001
4. Mr M V Rajasekharan
   Minister of State for Planning
   Yojana Bhawan, Government of India
   New Delhi 110 001
5. Mr Kapil Sibal
   Minister of Science & Technology, and
   Human Resource Development
   Government of India, Shastri Bhawan
   New Delhi 110 001
6. Mr Arjun Singh
   Minister for Human Resources
   Government of India
   New Delhi 110 001
7. Mr Kamal Nath
   Minister of Commerce,Government of India
   Udyog Bhawan, New Delhi 110 001

(iv) *Other Ministers in the Union Ministry of Agriculture*

8. Mr Kanti Lal Bhuria
   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. Dr Y S Rajasekhar Reddy
   Chief Minister holding charge for Horticulture
   Government of Andhra Pradesh
   Hyderabad (Andhra Pradesh) 500 022
10. Mr N Raghuveera Reddy
    Minister of Agriculture
    Government of Andhra Pradesh
    Hyderabad
    (Andhra Pradesh) 500 022
11. Mr Fareeduddin Mohammed
    Minister of Fisheries
    Government of Andhra Pradesh
    Hyderabad (Andhra Pradesh) 500 022
12. Mr Suryarao Gollapalli
    Minister for Animal Husbandry and Dairy Development
    Government of Andhra Pradesh
    Hyderabad (Andhra Pradesh) 500 022

**Arunachal Pradesh**

13. Mr Tsering Gyurme
    Minister for Agriculture
    Government of Arunachal Pradesh
    Itanagar (Arunachal Pradesh) 791 111
14. Minister of Fisheries
    Government of Arunachal Pradesh
    Itanagar (Arunachal Pradesh) 791 111

**Assam**

15. Dr Wazed Ali Choudhary
    Minister for Agriculture and Horticulture, Government of Assam
    Janta Bhavan, Guwahati (Assam) 781 006
16. Mr G C Langthasa
    Minister for Veterinary and Animal Husbandry,
    Hill Area Development
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006
17. Dr Nazrul Islam
    Minister for Fisheries and PWD
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006
18. Dr (Ms) Hemo Proba
    Minister of Horticulture
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006

**Bihar**

19. Minister for Agriculture
    Government of Bihar
    Patna (Bihar) 800 015
20. Minister for Animal Husbandry and Fisheries
    Government of Bihar
    Patna (Bihar) 800 015

**Chhattisgarh**

21. Mr Nankiram Kanwar
    Minister for Agriculture, Animal Husbandry & Fisheries
    Government of Chhatisgarh
    Raipur (Chhatisgarh)

**Delhi**

22. Mr Raj Kumar Chauhan
    Minister for Agriculture Development and Food,
    Animal Husbandry & Fisheries
    National Capital Territory of Delhi, Delhi

**Goa**

23. Mr Pratap Singh Rana
    Chief Minister holding charge of Agriculture
    Animal Husbandry and Horticulture
    Government of Goa, Panaji (Goa) 403 001
24. Mr Joaquim Alemao
    Minister for Fisheries
    Government of Goa, Panaji (Goa) 403 001

**Gujarat**

25. Mr Bhupendrasinh M Chudasama
    Minister for Agriculture, Animal Husbandry, Fisheries and Horticulture
    Government of Gujarat
    Gandhinagar, (Gujarat) 382 010

**Haryana**

26. Mr Bhupinder Singh Hooda
    Chief Minister for Agriculture & Horticulture, Animal Husbandry, Fisheries
    Government of Haryana
    Chandigarh (Haryana) 160 001

**Himachal Pradesh**

27. Mr Singhi Ram
    Minister of Horticulture
    Government of Himachal Pradesh
    Shimla (Himachal Pradesh) 171 001
28. Mr Raj Krishan Gaur
    Minister for Agriculture
    Government of Himachal Pradesh
    Shimla (Himachal Pradesh) 171 001
29. Mr Harsh Mahajan
    Minister of State for Animal Husbandry and Fisheries
    Government of Himachal Pradesh
    Shimla (Himachal Pradesh) 171 001

**Jammu and Kashmir**

30. Mr Abdul Aziz Zargar
    Minister for Agriculture, Animal Husbandry, Horticulture and Cooperation
    Government of Jammu and Kashmir
    Srinagar (Jammu and Kashmir) 190 001
31. Mr Gulam Mohuddin Sofi
    Minister of Fisheries
    Government of Jammu & Kashmir
    Srinagar (Jammu & Kashmir) 190 001

**Jharkhand**

32. Mr Arjun Munda
    Chief Minister holding charge of Animal Husbandry, Horticulture and Fisheries
    Government of Jharkhand, Ranchi (Jharkhand) 834 002
33. Mr Devidhan Besra
    Minister for Agriculture
    Government of Jharkhand
    Ranchi (Jharkhand) 834 002

**Karnataka**

34. Mr R Srinivas
    Minister of Fisheries and Horticulture
    Government of Karnataka
    Bangalore (Karnataka) 560 001
35. Mr Merajuddin N Patel
    Minister for Animal Husbandry and Wakf
    Government of Karnataka
    Bangalore (Karnataka) 560 001
36. Mr Srinivasa Gowda
    Minister for Agriculture
    Government of Karnataka
    Bangalore (Karnataka) 560 001

**Kerala**

37. Ms K R Gouri Amma
    Minister for Agriculture & Coir including Animal Husbandry and Horticulture
    Government of Kerala
    Thriuvananthapuram (Kerala) 695 001
38. Mr Dominic Presentation
    Minister of Fisheries
    Government of Kerala
    Thiruvananthapuram (Kerala) 695 001

**Madhya Pradesh**

39. Mr Gopal Bhargava
    Minister for Agriculture
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 423 006
40. Mr Moti Kashyap
    Minister for Fisheries
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 423 006
41. Mr Sunil Naik
    Minister for Animal Husbandry
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 423 006
42. Minister for Horticulture
    Government of Madhya Pradesh
    Bhopal (Madhya Pradesh) 432 006

**Maharashtra**

43. Mr Balasaheb Thorat
    Minister for Agriculture
    Government of Maharashtra
    Mumbai (Maharashtra) 400 032
44. Mr Anees Ahmad
    Minister for Fisheries, Animal Husbandry and Dairy Development
    Government of Maharashtra
    Mumbai (Maharashtra) 400 032
45. Mr Vinay Kore
    Minister for Horticulture and Non-conventional Energy
    Government of Maharashtra
    Mumbai (Maharashtra) 400 032

**Manipur**

46. Mr P H Parijat Singh
    Minister of Agriculture
    Government of Manipur
    Imphal (Manipur) 795 001
47. Mr M D Alauddin Khan
    Minister for Animal Husbandry
    Government of Manipur
    Imphal (Manipur) 795 001
48. Dr N Manji Singh
    Minister for Fisheries
    Government of Manipur
    Imphal (Manipur) 795 001

49. Mr Gaikhangam
Minister for Horticulture
Government of Manipur
Imphal (Manipur) 795 001

**Meghalaya**

50. Mr H R D Lyngdoh
Minister for Agriculture and Horticulture
Government of Meghalaya
Meghalaya Secretariat
Shillong (Meghalaya) 793 001
51. Dr M L Mukhim
Minister for Animal Husbandry
Government of Meghalaya, Meghalaya Secretariat (C)
Shillong (Meghalaya) 793 001
52. Mr F Lyngdoh
Minister for Fisheries
Meghalaya Secretariat (C)
Shillong (Meghalaya) 793 001

**Mizoram**

53. Mr H Rammawi
Minister for Agriculture and Horticulture
Government of Mizoram
Aizwal (Mizoram) 796 001
54. Mr Lalrin Chhana
Minister for Animal Husbandry
Government of Mizoram
Aizwal (Mizoram) 796 001
55. Mr B Lalthlengliana
Minister for Fisheries
Government of Mizoram
Aizwal (Mizoram) 796 001

**Nagaland**

56. Mr Neiphiu Rio
Chief Minister and holding charge of Horticulture and Fisheries
Government of Nagaland
Kohima (Nagaland) 797 001
57. Mr Kuzholuzo
Minister for Agriculture
Government of Nagaland
Kohima (Nagaland) 797 001
58. Mr Thenucho
Minister for Animal Husbandry
Government of Nagaland
Kohima (Nagaland) 797 001

**Orissa**

59. Mr Surinder Nath Naik
Minister for Agriculture and Horticulture
Government of Orissa
Bhubaneshwar (Orissa) 751 001
60. Ms Golak Bihari Naik
Minister for Animal Resources Development, Fisheries, Textiles and Handlooms
Government of Orissa
Bhubaneshwar (Orissa) 751 001

**Pondicherry**

61. Mr A Namassivayam
Minister for Agriculture, Horticulture, Animal Husbandry and Fisheries
Government of Pondicherry
Pondicherry 605 001

**Punjab**

62. Capt. Amarinder Singh
Chief Minister and holding charge of Agriculture
Government of Punjab
Chandigarh (Punjab) 160 001
63. Mr Jagmohan Singh Kang
Minister of Animal Husbandry, Fisheries and Dairy Development
Government of Punjab
Chandigarh (Punjab) 160 001
64. Mr Jasjit Singh Randhawa
Minister of Horticulture
Government of Punjab
Chandigarh (Punjab) 160 001

**Rajasthan**

65. Mr Prabhu Lal Saini
Minister of State for Agriculture, Animal Husbandry and Horticulture
Government of Rajasthan
Jaipur (Rajasthan) 302 005

**Sikkim**

66. Mr Somnath Poudyal
Minister for Agriculture, Horticulture, Irrigation and Flood Control
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 101
67. Ms Kalawati Subba
Minister for Animal Husbandry, Livestock and Fisheries
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 001

**Tamil Nadu**

68. Mr K Bandurangan
Minister for Agriculture
Government of Tamil Nadu
Chennai, (Tamil Nadu) 600 009
69. Mr M Radhakrishnan
Minister for Fisheries
Government of Tamil Nadu
Chennai (Tamil Nadu) 600 009
70. Mr P V Damodharam
Minister for Animal Husbandry
Government of Tamil Nadu
Chennai (Tamil Nadu) 600 009

**Tripura**

71. Mr Tapan Chakravorty
Minister for Agriculture, Animal Husbandry and Horticulture
Civil Secretariat, Government of Tripura
Agartala (Tripura) 799 001
72. Mr Khagentra Jamatia
Minister for Fisheries
Government of Tripura
Agartala (Tripura) 799 001

**Uttaranchal**

73. Mr Mahinder Singh Mahra
Minister for Agriculture
Government of Uttranchal
Dehradun (Uttranchal)
74. Mr Govind Singh Kunjwal
Minister for Horticulture
Government of Uttranchal
Dehradun (Uttranchal)
75. Mr Mantri Prasad Naithani
Minister for Co-operative, Fisheries, Milk, Animal Husbandry
Government of Uttaranchal
Dehradun (Uttaranchal)

**Uttar Pradesh**

76. Mr Shiv Pal Singh
Minister for Agriculture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
77. Dr Virendra Singh
Minister for Animal Husbandry
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
78. Mr Raj Kishore Singh
Minister for Horticulture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
79. Mr Shankh Lal Manji
Minister of Fisheries
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001

**West Bengal**

80. Mr Kamal Guha
Minister for Agriculture
Government of West Bengal Writers' Building
Kolkata (West Bengal) 700 001
81. Mr Anisur Rahman
Minister for Animal Resources Development
Government of West Bengal
Kolkata, (West Bengal) 700 001
82. Mr Kironmoy Nanda
Minister for Fisheries & Aquatic Resources and Fishing Harbours
Government of West Bengal
Kolkata (West Bengal) 700 001
83. Mr Sailen Sarkar
Minister for Horticulture and Food Processing Industries
Government of West Bengal
Writers Building
Kolkata (West Bengal) 700 001

(vi) *Member of Planning Commission, Incharge of Agriculture*

84. Mr Abhijit Sen
Member (Agriculture), Planning Commission
Yojana Bhavan
New Delhi

(vii) *Six members of Parliament (Four elected by Lok Sabha and two elected by Rajya Sabha)*

85. Shri Harish Rawat — 25.11.2008
Member of Parliament (RS)
Village Mohanari
P.O. Chaunalia
Tehsil Bhikaiasen
Distt. Almora, Uttaranchal and
12-A, Canning Lane
New Delhi 110 001
86. Shri S.S. Ahluwalia — 02.04.2006
Member of Parliament (RS)
Boring Canal Road
Ward No. 4, P.S. Krishna Puri
P.O. G.P.O Patna and
10, Gurudwara Rakab Ganj Road
New Delhi 110 001
87. Shri Dinsha Patel — Till the expiry of term in the Lok Sabha
Member of Parliament (LS)
17/B, Amra Kunj Society
V.K.V. Road, Nadiad
Distt. Kaira, Gujarat and
11-A, Pandit Pant Marg
New Delhi 110 001
88. Shri Mahdevrao Shivankar — -do-
Member of Parliament (LS)
Amgaon, Distt. Gundia
Maharashtra and
B-603, MS Flats, BKS Marg
New Delhi
89. Shri Manvendra Singh — -do-
Member of Parliament (LS)
Amagarh House, Dampier Nagar
Mathura (Uttar Pradesh) and
20, Willingdon Cresent, New Delhi
90. Shri Mahboob Zahedi — -do-
Member of Parliament (LS)
At Gushkara, Distt. Burdwan
West Bengal and
80, North Avenue
New Delhi 110 001

(viii) *Director-General, ICAR*

91. Dr Mangala Rai
Director-General, ICAR
Krishi Bhavan, New Delhi 110 001

(ix) *All Secretaries in the Ministry of Agriculture*

92. Ms Radha Singh
Secretary (Agriculture and Co-operation)
Ministry of Agriculture, Department of Agriculture, Krishi Bhavan,New Delhi 110 001
93. Mr P M A Hakeem
Secretary (Animal Husbandry and Dairying)
Krishi Bhavan,
New Delhi 110 001

(x) *Secretary, Planning Commission*

94. Mr R R Shah
Secretary, Planning Commission
Yojana Bhavan, New Delhi 110 001

(xi) *Chairman, University Grants Commission*

95. Dr A 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)*

96. Mr Anil Khakodkar
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, Alternate Member—Financial Adviser (DARE/ICAR)*

97. Mr Anurag Goel
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*

98. Vacant

99. Dr P K Singh 17.09.2006
Vice-Chancellor
Chandra Shekar Azad University of
Agriculture and Technology
Kanpur (Uttar Pradesh) 208 002

100. Vacant

101. Dr S S Magar 17.09.2006
Vice-Chancellor
Dr Balasaheb Sawant Konkan
Krishi Vidyapeeth, Distt. Ratnagiri
Dapoli (Maharashtra) 415 712

(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*

102. Agricultural Commissioner Ex-officio
Department of Agriculture and Co-operation
Krishi Bhavan,
New Delhi 110 001

103. Dr M L Choudhary
Horticultural Commissioner, Department of
Agriculture,
Krishi Bhavan, New Delhi 110 001

104. Ms Nita Choudhary
Joint Secretary and Animal Husbandry
Commissioner
Department of Agriculture, Krishi Bhawan,
New Delhi

105. Mr M K R Nair Ex-officio
Fisheries Development Commissioner
Department of Agriculture, Krishi Bhavan
New Delhi 110 001

106. Mr N K Joshi 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*

107. Dr Shiv Raj Singh 25.09.2006
15, Bhagirathi Colony
Sundarpur
Varanasi 221 005

108. Dr Y L Nene 25.09.2006
Ex. DDG, ICRISAT
47, ICRISAT Colony - 1
Brig. Sayeed Road
Secunderabad 500 009

109. Padmashri Dr J S P Yadav 25.09.2006
Ex-Chairman, ASRB
B-14, Indian Agricultural Research
Institute (IARI) Campus
New Delhi 110 012

110. Dr N Panda 25.09.2006
Ex. Dean
Department of Soil Science
Plot 62/63, PO Baramunda
Orissa University of Agriculture & Technology
Bhubaneshwar 751 003

111. Dr N N Goswami 25.09.2006
Ex. Vice-Chancellor., CSUAT, Kanpur
Specialization: Social Science
JD-2OD, Pitampura
Delhi 110 088

112. Dr S N Dwivedi 25.09.2006
Ex. Director, CIFE, Bombay
Specialization: Fisheries & Environment
E-1/106, Arera Colony
Bhopal 462 016
Madhya Pradesh

113. Dr M Y Kamal 25.09.2006
Ex-Vice-Chancellor
SKUAST
Shahjahanabad Society
602/2, Plot 1, Sector 1
Dwarka, New Delhi 110 075

114. Dr K Pradhan 25.09.2006
Ex Vice-Chancellor
RAU, Bikaner
H-101, Somvihar
New Delhi 110 022

115. Dr B S Pathak 25.09.2006
Director
SPRERI, PB No. 2
Vallabh Vidyanagr 388 120

116. Prof M M Mehta 25.09.2006
Ex Vice-President
M/s Escort Tractors
Consultant, 1179, Sector 15
Faridabad (Haryana)

117. Mr J N L Srivastava 25.09.2006
Former Secretary (A&C)
25, NRI Colony, Greater Kailash, Part IV
New Delhi 110 019

118. Mr Sudhir Bhargava 25.09.2006
Director
Agroman System Pvt. Ltd.
25/2, Tardeo Ac Market, Mumbai 400 034

119. Prof S K Jha 25.09.2006
Agril. Economics Department
Rajendra Agricultural University
Pusa, Samastipur 848 125

120. Prof N S L Srivastava 25.09.2006
Joint Director
SPRERI, Villabh Vidyanagar (Gujarat) 388 120

**Representative of the ICMR**

121. Dr Rakesh Mittal 17.9.2006
Deputy Director-General
Division of Reproductive Health & Nutrition
Indian Council of Medical Research
Ansari Nagar, PB 4911
New Delhi 110 029

(xvii) *Three representatives of Commerce and Industry, nominated by the President*

122. Shri Dilip Kumar Jaiswal 18.01.2007
MGM Medical College
Kishanganj
Bihar

123. Shri Vivek Saraogi 18.01.2007
Managing Director
Balrampur Chini Mills Ltd
'FMC Fortuna' 2nd Floor
234/3A, AJC Bose Road
Kolkata, West Bengal 700 020

124. Dr Mahesh Sharma 18.01.2007
Chairman and Managing Director
Kailash Hospitals & Res. Centre Ltd.
H-33, Sector 27, NOIDA
Uttar Pradesh

(xviii) *One farmer from each region mentioned in Rule 60(a) and four representatives of rural interest nominated by the President*

125. Shri Surya Deo Tyagi 08.10.2006
Tarni Moholla
Sardhana Distt., Meerut (Uttar Pradesh)

126. Dr Yogiraj B Patil 08.10.2006
'Annapurna', Opp. Shivalaya
Koppadakeri, Dharwad 580 008

127. Mr Subhash Bhatia 08.10.2006
R- 65A, Shakti Nagar
Gupteshwar, Jabalpur (Madhya Pradesh)

128. Mr Ajit Singh Kiran 08.10.2006
Ajay Bagh, Ajhota
Post Laved
Dist. Meerut (Uttar Pradesh)

129. Mr Asha Ram Yadav 08.10.2006
Ex-M.L.A.
Narghat
Mirzapur (Uttar Pradesh) 231 001 and
B-1/3, Gulab Bagh
Sigra, Varanasi 221 002 (Uttar Pradesh)

130. Mr D S Ananth 08.10.2006
Planter
Sri Satya Sai Estate
Mahadevapet, Madikeri
Distt. Coorg (Karnataka) 571 201 and
697/A, First Block, 3rd Stage, Basaveswara Nagar
Bangalore (Karnataka) 560 074

131. Mr Shakuntala Bapusaheb 08.10.2006
Shirgaonker
PO Ankalkhop, Tal. Palus, Distt. Sangli
Maharashtra 416 316

132. Mr Loloark Singh 18.02.2007
Village Dhaurhara
Post Khulwa
Tehsil Sadar
Distt. Mirzapur (Uttar Pradesh)

**Representatives of Rural Interest**

133. Dr S A Khanwilkar 08.10.2006
Nandashree Apartment
A/3, Block No.1
Near Hotel Vrindavan
Tal Dapoli
District Ratnagiri
Dapoli (Maharashtra) 415 712

134. Mr Gautam Murarka 15.02.2006
B-104, Gulmohar Park
New Delhi 110 049 and
511 Maker Chamber
221, Nariman Point
Mumbai 400 021

135. Mr Ramesh Dattambhat Vaidya 08.10.2006
Director
Raichur Distt. Coop. Bank Ltd.
Post Hitnal,
Tal & Distt. Koppal (Karnataka) 583 234

136. Mr Vijay Kumar Singh 18.02.2007
Vijay Lodge
Chandra Nagar
P.O. Koshi college
Khagaria (Bihar) 851 203

(xix) *Four Directors of the ICAR Research Institutes, nominated by the President*

137. 07.10.2006
Director
Indian Agricultural Research Institute
New Delhi 110 012

138. Dr S K Dwivedi 07.10.2006
Director
National Research Centre on Equines
Sirsa Road, Hisar (Haryana) 125 001

139. Dr A V Parthasarathy 07.10.2006
Director
Indian Institute of Spices Research
P B No. 1701
Marikunnu P O, Calicut (Kerala) 673 012

140. Dr S Sreenivasan 07.10.2006
Director
Central Institute for Research on Cotton Technoilogy
PB No. 16640, Adenwala Road, Matunga
Mumbai (Maharashtra) 400 019

(xx) *Secretary, Indian Council of Agricultural Research*

141. Ms Sushama Nath
Member-Secretary
Indian Council of Agricultural Research
Krishi Bhawan,
New Delhi 110 001

## APPENDIX 2

## GOVERNING BODY

**Chairman**

1. Dr Mangala Rai
   Director-General
   Indian Council of Agricultural Research
   Krishi Bhavan, New Delhi 110 001

**Ex-officio Members**

**Member-Finance**

Alternate Member–Financial Adviser (DARE/ICAR)

2. Mr Anurag Goel
   Additional Secretary to the Government of India
   Ministry of Finance, Department of Expenditure
   New Delhi 110 001

**Secretary, Planning Commission**

3. Mr R R Shah
   Secretary
   Planning Commission
   Yojna Bhavan, New Delhi 110 001

**Secretary, Agriculture**

4. Ms Radha Singh
   Secretary (Agriculture and Coop),
   Government of India
   Ministry of Agriculture, Department of
   Agriculture, Krishi Bhavan, New Delhi 110 001

**Chairman, University Grants Commission**

5. Dr A Nigavekar
   Chairman
   University Grants Commission
   Bahadur Shah Zafar Marg, New Delhi

**Secretary, Animal Husbandry and Dairying**

6. Mr P M A Hakeem
   Secretary
   Department of Animal Husbandry and Dairying
   Krishi Bhavan, New Delhi 110 001

**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 J N L Srivastava — 25.09.2006
   Former Secretary ( A&C)
   25, NRI Colony, Greater Kailash Part IV
   New Delhi 110 019

**Scientists**

8. Dr Y L Nene — 25.09.2006
   Ex. DDG, ICRISAT
   47, ICRISAT Colony - I, Brig. Sayeed Road
   Secunderabad 500 009
9. Dr Shiv Raj Singh — 25.09.2006
   Professor and Chief Scientist
   Institute of Agricultural Sciences
   BHU, Varanasi 221 005 and
   15, Bhagirathi Colony
   Sundarpur, Varanasi 221 005
10. Shri Sudhir Bhargava — 25.09.2006
    Director
    Agroman System Pvt. Ltd.
    25/2, Tardeo Ac Market
    Mumbai 400 034

**Three Vice-Chancellors (nominated by President)**

11. Dr R B Deshmukh — 18.07.2008
    Vice-Chancellor
    Mahatama Phule Krishi Vidyapeeth
    Ahmednagar
    Rahuri (Maharashtra) 413 722
12. Dr P K Singh — 17.09.2006
    Vice-Chancellor
    Chandra Shekhar Azad University
    of Agriculture & Technology
    Kanpur 208 002
    Uttar Pradesh
13. Dr S S Baghel — 18.07.2008
    Vice-Chancellor
    Assam Agricultural University
    Jorhat 785 013
    Assam

**Three Members of Parliament (Two from Lok Sabha and one from Rajya Sabha) nominated by the President**

14. Mr Dinsha Patel — 03.01.2008
    Member of Parliament (Lok Sabha)
    17/B, Amra Kunj Society
    VKV Road, Nadiad
    Distt. Kaira, Nadiad 387 001
    Gujarat and
    11-A, Pandit Pant Marg
    New Delhi 110 001
15. Mr Mahboob Zahedi — 03.01.2008
    Member of Parliament (Lok Sabha)
    Gushkara, Distt. Burdawan
    West Bengal and
    80, North Avenue
    New Delhi 110 001
16. Mr S S Ahluwalia — 28.09.2006
    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/Representatives of rural areas nominated by President**

17. Mr S A Khanwilkar — 08.10.2006
    Nandashree Apartment
    A/3, Block No.1, Near Hotel Vrindavan
    Tal Dapoli, District Ratnagiri
    Dapoli (Maharashtra) 415 712
18. Mr Gautam Murarka — 15.02.2006
    B-104, Gulmohar Park
    New Delhi 110 049 and
    511 Maker Chambers
    221, Nariman Point, Mumbai 400 021

19. Mr Surya Dev Tyagi — 08.10.2006
Tarni Mohalla
Sardhana, District Meerut, Uttar Pradesh

**Three Directors of Research Institutes of the Council nominated by the President**

20. Director — 07.10.2006
Indian Agricultural Research Institute
Pusa, New Delhi 110 012

21. Dr S K Dwivedi — 07.10.2006
Director
National Research Centre on Equines
Sirsa Road, Hisar (Haryana) 125 001

22. Dr V A Parthasarthy — 07.10.2006
Director
Indian Institue of Spices Research
P B No. 1701, Marikunnu P.O.
Calicut (Kerala) 673 012

**Member-Secretary**

22. Ms Sushama Nath
Additional Secretary (DARE) and Secretary,
Indian Council of Agricultural Research
Krishi Bhawan
New Delhi 110 001

## APPENDIX 3

## STANDING FINANCE COMMITTEE

| | | |
|---|---|---|
| **Chairman, Director-General** | 1. Dr Mangala Rai<br>Director-General<br>Indian Council of Agricultural Research,<br>Krishi Bhavan, New Delhi | |
| **Ex-officio Members**<br>**Member-Finance** | 2. Mr Anurag Goel<br>Additional Secretary to the<br>Govt. of India<br>Ministry of Finance<br>Department of Expenditure, New Delhi | Ex-officio |
| **Secretary, Agriculture** | 3. Ms Radha Singh<br>Secretary (Agriculture & Coop.)<br>Govt. of India<br>Ministry of Agriculture<br>Department of Agriculture<br>Krishi Bhawan, New Delhi | Ex-officio |
| **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 192nd (15.7.2003) and 193rd (24.12.2003) to the Standing Finance Committee for a fresh period of one year** | *SCIENTISTS*<br>4. Mr Sudhir Bhargava<br>Director, Agroman Systems Pvt. Ltd<br>25/2, Tardeo Ac Market<br>Tardeo, Mumbai 440 034 | 23.12.2004 |
| | 5. Dr Shiv Raj Singh<br>Professor and Chief Scientist<br>Institute of Agricultural Sciences<br>BHU, Varanasi 221 005 and<br>15, Bhagirathi Colony<br>Sundarpur, Varanasi 221 005 | 23.12.2004 |
| | *DIRECTOR*<br>6. Dr V A Parthasarathy<br>Indian Institute of Spices Research<br>Marikunnu, Calicut, Kerala 673 012 | 02.03.2006 |
| | *FARMER*<br>7. Mr Surya Deo Tyagi<br>Tarni Mohalla<br>Sardhana, Distt. Meerut<br>Uttar Pardesh | 02.03.2006 |
| | *MEMBER OF PARLIAMENT*<br>8. Mr Mahboob Zahedi<br>Member of Parliament (LS)<br>Gushkara, Distt. Burdwan<br>West Bengal and<br>80, North Avenue<br>New Delhi 110 001 | |
| | *MANAGEMENT EXPERT*<br>9. Mr J N L Srivastava<br>Former Secretary (A&C)<br>25, NRI Colony, Mandakini, Greater Kailash, Part IV<br>New Delhi 110 019 | |
| | *VICE-CHANCELLOR*<br>10. Vacant | |

*SPECIAL INVITEES*

11. Dr Rita Sharma
    Financial Adviser (ICAR & DARE)
    Krishi Bhavan, New Delhi 110 001
12. Mr Shailender Aggarwal
    Director (Agri) Room No. 276
    Dept. of Commerce
    Ministry of Commerce & Industry
    Udyog Bhavan, New Delhi 110 001
13. Dr R C Maheshwari
    Asstt. Director-General (TC)
    ICAR, Krishi Bhavan, New Delhi 110 001

*MEMBER - SECRETARY*

14. Ms Sushama Nath
    Additional Secretary (DARE) & Secretary
    Indian Council of Agricultural Research
    Krishi Bhavan, New Delhi 110 001

## 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

**2. Ms Sushama Nath**
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 V K Taneja (Animal Sciences)
3. Dr J S Samra (Natural Resource Management)
4. Dr G Kalloo (Horticulture and Crop Sciences)
5. Dr S Ayyappan (Fisheries)
6. Dr Nawab Ali (Agricultural Engineering)

### Assistant Directors-General

#### Crop Sciencces

1. Dr K C Jain (Commercial Crops)
2. Dr S N Shukla (Food and Fodder Crops)
3. Dr T P Rajendran (Plant Protection)

#### Horticulture

1. Dr S N Pandey (H&VC)
2. Dr K V Ramana (Plantation Crops)

#### Natural Resource Management

1. Dr P D Sharma (Soils)

#### Engineering

1. Dr P Chandra (Process Engineering)

#### Animal Sciences

1. Dr Lal Krishna (Animal Health)
2. Dr (Ms) P P Bhat (Animal Genetics)
3. Dr O P Dhanda (ANP)

#### Fisheries

1. Dr A D Diwan (Marine Fisheries)

#### Education

1. Dr G C Tiwari (EPD)
2. Dr H S Nainawatee (HRD II)
3. Dr B S Bisht (HRD I)

#### Extension

1. Dr Rajinder Parshad (Agril. Extn.)
2. Dr Ram Chand (KVK)

#### Others

1. Dr R C Maheshwari (Technical Co-ordination)
2. Dr J P Mishra (CSC)
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 Maurya [Commercial Crops; Addl. Charge ADG (IPR&P)]
4. Dr (Ms) P Kaur (Plant Protection)
5. Dr O P Dubey [Plant Protection; Addl. Charge ADG (O&P)]
6. Dr S Kochhar (Intellectual Property Rights)

#### Horticulture

1. Dr U C Srivastava

#### Natural Resource Management

1. Dr D K Paul (IWM)
2. Dr O P Sharma (AF)

#### Education

1. Dr G D Diwakar (Accreditation)

#### Fisheries

1. Dr Anil Aggarwal (Marine Fisheries)
2. Dr V R Chitranshi (Fisheries)

#### ARIS Unit

1. Dr A K Jain
2. Dr D K Aggarwal

#### Extension

1. Dr G Appa Rao
2. Dr A M Narula
3. Dr (Ms) Tej Verma

#### Engineering

1. Dr S K Tandon

#### Others

1. Dr A K Bawa (DG Section)
2. Dr V S Upadhyaya
3. Dr D B S Sehra (ES&M)
4. Dr R K Mittal (Tech. Cdn.)

### National Agricultural Technology Project

1. Dr Mruthyunjaya, National Director; Addl. Charge DDG (Edn.)
2. Dr J P Mittal, National Coordinator
3. Dr K P Agarwal, National Coordinator
4. Dr D P Singh, National Coordinator
5. Dr A Bandhopadhyay, National Coordinator

### Administration

#### Directors

1. Mr K K Bajpai, Director (P)
2. Mr H C Pathak, Director (F)
3. Mr H C Joshi, Director (OL)
4. Mr V P Kothiyal, Director (Works)

#### Deputy Secretaries

1. Mr Sanjay Gupta
2. Mr H L Meena
3. Mr Sodhi Singh
4. Mr J Ravi
5. Mr B N Rao

#### Others

1. Mr Prakash Magdum, Chief Publicity and Public Relations Officer

### Agricultural Scientists' Recruitment Board

1. Dr C D Mayee, Chairman
2. Dr N K Tyagi, Member
3. Mr Sanjay Kant, Secretary
4. Mr Vikram Singh, Controller of Examination

### Directorate of Information and Publications of Agriculture (DIPA)

1. Mr Kuldeep Sharma, Incharge
2. Mr V K Bharti, Chief Production Officer
3. Mr S K Joshi, Business Manager
4. Mr Han Raj, Information System Officer
5. Dr R P Sharma, Editor (English) and Unit Incharge
6. Mr B C Mazumder, Incharge (Art Unit)

## APPENDIX 5

## ICAR INSTITUTES AND THEIR DIRECTORS

### National Institutes

1. Dr A K Singh (Acting)
   Indian Agricultural Research Institute
   New Delhi 110 012
2. Dr M P Yadav
   Indian Veterinary Research Institute
   Izatnagar (Uttar Pradesh) 243 122
3. Dr Sushil Kumar
   National Dairy Research Institute
   Karnal (Haryana) 132 001
4. Dr Dilip Kumar
   Central Institute of Fisheries Education
   Jaiprakash Road, Seven Bungalow (Versova)
   Mumbai (Maharashtra) 400 061

### Agricultural Sciences

5. Dr R C Upadhyay
   Central Agricultural Research Institute
   Andaman and Nicobar Group of Islands
   P B 181 Port Blair
   (Andamans & Nicobar Islands) 744 101
6. Dr Pratap Narain
   Central Arid Zone Research Institute
   Jodhpur (Rajasthan) 342 003
7. Dr S D Kulkarni (Acting)
   Central Institute of Agricultural Engineering
   Berasia Road, Nabi Bagh,
   Bhopal (Madhya Prdesh) 462 038
8. Dr D G Dhandar
   Central Institute of Arid Horticulture
   Bikaner (Rajasthan) 334 006
9. Dr B M Khadi
   Central Institute for Cotton Research
   ICAR Housing Complex, Central Bazar Road
   Bajaj Nagar,Nagpur (Maharashtra) 440 010
10. Dr O D Wanjari (Acting)
    Central Institute of Post-Harvest Engineering and
    Technology, Ludhiana (Punjab) 141 004
11. Dr S Sreenivasan
    Central Institute for Research on Cotton Technology
    PB 16640, Adenwala Road, Matunga
    Mumbai (Maharashtra) 400 019
12. Dr B M C Reddy
    Central Institute for Sub-tropical Horticulture
    Rehmankhera, PO Kakori
    Lucknow (Uttar Pradesh) 227 107
13. Dr A A Sofi
    Central Institute of Temperate Horticulture
    Old Air Field
    Rangreth (Jammu and Kashmir) 190 007
14. Dr V Rajagopal
    Central Plantation Crops Research Institute
    Kasaragod (Kerala) 671 124
15. Dr S K Pandey
    Central Potato Research Institute
    Shimla (Himachal Pradesh) 171 001
16. Dr Y S Ramakrishna
    Central Research Institute for Dryland Agriculture
    Santoshnagar, P O Saidabad
    Hyderabad (Andhra Pradesh) 500 059
17. Dr H S Sen
    Central Research Institute for Jute and Allied Fibres
    Barrackpore, Distt 24 Paraganas
    (West Bengal) 700 120
18. Dr S G Sharma (Acting)
    Central Rice Research Institute
    Cuttack (Orissa) 753 006
19. Dr Gurbachan Singh
    Central Soil Salinity Research Institute
    Zarifa Farm, Kachwa Road, Karnal (Haryana) 132 001
20. Dr V N Sharda
    Central Soil and Water Conservation Research and
    Training Institute, 218 Kaulagarh Road
    Dehradun (Uttaranchal) 248 195
21. Dr V Krishnamurthy (Acting)
    Central Tobacco Research Institute
    Rajahmundry (Andhra Pradesh) 533 105
22. Dr S Edison
    Central Tuber Crops Research Institute, PB 3502
    Sreekariyam, Thiruvananthapuram (Kerala) 695 017
23. Dr V S Korikanthimath
    ICAR Research Complex for Goa,
    Ela, Old Goa (Goa) 403 402
24. Dr A K Sikka
    ICAR Research Complex for Eastern Region
    Walmi Complex, Phulwari Sharif
    Patna (Bihar) 801 505
25. Dr K M Bujarbaruah
    ICAR Research Complex for North-Eastern Hills Region
    Umroi Road, Barapani (Meghalaya) 793 103
26. Dr S D Sharma
    Indian Agricultural Statistics Research Institute
    Library Avenue, Pusa Campus, New Delhi 110 012
27. Dr K A Singh
    Indian Grassland and Fodder Research Institute
    Pahuj Dam, Gwalior-Jhansi Road
    Jhansi (Uttar Pradesh) 284 003
28. Dr S D Shikhamany
    Indian Institute of Horticultural Research
    P.O. Hassaraghatta Lake
    Bangalore (Karnataka) 560 089
29. Dr Masood Ali
    Indian Institute of Pulses Research
    Kanpur (Uttar Pradesh) 208 024
30. Dr A Subba Rao
    Indian Institute of Soil Science
    Nabi Bagh, Bhopal (Madhya Pradesh) 462 038
31. Dr V A Parthasarathy
    Indian Institute of Spices Research
    P B 1701, P O Marikunnu
    Kozhikode (Kerala) 673 012

32. Dr R L Yadav
Indian Institute of Sugarcane Research
P O Dilkusha, Lucknow (Uttar Pradesh) 226 002
33. Dr Bangali Baboo
Indian Lac Research Institute
Namkum, Ranchi (Jharkhand) 834 010
34. Dr Mathura Rai
Indian Institute of Vegetable Research
P.B. 01, P.O. Jakhini
Shahanshapur, Varanasi (Uttar Pradesh) 221 305
35. Dr S K Bhattacharya
National Institute of Research on Jute and
Allied Fibre Technology
12 Reagent Park, Calcutta (West Bengal) 700 040
36. Dr N Vijayan Nair
Sugarcane Breeding Institute
Coimbatore (Tamil Nadu) 641 007
37. Dr H S Gupta
Vivekananda Parvatiya Krishi Anusandhan Sansthan
Almora (Uttar Pradesh) 263 601

**Animal Sciences and Fisheries**

38. Dr Rajvir Singh
Central Avian Research Institute
Izatnagar (Uttar Pradesh) 243 122
39. Dr K K Vass
Central Inland Fisheries Research Institute
Barrackpore (West Bengal) 700 120
40. Dr P Ravichandran (Acting)
Central Institute of Brackishwater Aquaculture
75 Santhome High Road
R A Puram, Chennai (Tamil Nadu) 600 028
41. Dr K Devadasan
Central Institute of Fisheries Technology
Willingdon Island, P O Matsyapuri
Cochin (Kerala) 682 029
42. Dr N Sarangi
Central Institute of Freshwater Aquaculture
Kausalyaganga, Bhubaneshwar (Orissa) 751 002
43. Dr B S Punia
Central Institute for Research on Buffaloes
Sirsa Road, Hisar (Haryana) 125 001
44. Dr N P Singh
Central Institute for Research on Goats
Makhdoom, Mathura, (Uttar Pradesh) 281 122
45. Dr M J Modayil
Central Marine Fisheries Research Institute
P B 1603, Tatapuram, Kochi (Kerala) 682 018
46. Dr V K Singh
Central Sheep and Wool Research Institute
Avikanagar, District Tonk
Via Jaipur (Rajasthan) 304 501
47. Dr K T Sampath
National Institute of Animal Nutrition and Physiology
Adugodi, Bangalore (Karnataka) 560 030

**Other**

48. Dr S P Tiwari
National Academy of Agricultural Research and
Management, Rajendranagar
(Andhra Pradesh) 500 030

## APPENDIX 6

## NATIONAL BUREAUX AND THEIR DIRECTORS

### Agricultural Sciences

1. Dr A K Singh (Acting)
   National Bureau of Plant Genetic Resources
   FCI Building, Pusa, New Delhi 110 012
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

### Animal Sciences

3. Dr S P S Ahlawat
   National Bureau of Animal Genetic Resources
   PB 129, Karnal (Haryana) 132 001
4. Dr W S Lakra
   National Bureau of Fish Genetic Resources
   Radhaswami Bhavan, 351/28,
   Dariya Pur, Talkatora Road
   PO Dilkusha
   Lucknow (Uttar Pradesh) 226 002
5. Prof D K Arora
   National Bureau of Agriculturally Important Micro-organisms
   PB No. 6, Kusmaur
   Mau Nath Bhanjan
   Uttar Pradesh 275 101

## 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
2. Dr D M Hegde
   Directorate of Oilseeds Research
   Hyderabad (Andhra Pradesh) 500 030
3. Dr S V Subbaiah (Acting)
   Directorate of Rice Research
   Hyderabad (Andhra Pradesh) 500 030
4. Dr B Mishra
   Directorate of Wheat Research
   P B 158, Kunjpura Road,
   Karnal (Haryana) 132 001
5. Dr R J Rabindra
   Project Directorate of Biological Control
   Bellary Road, P B 2491, HA Farm Post, Hebbal
   Bangalore (Karnataka) 560 024
6. Dr R P Singh (Acting)
   Project Directorate of Maize Research
   Cummings Laboratory
   Indian Agricultural Research Institute, Pusa
   New Delhi 110 012
7. Dr S D Kulkarni
   Project Directorate on Soybean
   Processing and Utilization
   CIAE Complex, T T Nagar,
   Bhopal (Madhya Pradesh) 462 018
8. Dr A B Mondal
   Project Director
   Directorate of Seed Research
   Kusmaur, Mau Nath Bhanjan (Uttar Pradesh) 275 101

### Animal Sciences

9. Dr A K Mishra
   Project Directorate on Cattle
   Grass Farm Road, PB 17
   Meerut (Uttar Pradesh) 250 001
10. Dr R P Sharma
    Project Directorate on Poultry
    Rajendranagar
    Hyderabad (Andhra Pradesh) 500 030
11. Dr K Prabhudas (Acting)
    Project Directorate on Animal Disease Monitoring
    and Surveillance
    Hebbal, Bangalore (Karnataka) 560 024
12. Dr T J Rasool
    Project Directorate on Foot and Mouth Disease
    IVRI Campus, Mukteshwar
    Kumaon (Uttaranchal) 263 138

## APPENDIX 8

## NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

### Agricultural Sciences

1. Dr S K Dhyani
   National Research Centre for Agroforestry
   IGFRI Campus, Pahuj Dam, Gwalior-Jhansi Road
   Jhansi (Uttar Pradesh) 284 003
2. Dr S Sathiamoorthy
   National Research Centre for Banana
   Thogamalai Main Road, Thayanur Post
   Tiruchirapalli (Tamil Nadu) 620 102
3. Dr M Gopalakrishna Bhat
   National Research Centre for Cashew
   Kamminje, Puttur (Karnataka) 574 202
4. Dr Shyam Singh
   National Research Centre for Citrus
   PB 464, P.O. Shankar Nagar, Nagpur (Maharashtra) 440 010
5. Dr P G Adsule
   National Research Centre for Grapes
   PB No. 3, Manjri Farm Post
   Pune (Maharashtra) 412 307
6. Dr M S Basu
   National Research Centre for Groundnut
   Ivanagar Road, Timbawadi
   PB 5, Junagadh (Gujarat) 362 001
7. Prof. Amerika Singh
   National Research Centre for
   Integrated Pest Management
   Lal Bahadur Shastri Building
   IARI, Hillside Road, Pusa
   New Delhi 110 012
8. Dr K K Kumar (Acting)
   National Research Centre for Litchi, Manchi House
   Muzaffarpur (Bihar) 842 002
9. Dr Janardan Jee (Acting)
   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
11. Dr R P Tewari
    National Research Centre for Mushroom
    Chambaghat, Solan (Himachal Pradesh) 173 213
12. Dr M Kochu Babu
    National Research Centre for Oilpalm
    Pedavegi (Andhra Pradesh) 534 450
13. Dr K E Lawande
    National Research Centre for Onion and Garlic
    Rajguru Nagar, Pune, (Maharashtra) 410 505
14. Dr V Nagaraju (Acting)
    National Research Centre for Orchids
    Pakyang (Sikkim) 737 106
15. Dr K R Kaundal
    National Research Centre for Plant Biotechnology
    Indian Agricultural Research Institute, Pusa,
    New Delhi 110 012
16. Dr Arvind Kumar
    National Research Centre for Rapeseed and Mustard
    P B 41, Bharatpur (Rajasthan) 321 303
17. Dr B B Vashishtha (Acting)
    National Research Centre for Seed Spices
    Tabiji, Ajmer (Rajasthan) 305 206
18. Dr N Seetharama
    National Research Centre for Sorghum
    Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
19. Dr G S Chauhan
    National Research Centre for Soybean
    Bhawerkua Farm, Khandwa Road,
    Indore (Madhya Pradesh) 452 017
20. Dr Ashwani Kumar
    National Research Centre of Water Technology for
    Eastern Region,
    Chandrasekharpur, Bhubaneshwar (Orissa) 751 023
21. Dr A K Gogoi (Acting)
    National Research Centre for Weed Science
    Maharajpur, Adhartal, Jabalpur (Madhya Pradesh) 482 004
22. Dr A K Singh (Acting)
    National Research Centre on DNA Fingerprinting
    NBPGR, Pusa Campus
    New Delhi 110 012
23. Dr K Kumar
    National Research Centre on Pomegranate
    C/o Centre on Rabi Sorghum
    NH 9 Bye Pass
    Shelgi, Solapur (Maharashtra) 413 007

### Animal Sciences and Fisheries

24. Dr M S Sahani
    National Research Centre on Camel
    Jorbeer, PB 07, Bikaner (Rajasthan) 334 001
25. Dr P C Mahant
    National Research Centre for Coldwater Fisheries
    Saurabh Cottage, Thandi Sarak
    Naintal (Uttaranchal) 263 136
26. Dr S K Dwivedi
    National Research Centre for Equines
    Sirsa Road, Hisar (Haryana) 125 001
27. Dr T R K Murthy
    National Research Centre on Meat and
    Meat Products
    CRIDA Campus, Santoshnagar
    Hyderabad (Andhra Pradesh) 500 059
28. Dr Chandan Rajkhowa
    National Research Centre for Mithun
    ICAR Research Complex
    Jharnapani, Medziphema (Nagaland) 797 106
29. Dr K M Bujarbaruah (Acting)
    National Research Centre for Pigs
    Panjabari Road, 6th Mile
    Guwahati (Assam) 785 037
30. Dr Mohan Bhattacharya
    National Research Centre on Yak
    West Kemeng, Dirang (Arunachal Pradesh) 790 101

**General**

31. Dr Ramesh Chand (Acting)
National Centre for Agricultural Economics and Policy Research
Library Avenue, Pusa, New Delhi 110 012

32. Dr (Ms) Hema Pandey
National Research Centre for Women in Agriculture
1199, Jagamara
Bhubaneshwar (Orissa) 751 030

## APPENDIX 9

## A. ALL-INDIA CO-ORDINATED RESEARCH PROJECTS AND THEIR PROJECT CO-ORDINATORS

**Crop Sciences**

1. Dr S P Mishra
Project Co-ordinator (Chickpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
2. Project Co-ordinator (Cotton)
CICR Research Station, PO Lawley Road, Coimbatore (Tamil Nadu) 641 003
3. Dr S A Faruqui
Project Co-ordinator (Forage Crops)
Indian Grassland and Fodder Research Institute
PO Pahuj Dam, Jhansi-Gwalior Road
Jhansi (Uttar Pradesh) 284 003
4. Dr R K Lakra
Project Co-ordinator (Honeybees)
Division of Entomology
CCS Haryana Agricultural University
Hisar (Haryana) 125 004
5. Dr R L Srivastava
Project Co-ordinator (Linseed)
CSA University of Agriculture and Technology
Kanpur (Uttar Pradesh) 208 002
6. Dr K T Krishne Gowda
Project Co-ordinator (Small Millets)
University of Agricultural Sciences
GKVK Campus, Bangalore (Karnataka) 560 065
7. Dr B B Singh
Project Co-ordinator (MULLARP)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
8. Dr R K Jain
Project Co-ordinator (Nematodes)
Division of Nematology
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
9. Dr I S Khairwal
Project Co-ordinator (Pearl Millet)
Agricultural Research Station, RAU, Mandore
Jodhpur (Rajasthan) 342 304
10. Dr N D Majumdar
Project Co-ordinator (Pigeonpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
11. Dr S S Duhoon
Project Co-ordinator (Sesame and Niger)
JNKVV, Jabalpur (Madhya Pradesh) 482 004
12. Dr O K Sinha
Project Co-ordinator (Sugarcane)
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002

**Horticulture**

13. Project Co-ordinator (Floriculture)
Division of Floriculture and Landscaping
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
14. Dr S Arulraj
Project Co-ordinator (Palms)
Central Plantation Crops Research Institute
Kasaragod (Kerala) 671 124
15. Dr P S Naik
Project Co-ordinator (Potato)
Central Potato Research Institute
Shimla (Himachal Pradesh) 171 001
16. Dr Om Prakash
Project Co-ordinator (Subtropical Fruits)
Central Institute for Subtropical Horticulture
Rahmankhera, Lucknow (Uttar Pradesh) 227 107
17. Dr M Anandraj
Project Co-ordinator (Spices)
Indian Institute of Spices Research
PB 170, Marikunnu, Calicut (Kerala) 673 012
18. Dr M S Palaniswami
Project Co-ordinator (Tuber Crops), Regional Station
of the Central Tuber Crops Research Institute
Thiruvananthapuram (Kerala) 695 017

**Natural Resource Management**

19. Dr K P R Vittal
Project Co-ordinator (Dryland Agriculture)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 059
20. Dr Muneshwar Singh
Project Co-ordinator (Long-term Fertilizer Experiments)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
21. Dr M V Singh
Project Co-ordinator (Micronutrients and
Secondary Nutrients and Pollutant Elements in Soils and Plants)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
22. Dr Y Muralidharudu
Project Co-ordinator (Soil Test and Crop Response)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
23. 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

24. Dr G G S N Rao
Project Co-ordinator (Agricultural Meteorology)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 059

**Engineering and Technology**

25. Dr M M Pandey
Project Co-ordinator (Farm Implements and Machinery)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
26. Dr L P Gite
Project Co-ordinator (Human Engineering and Safety in Agriculture)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
27. Dr S K Nanda
Project Co-ordinator (Post-harvest Technology)
Central Institute of Post-harvest Technology
Ludhiana (Punjab) 141 004
28. Dr M Shyam
Project Co-ordinator (Renewable Sources of Energy for Agriculture and Agro-based Industries)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
29. Dr S K Rautaray
Project Co-ordinator (Utilization of Animal Energy)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
30. Project Co-ordinator (Application of Plastics in Agriculture)
Central Institute of Post-harvest Technology
Ludhiana (Punjab) 141 004

## B. OTHER ALL-INDIA CO-ORDINATED RESEARCH PROJECTS

**Crop Sciences**

31. Arid Legumes
Central Arid Zone Research Institute
Beehwal
Jodhpur (Rajasthan) 342 003
32. Wheat and Barley
Directorate of Wheat Research
Karnal (Haryana) 132 001
33. Groundnut
National Research Centre on Groundnut
Ivanagar Road, PB 5
Junagarh (Gujarat) 362 001
34. Jute and Allied Fibres
Central Research Institute for Jute and Allied Fibres
Barrackpore (West Bengal) 700 120
35. Maize
Directorate of Maize Research
IARI Campus, Pusa
New Delhi 110 012
36. Component of National Seed Project—Crops
Directorate of Seed Research
Kusmaur, Mau Nath Bhanjan (Uttar Pradesh) 275 101
37. Network on Pesticide Residues
Division of Agricultural Chemicals, LBS Building
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
38. National Research Centre for Rapeseed-Mustard
Sewar Farm, Distt Bharatpur (Rajasthan) 321 303
39. Biological Control
Profect Diretorate of Biological Control
Hebbal, Bengalore (Karnataka) 560 024
40. Sorghum
National Research Centre for Sorghum
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
41. Soybean
National Research Centre for Soybean
Khandwa Road, Indore (Madhya Pradesh) 452 017
42. Sunffower, Safflower, Castor
Directorate of Oilseeds Research
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
43. Under-utilized and Under-exploited Crops
National Bureau of Plant Genetic Resources
Pusa, New Delhi 110 012
44. Rice
Directorate of Rice Research
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030

**Horticulture**

45. Arid Fruits
Central Institute of Arid Horticulture
Bikaner (Rajasthan) 334 006
46. Cashew
National Research Centre for Cashew
Puttur (Karnataka) 574 202
47. Mushrooms
National Centre for Mushroom Research and Training
Chambaghat
Solan (Himachal Pradesh) 173 213
48. Tropical Fruits
Indian Institute of Horticultural Research
Hessaraghatta Lake Post
Bangalore (Karnataka) 560 089
49. Vegetable
Indian Institute of Vegetables Research
Varanasi (Uttar Pradesh) 221 005

**Natural Resource Management**

50. Agroforestry
National Research Centre on Agroforestry
Gwalior-Jhansi Road
(Uttar Pradesh) 284 003
51. Biological Nitrogen Fixation—Network on Biofertilizers
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
52. Cropping Systems Research
Project Directorate on Cropping Systems Research, Modipuram
Meerut (Uttar Pradesh) 250 110
53. Water Management Research
Khurda
Bhubaneshwar (Orissa) 751 023
54. Weed Control
National Research Centre for Weed Science
Adhartal, Jabalpur (Madhya Pradesh) 482 004
55. Optimization of Ground Water Utilization
Khurda
Bhubaneshwar (Orissa) 751 023

56. Processing, Handling and Storage of Jaggery and Khandsari
    Indian Institute of Sugarcane Research
    Lucknow (Uttar Pradesh) 226 002

**Animal Sciences**

57. Goat Improvement
    Central Institute for Research on Goats, Makhdoom
    Mathura (Uttar Pradesh) 281 122
58. Pigs
    Indian Veterinary Research Institute
    Izatnagar (Uttar Pradesh) 243 122
59. Improvement of Feed Resources and Nutrient Utilization for raising Animal Production
    Indian Council of Agricultural Research
    Krishi Bhavan, New Delhi 110 001
60. Cattle Research
    Project Directorate on Cattle
    Grass Farm Road, PB17
    Meerut (Uttar Pradesh) 250 001
61. Poultry
    Project Directorate on Poultry
    Rajendranagar, Hyderabad (Andhra Pradesh) 500 030

**Education**

62. Home Science
    Division of Education
    ICAR, Krishi Anusandhan Bhavan II
    Pusa, New Delhi 110 012

## APPENDIX 10

## AGRICULTURAL UNIVERSITIES AND THEIR VICE-CHANCELLORS

1. Dr S Raghuvardhan Reddy
   Acharya N G Ranga Agricultural University
   Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
2. Dr M C Varashneya
   Anand Agricultural University
   Anand (Gujarat) 388 110
3. Dr S S Baghel
   Assam Agricultural University, Jorhat
   (Assam) 785 013
4. Dr Deepak Kumar Bagchi
   Bidhan Chandra Krishi Vishwa Vidyalaya
   Mohanpur, Nadia (West Bengal) 741 252
5. Dr N N Singh
   Birsa Agricultural University
   Ranchi (Jharkhand) 834 006
6. Dr M M Agrawal
   Chandra Shekhar Azad University of Agriculture and Technology,
   Kanpur (Uttar Pradesh) 208 002
7. Dr J C Katyal
   Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) 125 004
8. Dr S A Nimbalkar
   Dr Panjabrao Deshmukh Krishi Vidyapeeth
   Akola (Maharashtra) 444 104
9. Dr Jagmon Singh Chauhan
   Dr Yashwant Singh Parmar University of Horticulture and Forestry
   Nauni, Distt Solan (Himachal Pradesh) 173 230
10. Dr P L Gautam
    Govind Ballabh Pant University of Agriculture and Technology
    Pantnagar (Uttaranchal) 263 145
11. Dr R N Sreenivas Gowda
    Karnataka Veterinary, Animal and Fisheries Sciences University
    Bidar (Karnataka) 585 401
12. Dr D S Rathore
    Ch Sarwan Kumar Krishi Vishwavidyalaya
    Palampur (Himachal Pradesh) 176 062
13. Dr C R Hazra
    Indira Gandhi Krishi Vishwavidyalaya
    Raipur (Chhattisgarh) 492 012
14. Dr D P Singh
    Jawaharlal Nehru Krishi Vishwa Vidyalaya
    Jabalpur (Madhya Pradesh) 482 004
15. Dr B K Kikani
    Junagarh Agricultural University
    Junagarh (Gujarat) 362 001
16. Dr K V Peter
    Kerala Agricultural University
    Vellanikara, Distt Thrissur (Kerala) 680 656
17. Dr S S Magar
    Dr Balaesahib Sawant Konkan Krishi Vidyapeeth
    Dapoli (Maharashtra) 415 712
18. Dr R B Deshmukh
    Mahatma Phule Krishi Vidyapeeth
    Rahuri (Maharashtra) 413 722
19. Dr S S Kadam
    Marathwada Agricultural University
    Parbhani (Maharashtra) 431 402
20. Dr S L Mehta
    Maharana Pratap University of Agriculture and Technology
    Udaipur (Rajasthan) 313 001
21. Dr S M Ilyas
    Narendra Dev University of Agriculture and Technology,
    Faizabad (Uttar Pradesh) 224 229
22. Dr R P S Ahlawat
    Navasari Agricultural University
    Navasari (Gujarat) 396 450
23. Dr B Senapati
    Orissa University of Agriculture and Technology
    Bhubaneshwar (Orissa) 751 003
24. Dr K S Aulakh
    Punjab Agricultural University
    Ludhiana (Punjab) 141 004
25. Dr Parmatma Singh
    Rajasthan Agricultural University
    Bikaner (Rajasthan) 334 002
26. Dr H P Singh
    Rajendra Agricultural University
    Samastipur, Pusa (Bihar) 848 125
27. Dr B S Chandawat
    Sardar Krishi Nagar Dantiwada Agricultural University
    Dantiwada (Gujarat) 385 506
28. Dr I B Singh
    Sardar Ballabh Bhai Patel University of Agriculture and Technology
    Modipuram, Meerut (Uttar Pradesh) 250 110
29. Dr Anwar Alam
    Sher-e-Kashmir University of Agricultural Sciences and Technology
    Srinagar (Jammu and Kashmir) 191 121
30. Dr Nagendra Sharma
    Sher-e-Kashmir University of Agricultural Sciences and Technology
    45-B, Gandhinagar, PB 37
    Jammu (Jammu and Kashmir) 180 012
31. Dr Priyadarshi Dash
    Sri Venkateswara Veterinary University
    Tirupati (Andhra Pradesh)
32. Dr C Ramasamy
    Tamil Nadu Agricultural University
    Coimbatore (Tamil Nadu) 641 003
33. Dr N Balaraman
    Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu) 600 051
34. Dr M N Sheelavantar
    University of Agricultural Sciences, GKVK
    Bangalore (Karnataka) 560 065

35. Dr S A Patil
University of Agricultural Sciences
Dharwad (Karnataka) 580 005
36. Dr A K Bandyopadhyay
West Bengal University of Animal and
Fishery Sciences, 68KB Sarani
Kolkata (West Bengal) 700 037
37. Dr A T Sherikar
Maharashtra Animal Sciences and Fisheries University
Nagpur (Maharashtra) 440 006
38. Dr S K Garg
Deen Dayal Upadhyaya Veterinary and Animal Science University
Mathura (Uttar Pradesh) 281 001
39. Dr M K Majumdar
Uttar Banga Krishi Vishwavidyalaya
Pundibari
Cooch Behar, (West Bengal) 736 165

**Central Agricultural University**

1. Dr S N Puri
Central Agricultural University
Imphal (Manipur) 795 004

**Central Universities**

1. Dr Naseem Ahmad
Aligarh Muslim University
Aligarh (Uttar Pradesh) 202 002
2. Dr Panjab Singh
Banaras Hindu University
Varanasi (Uttar Pradesh) 221 005
3. Professor S K Basu
Upacharya, Visva Bharati
Sriniketan (West Bengal) 731 236
4. Prof G D Sharma
School of Agricultural Sciences and Rural Development
Nagaland University
Medziphema (Nagaland) 797 106

**Deemed-to-be Universities**

1. Dr A K Singh
Indian Agricultural Research Institute
Pusa, New Delhi 110 012
2. Dr M P Yadav
Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122
3. Dr Sushil Kumar
National Dairy Research Institute
Karnal (Haryana) 132 001
4. Dr Dilip Kumar
Central Institute of Fisheries Education
Jaiprakash Road,
Seven Bungalows, Versova
Mumbai (Maharashtra) 400 061
5. Dr R B Lal
Allahabad Agricultural Institute
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. Post | 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 among them | Percentage to total employees |
|---|---|---|---|---|---|---|---|---|
| **1. Scientific Post** | | | | | | | | |
| Scientist | 3,881 | 3,518 | 317 | 9.01 | 49 | 1.39 | 218 | 6.19 |
| Senior Scientist | 1,651 | 510 | 56 | 10.98 | 18 | 3.52 | 46 | 9.01 |
| Prinicipal Scientist | 749 | 470 | 38 | 8.00 | 5 | 1.06 | 24 | 5.10 |
| RMP Scientist | 147 | 111 | 2 | 1.80 | 1 | 0.90 | 5 | 4.50 |
| **Total** | **6,428** | **4,609** | **413** | **8.65** | **73** | **1.58** | **293** | **6.35** |
| **2. Technical Posts** | | | | | | | | |
| Category I | 4,362 | 4,026 | 794 | – | 295 | – | 298 | – |
| Category II | 2,961 | 2,684 | 460 | – | 152 | – | 244 | – |
| Category III | 629 | 645 | 82 | – | 31 | – | 32 | – |
| **Total** | **7,952** | **7,355** | **1,336** | – | **478** | – | **574** | – |
| **3. Administration Posts** | | | | | | | | |
| (a) Directors/Dy.Secretaries Under Secretaries/ Sr. Admn. Officer/ Sr. Accounts Officer/ Admn. Officer/ F&AO/Legal, PS etc. | 225 | 189 | 51 | – | 21 | – | 3 | – |
| (b) Asstt. Fin. & Accounts Officer/Accounts Officer Section Officer/Hindi Officer/Desk Officer/ | 608 | 491 | 78 | – | 29 | – | 28 | – |
| (c) Assistants | 1,377 | 1,290 | 176 | – | 70 | – | 53 | – |
| (d) Stenographers | 617 | 570 | 80 | – | 29 | – | 50 | – |
| (e) UDC/Senior Clerk | 1,315 | 1,394 | 272 | – | 90 | – | 89 | – |
| (f) LDC/Junior Clerk | 961 | 771 | 169 | – | 59 | – | 109 | – |
| **Total** | **5,103** | **4,705** | **826** | – | **298** | – | **332** | **–** |
| **4. Supporting Staff** | | | | | | | | |
| Grade I | 3,797 | 3,216 | 703 | – | 109 | – | 358 | – |
| Grade II | 3,247 | 3,175 | 873 | – | 232 | – | 169 | – |
| Grade III | 1,879 | 1,806 | 499 | – | 131 | – | 87 | – |
| Grade IV | 982 | 800 | 268 | – | 116 | – | 33 | – |
| Group C (Non-Ministerial and Group D) | 53 | 70 | 63 | – | – | – | – | – |
| **Total** | **9,958** | **9,067** | **2,406** | – | **588** | **–** | **647** | **–** |
| **5. Supporting Staff** (*Safaiwala*) | 166 | 90 | 82 | – | – | – | – | – |
| **Auxillary posts** (dying cadre) | 21 | 17 | 05 | – | – | – | – | – |
| **Total** | **187** | **107** | **87** | – | **–** | **–** | **–** | **–** |

## APPENDIX 12

## AWARDS

| AWARD | AWARDEES |
|---|---|
| **Sardar Patel Outstanding Institution Award (2004)** | *ICAR Institutes*<br>(i) Central Institute for Research on Cotton Technology, Mumbai |
| **Jawaharlal Nehru Award for Outstanding Post-graduate Agricultural Research (2004)** | *Crop Improvement*<br>(i) Dr Rupakula Aruna, Osmania University, Hyderabad<br>(ii) Dr Geeta S Pillai, University of Calicut, Calicut<br>*Biotechnology*<br>(i) Dr V N Kulkarni, UAS, Dharwad<br>Dr Vijay Paul, NDRI, Karnal<br>*Plant Protection*<br>(i) Dr G Radha Krishnan, IARI, New Delhi<br>(ii) Dr Ashutosh Pathak, GBPUAT, Pantnagar<br>*Natural Resource Management*<br>(i) Dr Balram Panigrahi, IIT, Kharagpur<br>(ii) Dr Gopi Ramesh, ANGRAU, Hyderabad<br>*Horticulture*<br>(i) Dr C Lekha Rani, KAU, Vellayani<br>(ii) Dr T Damodaran, TNAU, Coimbatore<br>*Engineering and Technology*<br>(i) Dr Jaya Sundaram, IIT, Kharagpur<br>(ii) Dr S K Jana, IIT, Kharagpur<br>*Animal Sciences*<br>(i) Dr A K Mohanty, AIIMS, New Delhi<br>(ii) Dr S B Shivachandra, IVRI, Izatnagar<br>(iii) Dr S K Bhanja, IVRI, Izatnagar<br>*Fisheries*<br>(i) Dr Saly N Thomas, University of Science and Technology, Cochin<br>*Social Sciences*<br>(i) Dr N Anandaraja, TNAU, Coimbatore<br>(ii) Dr Sunanda K Itagi, UAS, Dharwad |
| **N.G. Ranga Farmer Award for Diversified Agriculture (2004)** | (i) Mr Nand Kishore Jaisalmaria, Vil. Manakla, Jodhpur |
| **Panjabrao Deshmukh Women Agricultural Scientist Award (2004)** | (i) Dr M Sujatha, DOR, Hyderabad<br>(ii) Dr A A Sherikar, Mumbai Veterinary College, Mumbai<br>(iii) Dr G Taru Sharma, IVRI, Izatnagar |
| **Vasantrao Naik Award for Research Applications in Dryland Agriculture (2004)** | (i) Dr Gauranga Kar<br>Dr Ravendra Singh<br>Dr H N Verma and Dr B K James, WTC for Eastern Region, Bhubaneshwar |
| **Chaudhary Devi Lal Outstanding AICRP Award (2004)** | (i) Longterm Fertilizer Experiment, IISS, Bhopal |
| **Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research & Development (2004)** | (i) Mr Anil Bansal, Jansatta Bureau, Meerut |

| AWARD | AWARDEES |
|---|---|
| **Rafi Ahmed Kidwai Awards for the Biennium (2003–2004)** | *Crop Improvement and Crop Protection*<br>(i) Dr F U Zaman, IARI, New Delhi<br>(ii) Dr B N Johri, GBPUAT, Pantnagar<br><br>*Natural Resource Management*<br>(i) Dr P Dureja, IARI, New Delhi<br><br>*Horticulture*<br>(i) Dr R K Pathak, CISH, Lucknow<br><br>*Engineering and Technology*<br>(i) Dr R C Srivastava, WTCER, Bhubaneshwar<br><br>*Animal Sciences*<br>(i) Dr M C Sharma, IVRI, Izatnagar<br>(ii) Dr Usha Rani Mehra, IVRI, Izatnagar<br><br>*Fisheries and Aquatic Life Sciences*<br>(i) Dr Iddya Karunasagar, UAS, Mangalore |
| **Hari Om Ashram Trust Awards for the Biennium (2003–2004)** | *Crop Sciences*<br>(i) Dr A B Mandal, CARI, Port Blair<br><br>*Natural Resource Management*<br>(i) Dr O S Tomar, Dr P S Minhas and Dr J C Dagar CSSRI, Karnal<br><br>*Horticulture*<br>(i) Dr B P Singh, Dr S Roy and Dr P H Singh, CPRI, Shimla<br><br>*Animal Sciences*<br>(i) Dr K T Sampath, Dr M Chandra Shekhariah and Dr (Ms) A Thulasi, NIANP, Bangalore |
| **Lal Bahadur Shastri Young Scientist Awards for Biennium (2003–2004)** | *Crop Sciences* (Crop Improvement and Protection)<br>(i) Dr R C Bhattacharya, NRC Plant Bio-Technology, New Delhi<br>(ii) Dr P D Kamala Jayanti, IIHR, Bangalore<br><br>*Soil Science, Agronomy and Agroforetry*<br>(i) Dr Dharam Vir Singh, CSWCRT&I, Dehra Dun<br>(ii) Dr U K Mandal, CRIDA, Hyderabad<br><br>*Horticulture*<br>(i) Dr Sanjeet Kumar, IIVR, Varanasi<br>(ii) Dr Subaharan, CPCRI, Kasaragod<br><br>*Animal Sciences*<br>(i) Dr T K Bhattacharya, IVRI, Izatnagar<br>(ii) Dr Bollini Sreedevi, College of Veterinary Sciences, Tirupati<br><br>*Social Sciences and Home Science*<br>(i) Dr Anjani Kumar, NCAP, New Delhi |
| **Swami Sahajanand Saraswati Extension Scientist/Worker Awards for the Biennium (2003–2004)** | *Crop Production*<br>(i) Dr R K Sohane, KVK, Begusarai, Bihar<br><br>*Livestock Production*<br>(i) Dr S C Pramanik, CARI, Port Blair<br>*Natural Resource Management*<br>(i) Dr P Anitha Kumari, CPCRI Regional Station, Kayamkulam, Kerala |
| **Jagjivan Ram Kisan Puraskar (2004)** | (i) Mr C H Bhadsavle, Malegaon, Raigod, Maharashtra<br>(ii) Mr Vinayak R Bari, Kankevadi, Thane, Maharashtra<br>(iii) Mr A K Sarkar, Samsapur, Dirajpur, West Bengal |

## APPENDIX 13

## AUDIT PARAS
## MINISTRY OF AGRICULTURE
## DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

### Extra expenditure due to excess contracted demand of power

Due to retention of contracted demand of power in excess of requirement DMS incurred avoidable expenditure of Rs 2.20 crore.

*(Report No. 2 of 2005)*
*Transaction Audit Observations*

### INDIAN COUNCIL OF AGRICULTURAL RESEARCH

### Management of projects relating to utilization and conservation of soil and water undertaken by ICAR

Natural Resource Management Division of Indian Council of Agricultural Research (ICAR) is responsible for research on conservation, improvement and efficient utilization of soil and water. Five research institutes of ICAR, viz. National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur; Indian Institute of Soil Science (IIS), Bhopal; Central Soil Salinity Research Institute (CSSRI), Karnal; Water Technology Centre for Eastern Region (WTCER), Bhubaneshwar, and Central Soil and Water Conservation Research and Training Institute (CSWCR&TI), Dehra Dun are engaged in research in these areas. Review of management of projects undertaken/completed by these institutes during 1999–2000 to 2003–04 disclosed the following:

(i) NBSS&LUP, Nagpur completed 45 projects and terminated 15 projects before their completion during 1999–04. Of the completed projects, research project files were available for 19 projects only which were examined in audit. It could not achieve objectives of soil survey, mapping and land use planning in three projects involving an expenditure of Rs 6.63 crore. Soil Survey reports were not prepared even after lapse of five to 25 years.

(ii) During the period 1999–04, IISS Bhopal completed 36 projects, of which 19 projects were test checked. It did not achieve the desired results in soil science research in two projects, despite expenditure of Rs 55.25 lakh. Apart from this, technologies developed in three projects at a total cost of Rs 1.18 crore were not transferred to the end-users. ICAR did not furnish reasons for non-transfer of technologies to the end-users.

(iii) CSSRI, Karnal completed 72 projects during 1999–2004, of which 40 were test checked. It could not solve effectively the issues relating to reclamation and management of alkaline and saline soils in two projects costing Rs 12.82 crore. Map of salt affected soils of India was also not prepared. In three projects, technology developed at a cost of Rs 47.12 lakh was not transferred to the end users.

(iv) WTCER, Bhubaneshwar completed 28 projects during 1999–04, of which 20 projects were test checked. It failed to accomplish targeted results in three projects costing Rs 36.39 lakh resulting in non-achievement of the objective of sustainable agricultural production through management of canal water, rain water and waterlogged land. Besides, it did not transfer to the end-users the technology developed at a total cost of Rs 66.13 lakh in six projects.

(v) CSWCR&TI, Dehradun completed 86 projects during 1999–2000 to 2003–04, of which 16 projects where project records were maintained were test checked. It did not achieve the objective of research in soil and water conservation measures and land use systems for sustainable crop production in three projects costing Rs 37.90 lakh. It also did not transfer to the end-users the technology developed in four projects at a total cost of Rs 12.31 lakh.

### Short recovery of electricity charges

Indian Council of Agricultural Research (ICAR) obtained temporary electricity connection of 340 KW from Delhi Vidyut Board (DVB) in May 1999 for their newly constructed National Agricultural Science Centre (NASC) complex. Apart from the residential quarters, some private and ICAR offices were also housed in the complex. Perusal of the electricity bills paid by ICAR relating to NASC complex and recoveries effected their against revealed that during the period June 1999 to March 2004, the residents of staff quarters had consumed 6,11,436 units of electricity for which an amount of Rs 47.35 lakh, including demand charges and electricity tax, was recoverable from them. However, the recovery made by ICAR against this was Rs 18.16 lakh only, resulting in short recovry of Rs 29.19 lakh.

*(Para 8.1 of Report No. 5 of 2005)*
*Scientific Departments)*

# Acronyms

| | | |
|---|---|---|
| AADU | : | Allahabad Agricultural Deemed University |
| AAU | : | Assam Agricultural University |
| AB | : | Accreditation Board |
| AER | : | Agro-ecological Region |
| AESR | : | Agro-ecological Subregion |
| AGRI-IS | : | Animal Genetic Resources of the India-Information System |
| AHRD | : | Agricultural Human Resources Development |
| AICRP | : | All-India Coordinated Research Project |
| AMS | : | Aggregate Measure of Support |
| ANGRAU | : | Acharya N G Ranga Agricultural University |
| APC | : | Agro-processing Centre |
| ANN | : | Artificial Neural Network |
| APEDA | : | Agricultural Products Export Development Agency |
| ARI | : | Agricultural Research Institute |
| ARIS | : | Agricultural Research Information System |
| ARS | : | Agricultural Research Service |
| ASRB | : | Agricultural Scientists Recruitment Board |
| ATICs | : | Agricultural Technology Information Centres |
| ATMA | : | Agricultural Technology Management Agency |
| AVT | : | Advance Varietal Trial |
| AWS | : | Ammoniated Wheat Straw |
| BBF | : | Broad Bed and Furrow |
| BBTV | : | Banana Bunchy Top Virus |
| BE | : | Budget Estimate |
| BPH | : | Brown Plant-hopper |
| BSMCs | : | Brood Subject Matter Committees |
| BVD | : | Bovine Viral Diarrhoea |
| CABI | : | Centre for Agriculture and Biosciences International |
| CAPART | : | Council for Advancement of People's Action and Rural Technology |
| CARI | : | Central Avian Research Institute |
| CARP | : | Council for Agricultural Research Policy (Sri Lanka) |
| CAS | : | Centres of Advanced Studies |
| CAU | : | Central Agricultural University |
| CAZRI | : | Central Arid Zone Research Institute |
| CCPP | : | Contagious Caprine Pleuro Pneumonia |
| CCSHAU | : | Choudhary Charan Singh Haryana Agricultural University |
| CEC | : | Cation Exchange Capacity |
| CFB | : | Complete Feed Block |
| CFC | : | Common Fund for Commodities |
| CGP | : | Competitive Grant Programme |
| CIAE | : | Central Institute of Agricultural Engineering |
| CIAH | : | Central Institute of Arid Horticulture |
| CIAT | : | Central International de Agricultural Tropical, Centre for Tropical International Agriculture |
| CIBA | : | Central Institute of Brackishwater Aquaculture |
| CIFA | : | Central Institute Freshwater Aquaculture |
| CIFE | : | Central Institute of Fisheries Education |
| CIFT | : | Central Institute of Fisheries Technology |
| CIMMYT | : | Centro International de Mejomento de Maize Trigo |
| CIPHET | : | Central Institute of Post-harvest Engineering and Technology |
| CIRCOT | : | Central Institute for Research on Cotton Technology |
| CIRG | : | Central Institute for Research on Goats |
| CISH | : | Central Institute for Subtropical Horticulture |
| CITH | : | Central Institute of Tropical Horticulture |
| CMFRI | : | Central Marine Fisheries Research Institute |
| CMS | : | Cytoplasmic Male Sterile |
| CP | : | Crude Protein |
| CPCRI | : | Central Plantation Crops Research Institute |
| CRIDA | : | Central Research Institute for Dryland Agriculture |
| CRIJAF | : | Central Research Institute for Jute and Allied Fibres |
| CRRI | : | Central Rice Research Institute |
| CSSRI | : | Central Soil Salinity Research Institute |
| CSWRI | : | Central Sheep and Wool Research Institute |
| CTCRI | : | Central Tuber Crops Research Institute |
| CTV | : | Citrus Tristeza Virus |
| CYMBV | : | Citrus Yellow Mosaic Badna Virus |
| CZ | : | Central Zone |
| DAC | : | Department of Agriculture and Cooperation |
| DARE | : | Department of Agricultural Research and Education |
| DAS | : | Days After Sowing |
| DBT | : | Department of Biotechnology |
| DCP | : | Digestible Crude Protein |
| DEE | : | Directorate of Extension Education |
| DIPA | : | Directorate of Information and Publications of Agriculture |
| DSIR | : | Department of Scientific and Industrial Research |
| DST | : | Department of Science and Technology |
| DUs | : | Deemed-to-be Universities |
| DWR | : | Directorate of Wheat Research |
| EADR | : | Equivalent Average Death Rate |
| ELISA | : | Enzyme-linked Immunosorbent Assay |
| EMC | : | Equilibrium Moisture Content |
| EPN | : | Entomopathogenic Nematode |
| ESP | : | Exchangeable Sodium Percentage |
| ETL | : | Economic Threshold Level |
| FAO | : | Food and Agriculture Organization |
| FCV | : | Flue-cured Virginia |
| FMC | : | Field Management Committee |
| FECRT | : | Faecal Egg Count Reduction Test |
| FFS | : | Farmers' Field School |
| FIM | : | Farm Implements and Machinery |
| FIRB | : | Furrow Irrigation Raised Bed |
| FLDs | : | Frontline Demonstrations |
| FMD | : | Food-and-Mouth Disease |
| FRP | : | Fibreglass Reinforced Plastic |
| FYM | : | Farmyard Manure |
| GBPUAT | : | Govind Ballabh Pant University of Agriculture and Technology |
| GDD | : | Growing Degree Days |
| GDP | : | Gross Domestic Product |
| GIS | : | Geographical Information System |
| GOI | : | Government of India |
| GPC | : | Grain Protein Content |
| GTR | : | Guided Tissue Generation |
| HAI | : | Health Assessment Index |
| HF | : | Holstein Friesian |
| HRD | : | Human Resource Development |
| HSD | : | High Speed Diesel |
| HYV | : | High-yielding Variety |
| IARI | : | Indian Agricultural Research Institute |

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| IASRI | : | Indian Agricultural Statistics Research Institute |
| IBR | : | Infectious Bovine Rhinotracheitis |
| ICAR | : | Indian Council of Agricultural Research |
| ICARDA | : | International Centre for Agricultural Rsearch in Dry Areas |
| ICAR-RC-NEH | : | ICAR Research Complex for North-Eastern Hills Region |
| ICMV | : | Indian Cassava Mosaic Virus |
| ICOR | : | International Capital Output Ratio |
| ICRISAT | : | International Crops Research Institute for Semi-arid Tropics |
| ICRSV | : | Indian Citrus Ringspot Virus |
| ICT | : | Information and Communication Technology |
| IDFS | : | International Dairy Federation Standards |
| IFSP | : | International Foundation for Science Project |
| IGFP | : | Insulin like Growth Factor Protein |
| IGFRI | : | Indian Grassland and Fodder Research Institute |
| IGKVV | : | Indira Gandhi Krishi Vishwa Vidyalaya |
| IGNOU | : | Indira Gandhi National Open University |
| IGP | : | Indo-Gangetic Plains |
| ILRI | : | Indian Lac Research Institute |
| ILRI | : | International Livestock Research Institute |
| IIVR | : | Indian Institute of Vegetable Research |
| IPGRI | : | International Plant Genetic Resources Institute |
| ITDP | : | Integrated Tribal Development Project |
| IWMI | : | International Water Management Institute |
| INARIS | : | Integrated National Agricultural Resource Information System |
| IIHR | : | Indian Institute of Horticultural Research |
| IIPR | : | Indian Institute of Pulses Research |
| IISR | : | Indian Institute of Sugarcane Research |
| IIT | : | Indian Institute of Technology |
| INM | : | Integrated Nutrient Management |
| IPM | : | Integrated Pest Management |
| ISD | : | Integrated System Development |
| ISNAR | : | International Service for National Agricultural Research |
| ISRO | : | Indian Space Research Organization |
| ITD | : | Innovations in Technology Dissemination |
| ITK | : | Indigenous Technical Knowledge |
| IVF | : | *In-vitro* Fertilization |
| IVLP | : | Institution-Village Linkage Programme |
| IVRI | : | Indian Institute of Vegetable Research |
| JD | : | Johne's Disease |
| JNKVV | : | Jawaharlal Nehru Krishi Vishwa Vidyalaya |
| KAU | : | Kerala Agricultural University |
| KKV | : | Konkan Krishi Vidyapeeth |
| KVKs | : | Krishi Vigyan Kendras |
| LCC | : | Leaf Colour Chart |
| LE | : | Larval Equivalent |
| LER | : | Land Equivalent Ratio |
| LIS | : | Library Information System |
| MABM | : | Master ofr Agri-business Management |
| MHRD | : | Ministry of Human Resource Development |
| MM | : | Mission Mode |
| MoA | : | Memorandum of Agreement |
| MoU | : | Memorandum of Understanding |
| MPKV | : | Mahatma Phule Krishi Vidyapeeth |
| MPTS | : | Multipurpose Tree Species |
| MRL | : | Maximum Residual Limit |
| MRP | : | Mussourie Rockphosphate |
| MS | : | Male-sterile |
| MV | : | Modern Varieties |
| NAA | : | Nophthalene Acetic Acid |
| NAARM | : | National Academy of Agricultural Research and Management |
| NABARD | : | National Bank for Agricultural and Rural Development |
| NADRES | : | National Animal Disease Referral Exert System |
| NAIP | : | National Agricultural Innovation Project |
| NAP | : | National Agricultural Policy |
| NARD | : | National Agricultural Research Database |
| NARP | : | National Agricultural Research Project |
| NARS | : | National Agricultural Research System |
| NASM | : | National Agriculture Science Museum |
| NATP | : | National Agricultural Technology Project |
| NBAGR | : | National Bureau of Animal Genetic Resources |
| NBFGR | : | National Bureau of Fish Genetic Resources |
| NBPGR | : | National Bureadu of Plant Genetic Resources |
| NBSS & LUP | : | National Burearu of Soil Survey and Land Use Planning |
| NCAP | : | National Centre for Agricultural Economics and Policy Planning |
| NDRI | : | National Dairy Research Institute |
| NDUAT | : | Narendra Deva University of Agriculture and Technology |
| NEH | : | North-Eastern Hills |
| NEPZ | : | North-Eastern Plains Zone |
| NET | : | National Eligibility Test |
| NGOs | : | Non-Government Organizations |
| NIRJAFT | : | National Institute of Research on Jute and Allied Fibre Technology |
| NRCAF | : | National Research Centre on Agroforestry |
| NRCC | : | National Research Centre on Camel |
| NRCE | : | National Research Centre on Equines |
| NRCWA | : | National Research Centre for Women Agriculture |
| NRSA | : | National Remote Sensing Agency |
| NTS | : | National Talent Scholarship |
| O&M | : | Organization and Management |
| OBCs | : | Other Backward Classes |
| OL | : | Other Languages |
| OUAT | : | Orissa University of Agriculture and Technology |
| PAGE | : | Polyacrylamide Gel Electrophoresis |
| PAU | : | Punjab Agricultural University |
| PCR | : | Polymerase Chain Reaction |
| PCR-RFLP | : | PCR-Restriction Fragment Length Polymorphism |
| PDKV | : | Dr Panjab Rao Deshmukh Krishi Vidyapeeth |
| PEQN | : | Post-Entry Quarantine Nursery |
| PERMISNET | : | Personal Management Informational System Network |
| PFP | : | Partial Factor Productivity |
| PIC | : | Polymorphism Information Content |
| P&L | : | Partnership and Linkages |
| PMC | : | Project Management Committee |
| PPR | : | Peste des Petitis Rumenentis |
| PRA | : | Pathogen Risk Analysis |
| PSB | : | Phosphate-solubilizing Bacteria |
| PSR | : | Production System Research |
| PTO | : | Power Take Off |
| QUEFTS | : | Quantitative Evaluation of Fertility of Tropical Soils |
| QRT | : | Quinquennial Review Team |
| RAPD | : | Random Amplified Polymorphic DNA |
| RAU | : | Rajendra Agricultural University/Rajasthan Agriculture University |
| RAWE | : | Rural Agriculture Work Experience |
| RDT | : | Rough-set-based Decision Tree |

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|---|---|---|
| RE | : | Revised Estimate |
| REP | : | Relative Erosion Potential |
| RFLP | : | Restricted Fragment Length Polymorphism |
| RPFs | : | Research Project Files |
| RSC | : | Residual Sodium Carbonate |
| RSPPT | : | Random Sample Poultry Performance Test |
| SAARC | : | South Asian Association for Regional Co-operation |
| SAP | : | Scientific Advisory Panel |
| SAR | : | Sodium Adsorption Ratio |
| SAUs | : | State Agricultural Universities |
| SC | : | Scheduled Caste |
| SFC | : | Standing Finance Committee |
| SHGs | : | Self Help Groups |
| SREP | : | Strategic Research and Extension Plan |
| ST | : | Scheduled Tribe |
| STCR | : | Soil Test-based Crop Response |
| STMS | : | Sequence Tagged Micro Satellite |
| TAR/IVLP | : | Technology Assessment and Refinement Institution Village Linkage Programme |
| TC | : | Technical Co-ordination |
| TDN | : | Total Digestible Nutrient |
| TDS | : | Total Dissolved Salts |
| TFP | : | Total Factor Productivity |
| TNAU | : | Tamil Nadu Agricultural University |
| TNUVAU | : | Tamil Nadu University of Veterinary and Animal Sciences |
| ToE | : | Team of Excellence |
| TTCs | : | Trainers' Training Centres |
| UAS | : | University of Agricultural Sciences |
| UG | : | Under-graduate |
| UGC | : | University Grants Commission |
| USIF | : | United States India Fund |
| VPKAS | : | Vivekananda Parvatiya Krishi Anusandhan Sansthan |
| WMD | : | White Muscle Disease |
| WTD | : | White Tail Disease |
| YSPUH&F | : | Dr Yashwant Singh Parmar University of Horticulture and Forestry |
| ZARS | : | Zonal Agricultural Research Station |
| ZCUs | : | Zonal Co-ordinating Units |
| ZECC | : | Zero Energy Cool Chamber |

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