1

Overview

The rainfall during the year 2008 (1 June to 30 September 2008) was 98% of its long period average (LPA) and a cumulative seasonal rainfall for the country as a whole was near normal. Monsoon covered the entire country on 10 July against its normal date of 15 July. Of the 36 meteorological subdivisions, 32 received excess/normal rainfall and the remaining 8% received deficient rainfall during the season. During the year country harvested a record 230 million tonnes of foodgrains and estimations for the year ahead are even higher. The production of rice, wheat and maize was highest so far. The fish production was 6.87 million tonnes and the milk production was over 100 million tonnes. The floods and outbreak of avian influenza in the eastern and NE parts of the country remained a cause of concern.

The Indian Council of Agricultural Research marched ahead in generating technologies towards sustainable advancements in agriculture and allied sectors, improving quality of higher agricultural education, institutional capacity building, fostering international linkages for co-operation in agricultural research etc. The research and development activities during the year covered wide areas, ranging from optimizing resources' use, improved cultivation techniques, development of improved varieties/breeds, excellence in agricultural education and frontline extension of technologies, providing improved planting materials, imparting training especially to rural women and youth and various stakeholders through the chain of Krishi Vigyan Kendras as a knowledge hub. In our efforts to improve the system's efficiency and to make the research and education programme more relevant in the present context, organization and management (O&M) reforms were put in place. Human resource development (HRD) programmes and talent search in agricultural sciences continued to meet the future needs of agricultural research, education and extension.

The Council has taken decision to reorient the functioning of some National Research Centres to work in Directorate mode such as Groundnut; Rapeseed-Mustard; Soybean; Sorghum; Coldwater Fisheries; Women in Agriculture; Oil Palm; Cashew; Medicinal and Aromatic Plants; Mushroom; Onion and Garlic; Floriculture; and Water Management. The National Bureau of Agriculturally Important Insects (NBAII) is established by reorienting the Project Directorate of Biological Control. In order to protect agriculture from the increasing abiotic stresses through technological intervention, a state-of-the-art National Institute of Abiotic Stress Management is contemplated.

The number of projects under the Basic and Strategic Research has gone up to 49 during the year. Some of the potential impact making areas under the scheme are controlling arsenic in food chain, genetic engineering for fixation of heterosis, developing wireless sensor for effective animal management, C_4 photosynthetic system in rice, stem cell research in cattle and buffaloes, nano-technology for higher utilization of native phosphorus in arid soils etc. Similarly, there are now 21 projects in network mode to address issues of climate change, control of diseases and pests in crops and livestock etc. Besides the research, continued efforts are on to develop competent Human Resources in frontier areas of science as well as in the IPRs. In order to improve the efficiency of system various measures were taken in the important areas of administration and finance management.

An Overview of the Council's initiatives and achievements during the year under report is presented here.

Soil and water productivity

Soil-erosion maps of districts like Kota

(Rajasthan) and Pauri Garhwal (Uttarakhand) were prepared for resource-conservation planning. Cost-effective bio-engineering structures were developed and locally adaptive flow-resistant vegetative species identified for training the river flow, bank-erosion control and protection of the agricultural land and other property along the banks. Assessment of rainwater harvesting potential across the major rainfed growing districts showed that about 39 million ha area under coarse cereals, rice, cotton, oilseeds and pulses could generate about 114 billion m^3 surplus water capable of providing supplemental irrigation in major part of rainfed areas. Field kits were developed for ascertaining soil sodicity and quality of bofertilizers. Liquid formulations were developed for enhancing the shelf-life of biofertilizers, viz. *Rhizobium, Azospirillum* and phosphate-solubilizing bacteria.

A molecular protocol developed for early and rapid detection of heavy metal pollution in open water can be used to assess the impact of pollution on freshwater fishes. Decision support software developed for shrimp aquaculture will help state governments and other regulatory organizations to regulate the level of shrimp farming activity for each receiving water body and in framing future guidelines and policies for sustainable development of shrimp farming.

Genetic resources

During the year, 33 explorations were undertaken and 2,203 accessions including 784 of wild species were collected. In the National Herbarium of Cultivated Plants, 371 herbarium specimens, 121 seed samples and 21 economic products were added. A total of 25,456 diverse crop accessions were introduced from various countries, and 15,000 accessions, including germplasm from the ICRISAT, were exported to 19 countries. About 13,850 accessions of orthodox seed species were added to the National Genebank.

Twenty accessions of fruit crops, 17 of bulb and tuber crops, five of medicinal and aromatic plants and three of spices were added to the *in-vitro* Genebank. In all, 1,991 accessions (nearly 32,000 cultures) belonging to 52 genera and 158 species of vegetatively propagated crops and medicinal and aromatic and threatened species were conserved. Accessions of fruits and nuts (214), spices (9), industrial crops (136) and medicinal and aromatic plants (72) were cryo-stored.

The community-level physiological profiling of soil microbes using BIOLOG showed significant shift in C-utilization pattern of effluent irrigated soils over the control soil. Forty-five fast-growing actinomycetes strains isolated from the effluent-contaminated sites were characterized at the molecular level. From salt lake of Sambhar, Rajasthan, unique bacterial isolates capable of growing at 20% NaCl and at pH 12 were isolated.

Development of a computational methodology based on genetic algorithm to solve the individual assignment problem using microsatellite data; phenotypic characterization of Bargur cattle, Malnad Gidda cattle, Balangir sheep, Surti goat, and Busra chicken; genotyping of Calpastatin gene, responsible for meat tenderness, in Deccani, Nellore, Sonadi, Malpura, Nali, Ganjam, Chokla and Garole sheep breeds; consistent superiority of naked neck birds to normal birds for broiler traits; and better genetic resistance in SDL-IC broilers than Aseel and Kadaknath against H5N1 infection, are the significant achievements in animals and poultry.

Development of microsatellite markers in *Macrobrachium rosenbergii*; initiation of marker to marker linkage study in rohu; revelation of captive breeding and milt cryopreservation techniques for Indian catfish *Horabagrus nigricollaris*, which was categorized as critically endangered; preparation of DNA barcodes for 180 fish species; and standardization of DNA based-diagnostic technique for species-specific identification of the trematode, *Gyrodactylus elegans*, a first attempt in the country, towards molecular detection of parasites, are some of the major accomplishments in the field of fish genetic resources.

Crop improvement

Seventy-six varieties/hybrids of major food crops including rice, wheat, barley, maize, pearl millet, and pulses and oilseeds have been released/identified for different agro-climatic regions of country.

Significant crop improvement research includes registration of 10 new genetic stocks of wheat, resistance of 78 wheat genotypes to stem rust Ug99, identification of dual-purpose hybrid sorghum CSH 25 for cultivation in *kharif* in Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh and Gujarat. Jute variety JRO 2003 H was recommended for entire tossa-growing belt of country. Sangami variety of tobacco was released for cultivation.

A coloured regular bearing hybrid Arunika of mango, having good fruit qualities, was released. Potato varieties Kufri Khayati and Kufri Sadabahar for plains and Kufri Girdhari (good for processing) for hills were released.

Three varieties of coconut Kalpa Pratibha, Kalpa Mitra and Kalpa Dhenu were released for commercial cultivation. A new high-yielding coconut variety Kalparaksha was recommended for release. A high-yielding and root (wilt)-resistant variety Gauthami Ganga with sweet nut water and high potassium was released for Andhra

Pradesh, Tamil Nadu and Maharashtra.

HH 67 (ew) sorghum bred using DNA markers for downy mildew resistance has significantly arrested spread of disease. A significant breakthrough is development of first public sector transgenic Bt cotton variety Bikaneri Narma (BN Bt) for commercial cultivation, and farmers can reuse seeds of this variety year after year.

Breeders seeds 7,162.4 tonnes of centrally released varieties and 2,788.1 tonnes of state-released varieties of field crops were produced. In fish, 1,502.5 lakh spawn of carps, 504.94 lakh fry + fingerlings of carps, 5.1 lakh fry and spawn of catfish, 22.03 lakh larvae of sweet-water prawn, 185.97 lakh larvae of marine prawn, 12.17 lakh seed of ornamental fishes, 12.7 lakh brackishwater fish fry and 848.87 lakh seed of other marine fishes were produced.

Livestock improvement

The XI set of 14 genetically superior Murrah breeding bulls was selected from the participating centres, and test mating was initiated from July 2008. Herds of elite Jaffarabadi buffaloes were established at the JAU, Junagarh, of elite Pandharpuri buffaloes at the MPKV, Kolhapur, and of elite Surti buffaloes at the MPUAT, Vallabhnagar. Under the programme for enhancing mutton production, the twining rate of 37.61% and triplets of 4.27% were achieved in Garole × Malpura sheep.

A demo microarray (biochip) was developed for the detection of economically important viral pathogens white spot syndrome virus (WSSV), monodon baculovirus (MVV) affecting shrimp and Koi herpes virus. *Lactobacillus* spp. inhibited four strains of *Listeria monocytogenes* and showed desirable characteristics for use as a biocontrol (competitive exclusion) culture. Silver barb, *Puntius sarana,* can be used for biological control of insects. Breakthrough in early carp breeding would enable the farmers to have fingerlings by May for stocking and utilize at least five more months as the growing period. Besides, this opens up the possibility of breeding and seed production of carps round the year. *Osteobrama belangeri,* an endemic species of Loktak lake, Manipur, that fetches high price in local market, was successfully bred under controlled conditions. Shrimp *Penaeus semisulcatus* and crab *Portunus pelagicus* seeds were produced in hatchery and sea ranched. Spawning, hatching and larval rearing of crucifix crab *Charybdis feriatus* was achieved for the first time.

Crop management

Groundnut-wheat-greengram cropping system recorded maximum productivity and improved soil nitrogen and organic-carbon. Sesbania as a green-manure crop preceding mustard recorded significantly higher mustard seed yield in the north-eastern Rajasthan and Haryana. An intercropping of pigeonpea and sorghum in 2:1 row ratio on the raised bed planting gave higher yield than flat bed planting.

Modified central leader system of training gave maximum yield in mango orchards at Pantnagar and Pusa. Saba, Karpuravalli and Ney Poovan banana showed normal finger development and fruit filling under salt-affected field (EC 1:2.5 = 3.34) and Nendran and Robusta recorded small and ill-filled fingers. Okra-gladiolus was found best intercropping in litchi (young) orchard, giving net returns of Rs 97,847/ha annually.

In mango, hot-water treatment of fruits at 48±1°C for 1 hour controlled all stages of fruit fly, *Bactrocera zonata* in Dashehari, Langra, Chausa, Amrapali and Mallika. At Gandevi, for sapota a trap named "NAUROH-STONEHOUSE FRUIT FLY TRAP" was designed and produced commercially for orchardists.

Livestock management

For enhancing the fibre digestibility of poor quality crop residues, cellulase gene obtained from the best fibre degrading fungi, was cloned to *Streptococccus bovis,* a predominant bacteria in rumen of crossbred cattle. A mixture of three plant species reduced methane emission by 12% in crossbred calves, showing that there is a potential in using tree leaves for reducing methane production from enteric fermentation. Dual-staining technique that saved time and chemicals, was standardized for testing viability and acrosomal integrity in frozen and fresh semen. The semen production was high in the intensively reared Jamunapari bucks.

A status of freedom from contagious bovine pleuropneumonia infection in cattle and buffalo was obtained from Office International des Epizooties (OIE). The Indian Veterinary Research Institute, Izatnagar, developed an effective PK-15 cell line-based live attenuated freeze-dried vaccine. To improve the diagnosis of foot-and-mouth disease (FMD) in suspected clinical samples, a multiplex PCR (m-PCR) was developed and by using it 42% of the outbreaks that went undiagnosed using ELISA, were identified. A large databank on the livestock diseases of the country, based on reports submitted to the Government of India by various state governments, was developed at the PD_ADMAS. A web-based interactive expert system on animal diseases of the country was developed, and it can be accessed at www.nadres.res.in.

Molecular diagnosis of brucellosis was standardized that helped in differential diagnosis

of *Brucella abortus* and *B. suis*. Molecular epidemiological studies are being standardized to diagnose and differentiate the brucellosis of cattle, ovine, caprine and humans. Molecular studies on BHV-1 were carried out. Occurrence of zoonotic bacterial pathogens from the livestock and livestock products was studied. A computer interface based BHV-1 whole antigen AB-ELISA developed, as per the standards of the International Atomic Energy Agency (IAEA), was standardized and validated. Serum Bank facility at PD_ADMAS has more than 170,000 serum samples from all over the country, which is being used for long-term national surveys on various diseases of economic importance.

Fish production improved by over 60% in reservoirs Dahod in Madhya Pradesh and Pahuj in Uttar Pradesh, through stocking of fish seed and improvement of institutional arrangements for fish catch and marketing. The compatibility of *Labeo gonius* with other major carps revealed that silver carp has higher overall species survival. A low fish meal shrimp feed was developed which could be successfully used for culturing tiger shrimp at low cost of production. The study on prevalence levels of white spot syndrome virus in crabs indicated that they do not pose any additional WSSV risks. Coconut wood of more than 50 years old was used for constructing a low-cost plank built type of canoe for gillnetting in backwaters. The price of coconut wood is less than half of the conventional boat building timber.

Post-harvest management and value-addition

A process was standardized to make osmotically dehydrated slices from papaya variety Taiwan Red Lady. Bittergourd chips were prepared and popularized among rural and urban areas as snack foods. A solar PV mobile unit was designed and developed to provide a complete self-sustained mobile power unit for domestic, small agricultural and other rural applications in isolated cluster of houses (*dhanis*) of arid region. Several sulphur dyes free from banned amines and safe from ecological considerations were used for dyeing jute fabric.

An immuno-diffusion test for detection of adulteration of soymilk in milk was developed. Whey-based oral rehydrating solution (ORS) was developed. A process was developed for manufacturing Quarg, a milk protein paste, from the milk of buffalo. Quarg cheese is of high nutritional value owing to high concentration of proteins and a carrier for probiotic micro-organisms.

Production of heavier broilers has indicated benefits of producing primal cuts, deboned meat and valuable protein at lower cost to benefit producers and consumers. The felts of less than 4-mm thickness were converted into value-added products like jackets and women ruffles. These products are in great demand and can create employment opportunity in rural/unorganized sector.

A method was developed for the preparation of Maricream, essentially a ready-to-eat and highly nutritious product, containing deodorized fish protein. Fish-enriched noodles were prepared to improve nutritional value (protein, calcium and phosphorus) and taste of the market noodles. Sandwich paste was prepared from Sciaenid fish and fortified with EPA and DHA in retortable pouch.

Agricultural engineering and energy management

Tractor-operated machinery developed includes rotary nozzles for mango orchard, chopper-type tynes for power tiller rotavator for sugarcane trash shredding, vegetable transplanter for brinjal, cauliflower and tomato, rotary weeder, farmyard manure spreader; and tractor-mounted includes onion harvester-cum-elevator. Controlled traffic rotary no-till slit drill was developed for sowing of soybean under wheat crop residue.

A manually-operated tool for desuckering and another equipment for desuckering and clump removal for hill banana were developed and well accepted by farmers. Drainage technologies were revelated for the crops sensitive to waterlogging in Vertisols. Parameters were optimized for utilization of paddy straw, kinnow pulp and pea pods for production of cellulases, ethanol and feed supplements. Paddy straw-based bio-methanation system was commissioned.

Agricultural human resource development

For maintaining and upgrading the standards and quality of higher agricultural education in the country, the ICAR continuously providing the professional and financial support to the Agricultural Universities (AUs). Admission of 1,687 students (up to 15% of total seats) in under-graduate (UG) and 1,875 students (up to 25%) seats in post-graduate (PG) programmes were made through central entrance tests to reduce inbreeding and foster national integration.

Besides organizing 61 trainings and capacity building programmes, the National Academy of Agricultural Research Management, Hyderabad, has embarked upon becoming an academic unit and has started two post-graduate diploma programmes, viz information technology management, and IP management.

The IV Deans Committee Report on reforms

in agricultural education has been implemented. The accreditation of 14 Agricultural Universities for assured quality of education was done. For skill development 138 Units were established in 43 universities for Experiential Learning. An ICAR net has been put in place for connecting the libraries of 35 State Agricultural Universities (SAUs), 69 ICAR institutes and 182 off-campus colleges. In order to further enhance capabilities of Deemed Universities and Agricultural Universities, the ICAR has launched a programme to promote Niche Area of Excellence in these institutions. Some important Niche Areas of Excellence include Hi-tech horticulture, Molecular diagnostics of avian diseases, Resource conservation technology, Soil and water management, Biofuels, Buffalo genomics, Arsenic management in soils, Fin-fish farming, Immunodiagnostics, Tropical home gardens and Agro-based nutraceuticals. Besides with the involvement of 180 academicians for over an year, PG course curricula was revised and is expected to be implemented in all the universities w.e.f July 2009.

A new activity on overseas fellowships is put under the continuing HRD programme to develop competent human resources that are trained in the best laboratories in the world (for Indian candidates) and expose overseas candidates to the best of the Indian Agricultural Universities for facilitating future co-operation with these countries. For ensuring quality research technology and human resource development, Rs 421 crore was allocated for modernization of the research farm of the universities. Scientists are being provided training in advanced laboratories in India and abroad to develop core competencies in select areas. Sixty scientists were trained and over 500 are to be trained abroad in 21 frontier areas during XI Plan and about 1,000 scientists are to be trained in the country. With a massive recruitment drive about 500 scientists have joined the ICAR and another over 500 will be joining during 2009 as per the recruitment programme already set in motion.

The model qualifications for various scientific positions under the ICAR were finalized and the number of disciplines for entry level ARS/NET Examination was reduced from 69 to 38 and notified.

Information, communication technology and publicity services

Directorate of Information and Publications of Agriculture has developed on-line scrolling day-to-day news, in addition to regular uploading the issues of *ICAR Reporter* and *ICAR News* on the ICAR web page. World-wide more than 753,039 visitors have browsed ICAR Web page during 2008. Two projects have been approved by the National Agricultural Innovation Project (NAIP): (i) E-publishing and Knowledge System in Agricultural Research – development of on-line electronic publishing and hosting of ICAR publications integrated with e-commerce, and (ii) Agro web – digital dissemination system for Indian Agricultural Research. Some new initiatives were also taken. English and Hindi Editorial Units have brought out 100 publications. E-library facility has been started at the ICAR(Hq). It is using latest information and communication technologies. The ICAR Library has been modernized with information kiosks, internet surfing, on-line catalogue etc. using latest ICT tools.

Technology assessment, refinement and transfer

A total of 520 technologies in various crops, livestock, fisheries, entrepreneurship and family health and nutrition were taken up for 20,002 on-farm trials with network of 562 Krishi Vigyan Kendras (KVKs). The Krishi Vigyan Kendras conducted 18,949 demonstrations on oilseeds spread over 6,379 ha, and 17,301 demonstrations on pulses in 5,433 ha, showing 33.17 and 41.14% more yield than farmers' practice respectively. Besides, demonstrations were conducted on cotton, covering an area of 8,347 ha, benefiting 4,211 and 5,628 farmers directly from demonstrations on production technology and farm implements, respectively, in 1,754 and 5,173 ha. The KVK also conducted 22,334 demonstrations, covering 6,295 ha on other crops, besides 2,168 on livestock and fishery, and 109 on other enterprises.

A total of 35,533 training programmes were organized on various technologies, benefiting 966,142 lakh farmers and farmwomen. Skill-oriented trainings were imparted in different areas of agriculture, benefiting 187,304 rural youth. A total of 3,487 training programmes were organized for 90,398 extension personnel to upgrade their knowledge and skills in frontier areas of agriculture technology. Besides, 6,099 sponsored training programmes were conducted for 232,951 lakh participants from government and non-government organizations.

The Government has recently approved conversion of existing 8 Zonal Co-ordinating Units to Zonal Project Directorates. Further, 28 KVKs in newly created districts and one additional KVK in 50 larger districts for wider coverage of KVK activities have been approved. Provision has been made for e-linkage of KVKs; establishment of facilities, namely the mobile diagnostic-cum-exhibition units; the soil- and water-testing labs; rain-water harvesting structures; the basic plant health diagnostics; minimal processing ; portable carp hatchery; integrated farming system ; and

support to Directorate of Extension of SAUs for knowledge empowerment of KVKs.

National Agricultural Innovation Project

The National Agricultural Innovation Project (NAIP) has made good progress in approving 112 subprojects at a total outlay of Rs 658 crore. Under the project, 28 value-chain models were approved covering niche agro-produce like millets, cotton, pelagic and freshwater fishes, coconut, seed spices, potato, banana fibre, carps and prawns, flowers, pork, maize etc., and 26 rural sustainable livelihood security models were approved covering 82 most backward districts directly benefiting about 83,000 households. Forty-nine Basic and Strategic Research (BSR) subprojects are pursued covering some of the most potential impact making areas like controlling the deadly arsenic problem in food chain, genetic engineering for fixation of heterosis; and 21 projects are in operation under National Fund for Basic and Strategic Research (NFBSRA) since February 2006.

Organization and management

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan and Non-Plan) for 2007-2008 are Rs 2,460 crores and Rs 2,337 crores, respectively, and BE for 2008-09 (Plan and Non-Plan) is Rs 2,680 crores. Patents were granted to the ICAR in 11 fields of invention. The world patent search for ICAR as the applicant (at the European free search facility http://ep.espacenet.com), revealed 35 patent records. Policy issues were decided for Guidelines for management of ICAR services and contracts, IPR clearance of collaborative research projects, and Business Planning and Development.

One hundred eleven awardees under twelve different categories were conferred awards. These comprised four Institutions, 103 scientists, 3 farmers and one journalist. Out of 103 scientists there were 13 women scientists.

Partnership and linkages

Work plans were signed with the Islamic Republic of Iran, the Republic of Ecuador for co-operation in agricultural research and education. A total of 208 foreign nationals of 20 countries have completed post-graduate degree programme in ICAR Institutes and State Agricultural Universities. The ICAR in November 2008 also organized an extra-ordinary meeting of SAARC Agriculture Ministers in New Delhi wherein SAARC Declaration on UG 99 was made for addressing the problem jointly. The ICAR hosted a Global Agro-Industries Forum 2008 and about 500 senior delegates and professionals from 111 countries participated and shared world experience in promoting agro-industries for greater profitability of agriculture. A notable feature of the conference was the active participation of Central Ministries of Agriculture, Commerce and Industries, and Food Processing Industries and Directors-General of FAO, UNIDO and President, IFAD of UN. The ICAR has initiated a major programme on agricultural knowledge empowerment of African countries.

The Council is marching ahead to ensure sustainable development of agriculture through technological developments and in this endeavour timely completion of 11th Plan EFC/SFC meetings for all the schemes under ICAR is expected to provide impetus. This will certainly help us in effective implementation of the research and educational programmes and other activities envisaged.

(Mangala Rai)
Secretary,
Department of Agricultural Research and Education,
and
Director-General
Indian Council of Agricultural Research

2

Soil and Water Productivity

Soil Resource Inventory and Management

District-level land-resource inventory for farm planning: Soil-resource inventory of Lohardaga district (149,100 ha), Jharkhand, was prepared on 1:50,000 scale and 26 soil series were identified under two broad physiographic units, viz. hills (36.6%) and plateau (62.2%). The soil resource data were mapped into 35 mapping units at soil series association level. The soils of Lohardaga district belong to 3 orders, Alfisols being the most dominant (45.09%) followed by Inceptisols (28.03%) and Entisols (16.58%).

Evaluation of land capability, irrigability and soil-site suitability for various crops showed that majority area (33.1%) of the district was under capability class IIIw which is mostly in low-lying area of the district. About 31.3% area is under capability class VII, which is mostly in hilly terrain**.** The available water-holding capacity of the soils of 51.8% area of the district is high.

Soil erosion map of Kota, Rajasthan: The digitized soil erosion map of Kota (Rajasthan) has been generated from soil loss value estimates for each of 10 km grid point using universal soil loss equation (USLE). Despite relatively low annual rainfall, water-induced erosion is a serious problem in the region. About 66% area has annual soil loss higher than 10 tonnes/ha and about 15% of the area show severe erosion rates with soil loss rates exceeding 40 tonnes/ha/year. The relatively higher rates of erosion per unit of rain energy are primarily due to poor ground cover during the monsoon season and slope steepness of the rolling and hilly terrain.

Four grass barriers, *Vetiveria zizanioides* (*khus*), *Saccharum munja* (*munj*), *Cenchrus ciliaris* (*dhaman*) and *Dichanthium annulatum* (*karad* grass) were evaluated for their conservation value and compatibility with rainfed sorghum and soybean on 1% slope at Kota, Rajasthan. *C. ciliaris* and *D. annulatum* were the most effective in reducing runoff with significant grain (~23%) and straw (~13%) yield of sorghum and soybean besides providing about 0.4-0.5 tonne/ha air dry forage.

Soil erosion map of Pauri Garhwal district, Uttarakhand: Digitized soil erosion maps of Pauri Garhwal district, on 1:50,000 scale, have been generated. The soils are mostly moderately shallow, excessively drained, sandy loam, occur on very steep slopes, very severely eroded, largely

Land degradation status in arid desert

Land degradation under different land uses in the arid desert of western Rajasthan and Gujarat, covering 28.5 million ha area, was mapped on 1:0.5 million scale using remote-sensing technique. It revealed that ~76% area of western Rajasthan was affected by wind erosion, encompassing all the major land uses but mostly croplands and dunes/sandy areas, while water erosion affected ~2% area (mostly in croplands and scrublands), salinization ~2% (mostly in croplands) and vegetation degradation ~3% (especially in scrublands and forests). Mining activities have spoiled so far only 0.10% area, and degraded rocky areas covered 1% area. About 18% area was severely degraded and 66% slightly to moderately, while 16% area was not affected by degradation. The mapping showed that ~1.3 million ha area of croplands in western Rajasthan was under severe wind erosion (mostly unirrigated).

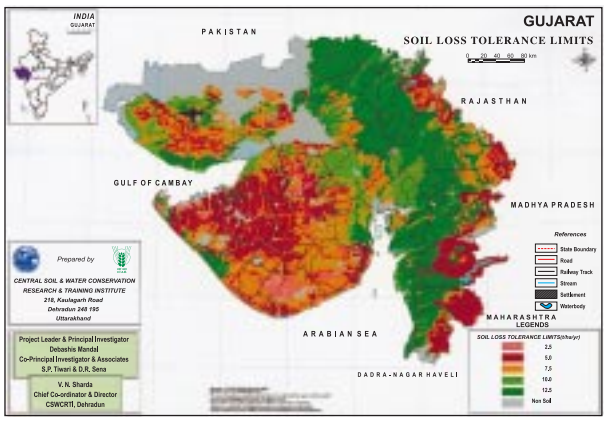
In arid Gujarat, water erosion was the most dominant process, affecting ~43% of the total area (mostly in croplands), followed by salinity (38%), while vegetation degradation (10%) and wind erosion (5%) covered smaller areas. About 44% area was severely affected, 53% slightly to moderately, and 3% not affected. Large area under severe degradation was due to the huge area of the Great Rann of Kachchh and the Little Rann that have high natural salinity.

stony, slightly acidic and dominantly rated as class III lands.

Soil loss tolerance limits for Gujarat: Gujarat, covering an area of 19.6 million ha was divided into three major physiographic regions, viz. Central High Lands, Western Hills and West Coast Kathiawar. Major area (42.4%) of the state falls under SLTL class IV and V, i.e. 10.0 to 12.5 tonnes/ha/year. About 20.0% area falls in SLTL class I and II, i.e. 2.5 to 5.0 tonnes/ha/year. About 35.7% area falls under soil tolerance class III, i.e. 7.5 tonnes/ha/year. The soil loss tolerance limit (SLTL) map has been developed for Gujarat state.

Integrated Water Management

Assessment of water harvesting potential in rainfed areas: Assessment of rainwater harvesting potential across the major rainfed crop growing districts for providing supplemental irrigation using FAO water balance model revealed that about 10.6 million ha area under coarse cereals, 6.4 million ha area under rice, 4.1 million ha area under cotton, 10.5 million ha area under oilseeds, 7.2 million ha area under pulses totalling 39 million ha could generate about 114 billion m^3 surplus water capable of providing supplemental irrigation in major part of rainfed areas. Based on the available surplus, the area that can be provided with single supplemental irrigation of 100 mm at reproductive stage of the crop was estimated for both normal rainfall and drought years. Out of 114 billion m^3 available as surplus, about 28 billion m^3 (19.4%) is needed for one supplemental irrigation on an area of 25 million ha during normal monsoon year, thus leaving about 86 billion m^3 (81.6%) to meet river/environmental flow and other requirements. During drought years also, about 31 billion m^3 is still available even after making provision for irrigating 20.6 million ha. By introduction of supplemental irrigation (with 'Business as Usual' scenario), the crop production can be enhanced by a total of 28-36 million tonnes from an area of 20 -25 million ha during drought and normal monsoon periods which accounts for about 12% increase over the present production. The benefits could be still higher if initiatives like improved cultivars, SRI cultivation in rice, crop and land use diversification, use of improved irrigation techniques like drip and micro-sprinkler (which further increase water-use efficiency etc.) are taken up. Thus supplemental irrigation through water harvesting would be a viable option in major part of rainfed area which otherwise have no environmental problems like waterlogging etc. These areas are more in the sub-humid climatic zone of the country.



Soil loss tolerance limits for Gujarat

Micro-tubewell for coastal saline area: In coastal saline area of Orissa in Astarang block of Puri district, micro-tubewell was constructed which was helpful for small farmers irrigating their *rabi* crops/vegetables. The groundwater was saline beyond 20 m (4.8 dS/m). Hence, the depth of tube-well was limited to 10 m to 12 m depth and the diameter of tube well was limited to 5 to 7.5 cm. The energy for drawing the water was limited to 2 HP.The discharge from the tube-well varied between 3.5 to 5 lps. The aquifer, full of fresh water from deltaic rivers and huge monsoon rainfall, is a perched one and it extends from 3 m below ground level onwards. Top 3 m is clayey zone and rest is sandy zone. The cost of 7.5 cm diameter tubewell with 12 m depth is Rs 4,800 only and it irrigates almost 1 ha vegetable crops. The water productivity varies from Rs 2.87/m^3 to Rs 4.52/m^3 in case of 10:90 (farmers share: project share) participation. The water productivity increases from Rs 3.65 to Rs 5.46 when the participation of farmer increases up to 30%.

Long-term effects of sewage irrigation: Intensification of industrialization has resulted in effluent and wastewater production in large

Bio-engineering measures for protection of river banks

Seasonal rivers (torrents) cause a huge damage to the life and property due to flash floods during the monsoon season in the Shiwaliks and foothills of outer Himalayas. Cost-effective bio-engineering structures (spurs, protection walls and embankments) were developed and locally adaptive flow-resistant vegetative species identified for training the river flow, bank erosion control and protection of the agricultural land and other property along the banks. Nearly 2.2 km stretch on Song river near Dehradun was recently protected through construction of 93 spurs. The technology is being extended to the other development agencies. The silvi-pastoral system consisting of *Grewia optiva* (managed under three lopping practices), *Chrysopogon fulvus* and *Panicum maximum* was also developed on old riverbed lands for their productive utilization.

Performance of different crops under sewage irrigation

quantities, which has become a matter of serious concern in terms of their safe disposal. These wastewaters have high nutrient value and the irrigation potential for increasing crop production, but due to heavy metal and pathogen loads these waters have to be used judiciously, otherwise will pollute our natural resources. Long-term field studies on development and refinement of low cost-management practices of sewage and agro-industrial wastewater under different cropping systems (vegetable, fodder, cereal and agro-forestry based systems) indicated that the yields of most crops like Egyptian clover and wheat increased by 10 to 28% when sewage water was used for irrigation. Further, sewage irrigation supplemented with N and P at 50% of recommended levels and tube-well water irrigation with recommended levels of both nutrients produced almost similar yields. In the 5th year, rice productivity in association with poplar was 73% less than the rice yield in the open.

Integrated Nutrient Management

Site-specific nutrient management: The verification trials with rice (JR 201) – wheat (GW 273) and soybean (JS 93-05) – wheat (JG 273) systems were conducted on Vertisols at Jabalpur. All the crops received recommended dose of N, P and K, while rice received FYM @ 5 tonnes/ha. In rice-wheat system, the average grain yields with target yield approach with and without Integrated Plant Nutrient Supply System (IPNS) were 8.5 and 10.97 tonnes/ha, respectively, compared to 6.35 tonnes/ha with general recommended dose (GRD). The net returns due to IPNS target yield approach over GRD were Rs 10,787/ha in paddy and Rs 24,689/ha in wheat. In soybean-wheat system, the average annual seed yields with and without IPNS target yield were 8.56 tonnes/ha and 6.68 tonnes/ha, respectively, compared to 6.3 tonnes/ha with GRD.

Crop-residue management in farmers' field: In irrigated areas, about 90% of wheat is cultivated after harvest of rice and cotton. Accordingly, there is short time for land preparations for establishing wheat due to late-maturing long-grain rice varieties. It normally takes 2-3 weeks for rice fields to become workable for land preparations due to antecedent moisture. The delay in planting of wheat after 20 November results in reduction of potential wheat yield by about 1% per day. Moreover, farmers cultivate land often without achieving suitable seedbed conditions for planting wheat, which results in poor crop yields.

The on-farm evaluation trial was conducted (12 farmers) during 2006-07 by using the second generation machineries as Happy and Turbo Seeder in condition of 6 tonnes/ha of rice residues left on the field which was to be cultivated for the next wheat crop. Wheat was sown with these machines under zero-till condition. There was increase in wheat grain yield with both Happy Seeder (5.75 tonnes/ha) and Turbo Seeder (5.8 tonnes/ha) over conventional method (5.55 tonnes/ha). Further, resource saving was also recorded when both the seeders used for sowing. About 7-10 days time saving was recorded with Happy and Turbo seeder as compared to conventional method. About Rs 1,500-2,000 and Rs 1,200-1,800 were saved, respectively, owing to use of Happy and Turbo seeders. Besides, use of these seeders under standing residue conditions saves 20-30 % irrigation water in the case of first irrigation after sowing and 10-15 % in subsequent events.

Field test kit for determination of sodicity level and reclamation material: A field test kit was developed for easy determination of soil sodicity level and amount of reclamation material required, for the sodic soil of Uttar Pradesh to be used by farmers/extension worker. Determination of soil sodicity has been proposed by way of turbidity, dispersion and swelling tests for their categorization into sodic , moderately sodic and non-sodic soils. To reclaim such types of salt-affected soils, suitable amendments are required based on the soil-test value. Ten surface (0-15 cm) soil samples per hectare at random locations are to be collected from the field during April-May for determination of the extent of soil sodicity and the amount of reclamation materials required. The recommendation for amendments required for different sodicity classes are as follows:

Non-sodic: No amendment recommended.

Moderately sodic: An amendment of 6 tonnes/ha sulphitation pressmud is recommended.

Sodic: An amendment of 12 tonnes/ha gypsum or 6 tonnes/ha gypsum along with salt-tolerant rice and wheat varieties is recommended.

Improving biofertilizer quality: The widely used carrier based inoculants have a short shelf-life of up to 6 months and are of variable quality.

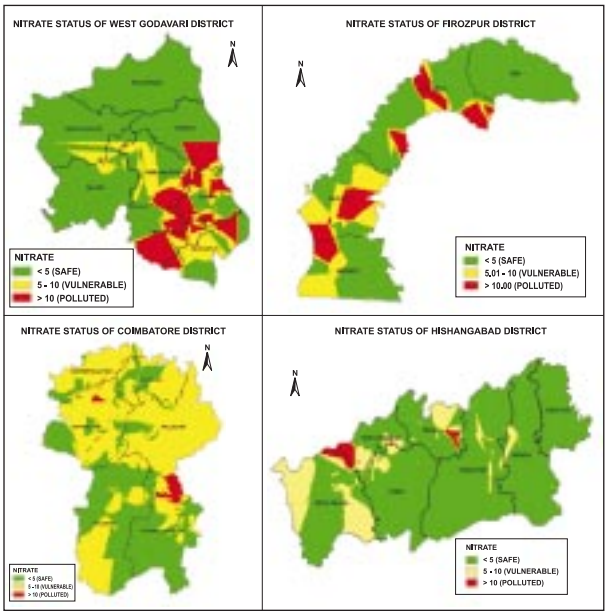
Biofertilizer quality testing kit

A quick method for estimating biofertilizer quality was devised for *Azotobacter, Pseudomonas, Bacillus* and *Rhizobium* bioinoculants which were tagged with a genetic marker encoding for the enzyme ß-galactosudase and the end produce was detected using chromogenic substrate. The amount of enzyme activity was correlated with the viable cell number to estimate the viable cell population in broth as well as charcoal-based inoculants. This test can be performed either quantitatively in liquid culture or qualitatively by using filter paper discs. A quality-assurance kit was developed which can test the quality of biofertilizers in 1-2 hr. The cost of assay is approximately Rs 100/assay.

Liquid cultures containing cell protectants not only maintain high microbial numbers but also promote the formation of resting cells like cysts and spores which result in better resistance to abiotic stresses, thus improving the product shelf-life. Three liquid media formulations containing different concentrations of arabinose, trehalose, glycerol and polyvinyl pyrrolidone (PVP) were devised for *Rhizobium*, *Azospirillum* and P-solubilising *Bacillus megaterium*. Even after one year of storage, in case of *Rhizobium* the liquid medium maintained good titre (2.7×10^8 cells/ml), whereas in lignite carrier it had come down to negligible level (12 cells/g). In case of *Azospirillum* (AZS 303) liquid medium maintained 4.4×10^8 cells/ml, whereas in lignite it had come down to 9.8×10^2 cells/g. In case of phosphate solubilising bacteria (*Bacillus*) the liquid inoculant medium could maintain 1.0×10^8 cells/ml, whereas in lignite it had come down to 145 cells/ml. No contamination was observed until 360 days in any of the liquid inoculants. The dose of 4 ml of liquid *Rhizobium* inoculants per kg of seed could satisfactorily retain the maximum number of viable cells on the seeds up to 24 hr of bacterization.

Biofertilizers for vegetables in tribal areas: Bioinoculants (*Azotobacter* and *Azospirillum*) were developed for tropical vegetables (brinjal, tomato, potato, onion, bean, cowpea, okra, carrot, yam, elephant foot yam, chilli, radish). Bioinoculation in acid Alfisols of Orissa in the tribal areas of Dhenkanal district enhanced yields (8 – 21% for above ground grown crops and 25 – 50% for underground crops and brought fertilizer savings of 20-25 % of plant nutrient cost incurred for N and P. Nutrient-use efficiency improved by 12-36% for N, 18-28% for P, 9-15% for K and 16-18% for S owing to inclusion of biofertilizers. Biofertilization improved produce quality (Vitamin C, curcumin, lycopene). Response of corm and yam to bioinoculation in farmers' fields in acid soils of Majhishahi, Dhenkanal and Orissa.

Nitrate contamination in groundwater: The extent of nitrate contamination in groundwater in six intensively cultivated districts was evaluated. Geo-referenced maps with block boundaries of six target districts, viz. West Godavari (AP), Ferozepur (Punjab), Hooghly (WB), Jalgaon (Maharastra), Coimbatore (TN) and Hoshangabad (MP) have been prepared for delineating nitrate contamination using data of pre-monsoon 2007. While about 20% stratified random samples of West Godavari district had nitrate concentration in groundwater beyond the permissible safe limit of 10 mg NO_3-N/litre, three districts, viz. Ferozepur, Coimbatore and Hoshangabad, recorded moderate level of nitrate pollution. Hooghly and Jalgaon district did not show any nitrate pollution in groundwater. The shallow and unconfined or semi-confined aquifers like dugged wells, open wells and hand pumps were more polluted than deep and confined aquifers in all the districts. In all districts higher nitrate was recorded in groundwater in areas under vegetables and orchards/plantation crops than rice-based/soybean-based cropping systems and other field crops.



Delineation of nitrate contaminated areas in West Godavari, Ferozepur, Coimbatore and Hoshangabad districts

Rapid composting through fungal bioinoculum: Microbial enriched composting technique using fungal bioinoculum such as *Aspergillus heteromorphus, A. terrus, A. flavus* and *Rhizomucor pusillus* was developed to accelerate the process of decomposition of organic waste such as wheat straw, soybean stalk, pigeonpea straw, cotton stalk, sugarcane trash and vegetables waste. These wastes were mixed with fresh cowdung in the ratio of 1: 0.2 (w/w) and starter nitrogen @ 0.5% on materials on dry-weight basis. Fungal bioinoculum was added to accelerate the

process of decomposition at 5 and 30 days of decomposition @ 500 g mycelial mat/q materials on dry-weight basis.

After decomposition, addition of fungal bioinoculum helped in attaining early maturity indices for all the composts. Compost prepared from vegetable waste, pigeonpea straw, soybean straw and wheat straw with fungal bioinoculum decomposed faster and attained maturity in 120 days compared to uninoculated control (180 days), thus reducing the composting period from 6 months to 4 months. Cotton stalk and sugarcane trash, however, took some more maturity time to produce good quality compost.

FISHERIES

Water Management

Decision support software for shrimp aquaculture: Decision support software was developed to estimate the maximum allowable shrimp farming area based on the assessment of carrying capacity of particular water body. Based on the monthly estimates of nutrient loading from the shrimp farms and assimilation capacity for one year, area recommendations for shrimp aquaculture were made taking into consideration of Coastal Regulation Zone rules, Coastal Aquaculture Authority guidelines and supportive capacity of the ecosystem in Andhra Pradesh. This tool will help state governments and other regulatory organizations to regulate the level of shrimp farming activity for each receiving water body and in framing future guidelines and policies for sustainable development of shrimp farming.

Impact assessment of aquaculture on mangroves using remote sensing and GIS

Satellite images of Punnakayal mangroves, Tamil Nadu, were georeferenced to assess the impact of aquaculture development on mangroves. The land use maps indicated that no aquaculture farms are located around mangrove areas. GIS change detection analysis found that saltpans nearer to mangrove areas were the main reason for the degradation. The mangroves of 7.9 ha were converted to saltpan and 29.4 ha were degraded to scrub land. The soil and water analysis nearer to mangrove areas revealed that the electrical conductivity values (measure for salinity) in soil and water were more than 59 dS/m and 110 dS/m in soil and water samples, respectively. The high salinity observed in the vicinity of salt pans could be the reason for mangroves getting degraded into scrub land. The study indicated that aquaculture is not responsible for the mangrove degradation in Punnakayal area.

Development of diversified farming systems

As a part of diversified farming practice, the monoculture of the seaweed, *Hypnea valentiae,* was carried out by raft culture method at Navibunder, Gujarat. A maximum of 5.2-fold increase in yield was observed in 50 days during the post-monsoon period of December and January. The monoculture of *Hypnea musciformis* recorded a maximum of 6.2-fold increase in yield in 61 days during post-monsoon periods of January and February at Chorwad.

Molecular protocol to assess pollution effect: A molecular technique was developed for early and rapid detection of heavy metal pollution in open waters. The protocol could be used to assess the impact of pollution on freshwater fishes.

Assessment of inland fishery resources using remote sensing techniques: For the development of digital map of inland water bodies of the country using remote sensing satellite data, water bodies of 0.5 ha and above were identified and mapped for Punjab, Haryana and Orissa. The mapping of water bodies with area above 10 ha was completed in Madhya Pradesh. The ground-truthing was undertaken in 27 districts in Orissa and Uttar Pradesh for the verification of imageries with physical presence of the water bodies. Spatial and other information was attached with GIS format. Murugama (Sahara Jore) watershed in Purulia district of West Bengal was delineated and digitized for first, second and third order streams of the watershed.

3

Farming Systems

Farming/Cropping Systems Research

Mechanical transplanting of rice: Rice transplanting is a very cumbersome and labour intensive process. To overcome this problem, a mechanical transplanter was developed. It was evaluated both in on-station and on-farm locations. The rice transplanter covered 0.18–0.20 ha/hr area with a cost of Rs 1,240/ha, which provided higher rice yield (10%), cost effectiveness (25%) and energy efficiency (12%) as compared to hand transplanting.

Multi-enterprise agriculture model: A multi-enterprise model based on an integrated farming system and multiple water-use approach involving components of crops, fisheries, dairying, horticulture, vegetables, bee-keeping, poultry, duckery, *gobar* gas plant, solar heating system etc. was developed on 2.0 ha reclaimed sodic land, to provide regular income, employment and livelihood to small farmers. The preliminary results indicated that the field crops (rice and wheat) gave a net income of Rs 51,519, *berseem* Rs 45,768 and bottle gourd Rs 61,650/ha. Fish worth Rs 12,528 was sold during the year from 0.2 ha fish pond. The net income from bee-keeping was Rs 2,928 per annum with a benefit:cost ratio of 1:0.8 when 25 honey boxes were kept in the farm for honey production. Milk worth Rs 113,373 was sold from four buffaloes/cows. The studies indicated that the vegetables planted on the dykes of the pond can generate a regular income of Rs 1,000-1,500/month to meet daily cash requirements of the small farm family. The income is likely to increase manifold when fruit trees start bearing fruits. The cooking gas generated from the *gobar* gas plant was sufficient to meet energy requirement of a family of six persons throughout the year. In addition, the gas is used for lighting purpose.

Multi-entreprise agriculture model

The above model was also replicated at Sharda Sahayak Canal Command, village Kashrawan, Raibareli district, Uttar Pradesh. The area is suffering from shallow water table conditions and is not suitable for cultivation even after gypsum based reclamation. A land reclamation model based on the concept of land modifications (physical land reclamation) and pond-based integrated farming systems (bio-drainage) was conceived for this purpose. A model of one ha comprising 0.4 ha fish pond, 0.2 ha field crops, 0.2 ha fruit crop,

Farming systems modules for small farmers in drylands

Studies of the farming systems modules on micro-watershed basis conducted on Alfisols during 2005-08 indicated that a farming system module for 1.1 ha area with arable crops (0.4725 ha), agro-forestry (0.3496 ha), vegetables (0.1150 ha), grasses (0.1256 ha) and bushes (0.0890 ha) gives the highest gross income of Rs 16,080, and net income of Rs 9,793 and a benefit:cost ratio of 2.38. The individual enterprises of arable cropping, agro-forestry, vegetables, grasses and bushes contributed 38.2, 10.3, 27.2, 7.1 and 17.2%, respectively, to the total net income.

Fish production in multi-enterprise agriculture model in Sharda Sahayak Canal Command, Uttar Pradesh

0.1 ha forage and 0.1 ha vegetable crops was developed. Fish were grown in the pond after suitable initial pond treatment and raised beds were utilized for the field crops and horticultural crop without gypsum application. The slopes of embankment and the raised bed were utilized for the eucalyptus plantation, which served as bio-shield and bio-drainage purpose in the system. The preliminary data indicate that the pH of the pond water remained below 8.4 over the period under study. The pond water pH was almost same as that of canal. In the first year, 4.0 tonnes/ha of rice, 2.7 tonnes/ha of wheat was obtained without application of gypsum; green forage yield of 15.0 tonnes/ha and 15.4 tonnes/ha of sorghum and berseem was recorded in a soil where nothing could be produced before the implementation of this project. A yield of 5.5 tonnes/ha and 4.5 tonnes/ha of spinach (palak) and garlic, respectively were harvested from this integrated farming system. Fish production of 2.5 tonnes/ha was also obtained from fish farming. The benefit : cost ratio of the various components under study varied from 1.70 in fruit-based system to 2.63 in fish farming system. The whole system benefit:cost ratio comes to 2.21. Thus multi-enterprise agriculture is a better option to generate regular income and employment from small farm holdings than solely crop-based systems.

Tree root management in agri-horti system: Pearlmillet-wheat is the predominant cropping system in semi-arid region of the Indo-Gangetic plains under irrigated conditions. Agri-horti system having a fruit crop tolerant to these stress conditions opens up an opportunity for the farmer to get more assured income. It is feasible to grow pearlmillet and wheat with *ber*. The suppression effect of *ber* tree was noticed on wheat and pearlmillet. Among root management practices, tree planted in bottomless bitumen drum gave significantly higher grain yield of wheat. The yield of *ber*, pearlmillet and wheat adopting bottomless bitumen drum was 7.4, 1.73 and 3.18 tonnes/ha, respectively. Net returns of around Rs 50,000 were recorded from *ber*, pearlmillet and wheat crops.

Agroforestry system in coastal salt-affected soils: The cropping pattern in the high rainfall coastal region of the country is entirely monocropped with rice in the *kharif*. Due to heavy rainfall in monsoon, flat topography, low infiltration rate and lack of proper drainage facility, most of the cultivated fields are deeply waterlogged in the *kharif* season. Under the situation, there is hardly a choice for alternate crops other than poor yielding and long duration tall *indica* type traditional rice varieties in the *kharif* season. Due to increase in salinity in dry months with no irrigation facility, the land remains almost fallow throughout the year after *kharif*. Alternate farming in the salt-affected coastal areas has become essential. Agroforestry system could be an alternative and sustainable farming system for the low-lying salt-affected coastal land. Low-lying agricultural lands in the coastal region suffer from severe drainage congestion in the *kharif* and acute shortage of freshwater during *rabi* season. Studies were conducted to develop appropriate agroforestry system for such situations. Evaluation of various tree species revealed that *Eucalyptus* sp., *Acacia auriculiformis*, *Casuarina* sp., *Heritiera fomes*, *Brugeria gymnorhiza* and *Xylocarpus mekongensis* can be grown after suitable land shaping under this situation.

Economic fortification of existing forest and horti-land use system

Aloe vera was cultivated in the interspaces of matured *ber* trees that were planted in 8 m × 4 m spacings. Planting distance of *Aloe vera* was 0.5 m × 0.5 m and 1 m space was left out after every two rows of *Aloe vera*. When raised as an intercrop with *ber*, the growth and yield parameters such as plant height, spread and yield of *Aloe vera* were 68 cm, 70 cm and 47 tonnes/ha/year, respectively, and yield of *ber* fruits was around 7.5 tonnes/ha/year. As a result, gross and net income from the *ber* – *Aloe* system was estimated to be Rs 123,000 and Rs 73,000, respectively.

A new rust bio-agent, *Puccinia* sp. for management of exotic weed, *Lagascea mollis*: A new rust fungus, a species of *Puccinia* (Isotype NRCWSR-3 and holotype HCIO 48,126) identified for management of velvet bush or silk leaf (*Lagascea mollis*), a fast-spreading weed in cropped and non-cropped areas in India. It also serves as an alternate host for some insect pests of legume crops and diseases of rice, French bean, chilli, tomato etc. Inoculation of fungus under micro-plot experiment caused drastic reduction in the seed production/plant (91.68%) compared to fungicide-protected control plants of *L. mollis*.

Seed weight (1,000 seed) and germination (%) as observed from inoculated plants also showed remarkable reduction by 68.20% and 77.78% respectively. In another field trial of host specificity testing on about 150 crop species and resident weeds the bioagent was found safe to the tested plants and restricted only to the *L. mollis*. This heavy damage potential of this safe rust bioagent is being tested for further bio-intensified management of this exotic weed.

New varieties/hybrids: A new tomato hybrid namely Swarna Vijaya was recommended for commercial cultivation in Zone I (Uttarakhand, Himachal Pradesh and Jammu and Kashmir). The plants are of medium height (50-60 cm). It takes 25-30 days to flower after transplanting. It is resistant to bacterial wilt under normal field condition and is suitable for winter and summer season cultivation. The mean yield potential in winter crop is 90-100 tonnes/ha.

A promising hybrid brinjal Swarna Neelima has been recommended for commercial cultivation in Zone IV (Jharkhand, Bihar, Uttar Pradesh and Punjab). The plants are of medium height (80-100 cm), prostrate growth habit with broad plant spread. It takes 55-60 days to flower after transplanting. The fruits become ready for first harvest after 65-75 days of transplanting. The variety is resistant to bacterial wilt under normal field conditions and is suitable for winter and summer season cultivation. The mean yield potential in *rabi* is 70-80 tonnes/ha.

CS 234-2, a new salt-tolerant raya variety identified for late-sown irrigated conditions of Zone II (Sriganganagar, Bathinda, Ludhiana, Hisar, Bawal, Navgaon, Delhi) with an yield potential of around 1.28 tonnes/ha, which was nearly 15.2, 57.8 and 17.2% higher over the national checks, viz. Vardan, Varuna and Kranti, respectively.

KRL 119, a salt-tolerant new wheat genotype has been identified, which can be grown up to pH 9.3. Its plant type is semi-dwarf, resistant to lodging and has dense ears, easy threshability and bold grains. The genotype is resistant to all the three rusts and other diseases, viz. leaf blight, Karnal bunt, flag smut, head scab and foot rot.

4

Climate Change

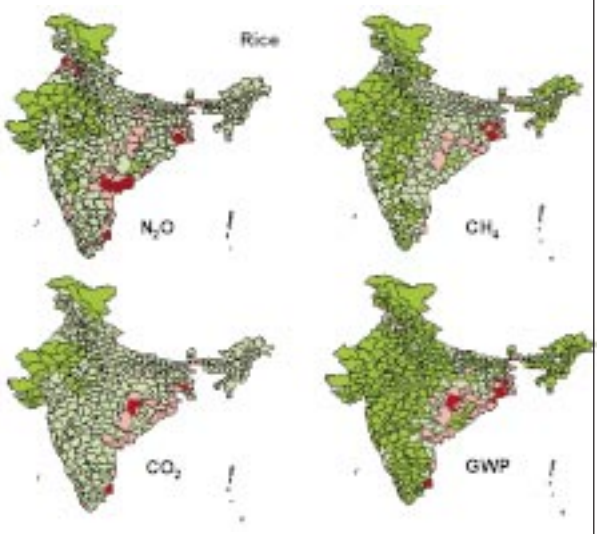
Spatial inventory of greenhouse gases emission from rice fields in India

Emission of greenhouse gases (GHGs), responsible for global warming, is a matter of concern. For its mitigation, it is important to quantify the total emissions of GHGs from different sectors, including agriculture. Field experiments and a validated InfoCrop model were used to estimate emissions of methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) from rice systems in India. Global warming potential (GWP) of these GHGs was calculated.

Simulated annual emissions from 42.21 million ha of rice fields of India were 2.07, 0.19 and 72.90 Tg (1 Tg = 10^{12} g) of CH_4-C, N_2O-N and CO_2-C, respectively. The global warming potential of the rice fields was 316.6 and 13.7 Tg CO_2 equivalents with and without CO_2 respectively. High emission of CH_4 was observed in some districts of West Bengal, due to their relatively higher soil organic carbon content, maintenance of continuous submergence and large area per district under rice. Emissions of N_2O-N were higher from the Andhra Pradesh and northern states because of large rice area and the use of relatively more N fertilizer. The eastern and southern parts of the country showed higher GWP, mainly because of higher CH_4 and CO_2 emissions with larger rice area per district. The GWP of the rice growing regions throughout the country was <1 to 10 Tg CO_2 equivalent per district. This spatial inventory will be helpful in identifying the regions from where excessive emissions of greenhouse gases are taking place and subsequently focused management practices can be implemented in these regions for mitigating the emissions.

Inventory of methane emission from livestock in India

Livestock sector is one of the main contributors to green house gases emission. An inventory of methane emission from enteric fermentation from livestock has been developed using the revised 1996 IPCC tier-2 approach for cattle and buffalo and tier-1 methodology for estimating emissions from small animals. The total emission of methane from the entire Indian livestock is estimated to be 9.37 Tg for the year 2003. Earlier studies showed



Legend	Emission per district			
	Methane (Gg C)	Nitrous oxide (Mg N)	Carbon dioxide (Gg C)	GWP (Tg CO_2 equiv.)
	<1	<1	<1	<0.001
	1-20	1-100	1-500	0.001-2.0
	20-40	100-300	500-1000	2.0-4.0
	40-80	300-500	1000-2000	4.0-10.0

Annual emissions of methane, nitrous oxide, carbon dioxide, and global warming potential from Indian rice fields. The spatial distribution of GHG emission and their GWP from the rice-growing areas of the country is presented at the district scale.

this value vary from 7.26 to 10.4 Tg. Buffaloes and indigenous cattle were the dominant source; both contributed 40% each. Indigenous female cattle contributed 2.2Tg and indigenous males emitted 1.55 Tg methane. Crossbred females, though small in number compared to indigenous cattle, emitted more methane per animal (0.63 Tg methane from 19.74 million heads). Emission from buffalo females was also higher (3.42 Tg- 36.5% of the total methane emission). Dairy cattle and buffaloes contributed 3.42 Tg methane. Contribution of milch buffaloes, crossbred cows, and indigenous cows was 59.6%, 11.4% and 28.9%,

Total methane emission from Indian livestock in 2003

Species	Enteric fermentation (Tg/year)	Manure management (Tg/year)	Total emission (Tg/year)
Indigenous cattle	3.34	0.41	3.75
Crossbred	0.63	0.08	0.71
Buffalo	3.34	0.46	3.8
Sheep	0.31	0.01	0.32
Goat	0.62	0.02	0.64
Others	0.09	0.06	0.15
Total	8.33	1.04	9.37

respectively, to the total emissions from dairy animals. The total emission from draught animals has been estimated to be 1.2 Tg. Contribution of bullocks (indigenous and crossbreds) was 85%, while that of buffalo males was 10% and other transport and pack animals contributed about 5% of total methane emission.

Change in temperature trends over India

Rise in temperature is one of the predicted impacts of climate change with significant implications for agricultural productivity. In order to assess the long-term trends in temperature, the minimum and maximum temperature data for 47 stations across the country for more than 50 years was analyzed. Overall, 55 to 80% stations located across the country showed increasing trends in average annual temperature. About 75, 60 and 54% of the stations in south, east and central India, respectively, showed increasing trend in maximum temperature, whereas only 8 and 13% of the stations in central and west India, respectively, showed decreasing trend. Similarly 80, 78 and 75% of the stations in east, north and south, respectively, showed increasing trends in minimum temperature.

Impact of temperature rise on crop water requirements

Rise in temperature is likely to increase the water requirement of crops due to high evaporative demand and crop duration due to forced maturity. The impact of simulated rise in temperature of one degree by 2020 (over the base year of 1990) on water requirement of major crops grown in Andhra Pradesh was assessed. The water requirement of all the major crops like maize, groundnut, pigeonpea and cotton will be increased with rise in temperature. The crop duration is expected to decrease by 1-2 weeks.

Projected changes in crop water requirements and crop duration of major rainfed crops in Andhra Pradesh by 2020

Station	Agro-climatic zone	Crop	Increase in water require-ment (mm)	Reduction in crop duration (weeks)
Anakapalli	North Coastal	Maize	51.7	1
		Groundnut	61.3	1
Anantapur	Scarce Rainfall	Groundnut	70.1	1
		Red gram	174.3	1
Jagtiyal	North Telangana	Cotton	60.5	2
		Maize	49.0	1
Rajendra-nagar	South Telangana	Red gram	114.5	2
		Groundnut	73.0	1
Tirupati	Southern	Groundnut	73.0	1

Micro-organisms for enhancing high temperature tolerance in plants

Rise in temperature is one of the causes of the predicted climate change. Role of micro-organisms in protection of plants from high temperature stress was investigated. It was found that seed inoculation with stress-tolerant strain of *Pseudomonas putida* helped sorghum and pearl millet seedlings survive at 50° C up to 21 days, whereas the controlled seedlings could survive only up to 10 days.

This remarkable protective effect was mediated through induction of the synthesis of novel high molecular weight proteins in the leaves, which were not found in the controlled seedlings. Inoculation also reduced the oxidative stress in seedlings exposed to high temperature (50°C) as evidenced by significantly lower oxidative enzyme activity in treated seedlings. The introduced organism successfully entered into the roots and induced the physiological changes at the whole plant level as confirmed by electron micrography.

Impact of elevated CO_2 on castor

Elevation of CO_2 is another phenomenon likely to be caused due to climate change. In order to assess the changes that might be caused under high CO_2, the growth, flowering and yield of castor were studied under elevated CO_2 conditions (700, 550 and 365 ppm) in open top chambers. All

growth parameters of castor showed maximum response under elevated CO_2 of 700 ppm followed by 550 ppm. Elevated CO_2 improved total biomass, which was highest at 700 ppm (22%) followed by 550 ppm (11%). Elevated CO_2 also reduced the days to initiation of flowering by three days and days to 50% flowering by 15 days. At the maturity of first order spikes, the increase of reproductive biomass was 47% at 700 ppm and 35% at 550 ppm over ambient control. The improvement in effective spike length (12 and 15%), spike weight (46% and 47%), capsule number (65 and 98%), capsule dry weight (46 and 54%) and seed weight (155 and 167%) of primaries were recorded with CO_2 enrichment at 550 and 700 ppm, respectively. Oil content and quality were not changed significantly. However, the total oil yield was significantly higher due to higher seed yield. These results indicated that elevated CO_2 is a positive factor of climate change for castor bean. Under irrigated conditions where water is not a limitation, it is possible to realize higher yields due to elevation of CO_2 in castor bean.

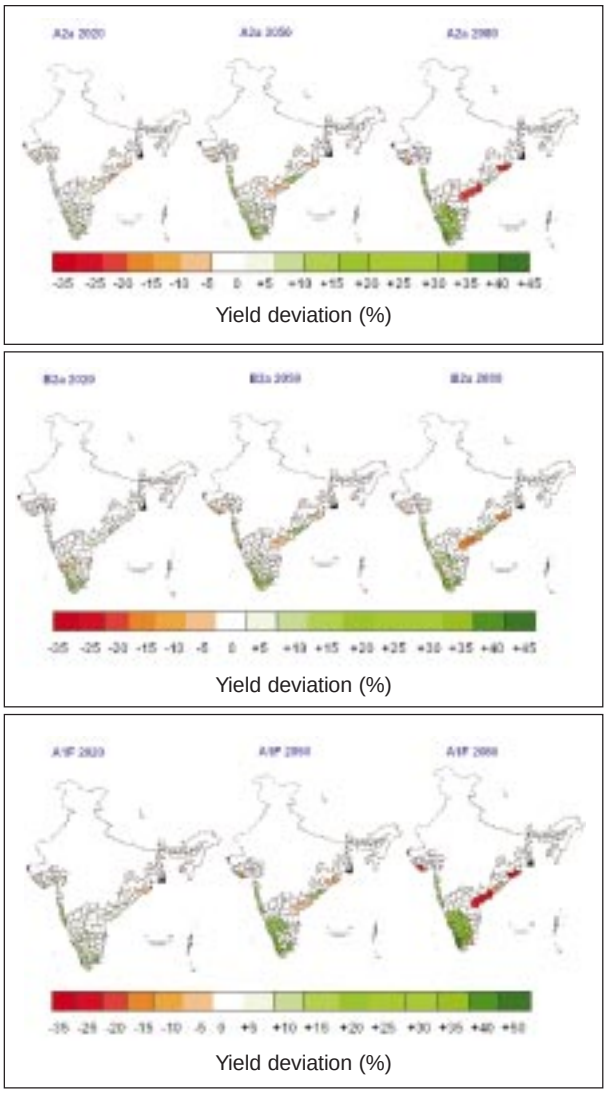
Impact of Climate Change on

Coconut production

Impact of climate change on coconut production was assessed for 13 agro-climatic zones represented by 16 centres using validated Info Crop-Coconut simulation model. These areas contribute over 90% to the coconut production in India. The model output on temperature and rainfall projections as simulated by Had CM3 model for the years 2020, 2050 and 2080 for 3 scenarios viz., A2a, B2a and A1F wherein which the atmospheric concentrations would reach by 715, 562 and 1150 ppm and the corresponding increase in global temperatures would be about 3.3°, 2.3° and 4°C, respectively by the end of the century. Also location weather data for past 30 years, major soil type of the agro-climatic zones, and currently followed farmers' practice for crop management in each Agroclimatic zones were used as inputs into the coconut simulation model. Outputs were obtained on yearly basis for 30 years and mean effects of 30 years were used to compute relative impacts over current yields. Relative impacts on yield were worked out to district level in each agro-climatic zone and up-scaled to the state and national projections assuming that the area under coconut remains unchanged in future scenarios.

Results indicate that under all scenarios, coconut productivity on all India basis is likely to go up by up to 4% during 2020, up to 10% in 2050 and up to 20% in 2080 over current yields due to climate change. In west coast, yields are projected to increase by up to 10% in 2020, up to 16% in 2050 and up to 39% by 2080 while in east coast yields are projected to decline by up to 2% in 2020, 8% in 2050 and 31% in 2080 scenario over current yields. Yields are projected to go up in Kerala, Maharastra and parts of Tamil Nadu and Karnataka while they are projected to decline in Andhra Pradesh, Orissa, Gujarat and parts of Tamil Nadu and Karnataka. However, situations may vary if future irrigation sources are limited particularly in currently irrigated areas such as in Tamil Nadu and Karnataka.

Coconut yield relative deviation from current yield due to climate change



Projections on relative yield change of coconut in A2a, B2a and A1F scenarios (please note that the districts with white colour are not simulated.)

Apple cultivation in Himachal Pradesh

The impact of climate variability/change on apple cultivation in Himachal Pradesh was studied. Temperature in apple growing regions of Himachal Pradesh showed increase, whereas precipitation showed decrease in recent years. This led to

reduction in chilling units in the normal apple growing zone (1200-1800 msl) which led to reduction in this zone under apple orchards but increased area at higher elevation (2400-2700 msl) where optimum chilling units are available for this crop. These findings were also corroborated by socio-economic surveys by farmers in the region which stated that apple cultivation is expanding to higher altitudes in Lahaul and Spiti and Kinnaur districts in recent years.

Marine fisheries

The Indian mackerel is able to adapt to rise in sea temperature by extending its distribution towards northern latitudes, similar to oil sardine and also by descending to depths. The carbon footprint of marine fishing boats was determined and an inventory on vulnerability of coastal fishing villages to sea level rise was made.

The catch data of oil sardine and mackerel from 1926 to 2005 showed that the revival of oil sardine fishery in 1950's and late 1990's coincided with heavy rainfall and presence of an opitmal environmental window (OEW).

Inland fisheries

A perceptible shift was observed in geographic distribution of the warm water fish species, *Glossogobius giuris*, *Puntius ticto*, *Xenentodon cancila* and *Mystus vittatus* towards the colder stretch of the river Ganga up to Haridwar with an enhancement of annual mean minimum water temperature of 1.5ºC in the Haridwar stretch during the period 1970-86 to 1987-2003. This has become a congenial habitat for these warm water fishes.

Elevated temperature range (0.37ºC–0.67ºC) and alteration in the pattern of monsoon proved a major factor for shifting the breeding period of Indian major carps from June to March in fish hatcheries of West Bengal and Orissa. *Ex-situ* experiment carried out indicated a rising trend in the specific growth rate of *Labeo rohita* with increasing temperature between 29ºC and 34ºC.

Livestock production

Preliminary studies indicated that an increased temperature of 2°C above the minimum temperature led to measurable reduction in milk production in Murrah buffaloes. Extreme events like heat wave (>40°C and cold wave <3°C) reduced the milk yield by 10-30% in first lactation and 5-20% in second and third lactations in cattle and buffaloes. The results were *in situ* and not observed after the events.

Insect host plant interaction

Studies on the impact of elevated atmospheric CO_2 on insect pests showed that larvae of *Spodoptera litura* consumed more foliage of plants raised under high CO_2 than ambient CO_2. The total consumption of castor foliage during entire feeding period was significantly more under elevated CO_2 than ambient CO_2. Final larval dry weights differed among treatments and the impact of elevated CO_2 on larval weight of *S. litura* on castor was significant. The larval weights were higher with elevated CO_2 foliage compared to ambient CO_2 foliage. The developmental period for larvae fed with castor foliage grown under elevated CO_2 conditions was longer (18 days) compared to larvae fed with ambient CO_2 foliage. The study showed that elevated CO_2 results in increased foliage feeding by the insect larvae and an increase in larval duration.

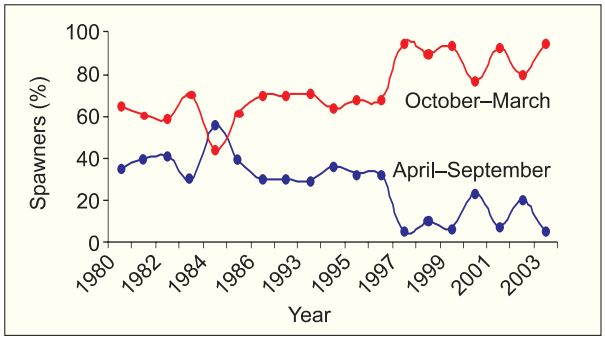
Effect of elevated CO_2 on *Spodoptera litura* reared on castor foliage

CO_2 enrichment	Weight of leaf ingested (g)	Larval weight (g)	Larval duration days
Elevated CO_2 550 –foliage	0.820 ±0.131	0.137 ±0.002	18.27 ±0.113
Elevated CO_2 700 –foliage	0.869 ±0.054	0.137 ±0.001	18.22 ±0.195
Ambient CO_2 Chamber foliage	0.594 ±0.044	0.117 ±0.006	16.11 ±0.253
Ambient CO_2 Open foliage	0.588 ±0.192	0.118 ±0.002	16.13 ±0.083
SEm±	0.048	0.0003	0.085
LSD (p=0.05)	0.166	0.011	0.261
CV%	11.59	4.70	3.10

Spawning season of *Nemipterus japonicus*

The threadfin breams *Nemipterus japonicus* and *N. mesoprion* are the dominant fish species distributed along the entire Indian coast at depths ranging from 10 to 100 m. Past data (1981 to 2004 except for the years 1988-1992) were analyzed to determine if there has been any change in the spawning season of *N. japonicus* and *N. mesoprion* off Chennai coast. The months in which the spawning females occur are taken as the months of spawning, as males too spawn during those months.

Though there were wide monthly fluctuations in the number of spawners, grouping the number of spawners into two major seasons, i.e., warm (April to September) and cool (October to March) seasons showed a clear pattern in the shift of the spawning season. Whereas 35.3% of the spawners occurred during the warm months in 1980, the number of spawners gradually reduced and only 5.0% of the spawners occurred during the same season in 2004. In 1980, it was observed that 64.7% of the spawners occurred during October-March, whereas as high as 95.0% of the spawners



Change in spawning season of *Nemipterus japonicus* off Chennai

occurred during the same season in 2004. In other words, the number of spawners reduced in summer and shifted towards cooler months.

Analysis of historical weather data showed that during April – September, the annual average sea-surface temperature (SST) off Chennai coast increased from 29.07°C during 1981-85 to 29.38°C by 2001-04; and from 27.86°C to 28.01°C during October-March. There was good correlation between SST and spawning activity of the two species of threadfin breams. The occurrence of spawners (percent of spawners in the annual total number of spawners) of *N. japonicus* linearly decreased with increasing temperature during April – September, and increased positively during October – March. It appears that SST between 28° C and 29° C may be the optimum and when the SST exceeds 29°C, the fish shift the spawning activity to seasons when the temperature is around the preferred optima.

5

Genetic Resources

CROPS

Plant exploration and germplasm collection: Explorations (33) were undertaken, and 2,203 accessions were collected including 784 of wild species. In the National Herbarium of Cultivated Plants (NHCP), 371 herbarium specimens, 121 seed samples and 21 economic products were added; and the total reaches to 19,688 specimens.

Diverse crops accessions (25,456) including international trial materials (7,485) were introduced from various countries. About 15,000 accessions including ICRISAT germplasm were exported to 19 countries. Nearly 15,500 samples of crops and their wild relatives were supplied to Indian researchers.

A total of 13,850 accessions of orthodox-seed species were added to the National Genebank for long-term storage at –18°C.

Accessions of fruit crops (20), bulb and tuber crops (17), medicinal and aromatic plants (5) and spices (3) were added to *in-vitro* Genebank. In all, 1,991 accessions (nearly 32,000 cultures) belonging to 52 genera and 158 species of vegetatively propagated crops, medicinal and aromatic plants and threatened species were conserved. Accessions of fruits and nuts (214), spices (9), industrial crops (136) and medicinal and aromatic plants (72) were preserved.

Introductions of germplasm from other countries

Country	Species	Registration No.
Serbia	Winter wheat *Triticum aestivum*	EC 609394–9413 631734
USA	*T. aestivum* translocation line with grain softness gene	-
Kenya	*Oryza sativa* inbred and thermosensitive genetic male sterile lines	EC 609524–47
USA	*Hordeum vulgare* spring lines with low phytate and good quality grain	EC 607790
USA	*Hordeum vulgare* cv. Lentah with good yield	EC 631731
USA	*Lens esculenta* cv. Morton with winter hardiness	EC 608175
Taiwan	*Lycopersicon esculentum* resistant to bacterial wilt, *Fusarium* wilt, gemini virus, grey leaf spot pathogen, tomato mosaic virus	EC 606703–04
Taiwan	*Capsicum* sp. resistant to chilli veinal mottled virus, poty virus Y and bacterial wilt	EC 628903–08
USA	Apple, pear, peach and apricot cultivars	EC 616557–63

Wild sugarcane from Gujarat

Saccharum spontaneum in Gujarat riverbeds

A total of 32 accessions of *Saccharum spontaneum* were collected from different districts. Another related wild species *Erianthus bengalensis* was found on the field bunds in north Gujarat.

Plant quarantine: Ten phytosanitary certificates were issued for export of 873 samples. Over 25,000 accessions were processed for quarantine clearance. About 540 samples were found infested/infected with different pests; out of which 526 were salvaged. Important interceptions include **insects:** *Araecerus fasciculatus, Bruchus lentis, Callosobruchus subinnotatus, Chrysomphalus dictyospermi, Pectinophora gossypiella, Rhizopertha dominica, Tribolium castaneum, Sitophilus oryzae, S. zeamais, Sitotroga cerealella*; **nematodes:** *Aphelenchoides besseyi*; **fungi and bacteria:** *Alternaria brassicae, A. brassicicola, Botrytis cinerea, Colletotrichum dematium, C. graminicola, Drechslera maydis, Fusarium solani, Peronospora manshurica, Puccinia helianthi, Xanthomonas campestris* pv. *campestris* and *Xanthomonas vesicatoria*; **viruses:** Alfalfa mosaic virus, Bean common mosaic virus, Bean yellow mosaic virus, Cowpea mottle virus, Pea enation mosaic virus and Raspberry ring spot virus.

DNA fingerprinting: In watermelon, 232 simple sequence repeats (SSRs) were identified, and primers for the amplification of the sequences were designed and tested using selected cultivars.

PCR-based detection protocols were worked out for detection of late-blight resistant *RB* gene in genetically modified potato (with *RB* gene up to a limit of detection of 0.01%); *cry1Ac* gene in *Bt* okra up to a limit of detection of 0.01%; multiplex PCR-based detection of *ama1* gene, 35S promoter, *nos* terminator and *nptII* marker genes in genetically modified potato with *ama1* gene; and *cry1Ac* gene, endogenous *β-tubulin* (*TubA*) gene and *nos* terminator/*nptII* marker gene in *Bt* rice. Qualitative detection procedures using Real Time PCR were developed for *cry1Ac* gene in *Bt* brinjal. PCR-based diagnostic kits were developed and released for detection of endogenous genes, specific transgenes and 35S promoter sequence in genetically modified cotton (*cry1Ac*, *cry2Ab* genes), brinjal (*cry1Ac* gene), cauliflower (*cry1Ac* gene), mustard (*barnase* and *barstar* genes) and tomato (*osmotin* gene).

AGRICULTURALLY IMPORTANT MICROORGANISMS

Isolation, characterization and documentation: In the northern Indo-Gangetic plains, based on sequencing of 16S rDNA, isolates from the effluent-treated soils are *Bacillus humi, B. drentensis, B. asahii, B. cohnii, B. pumilus, B. niacini, B. djibeloresis, B. fumarioli, B. senequalensis, B. oleronius* and *B. sporothemodurans*. Functional diversity with regard to production of IAA and siderophore and p-solubilization has revealed that over the years there has been enrichment of species of *Bacillus* and *Pseudomonas* that have lost plant-growth promoting traits.

Microbial consortia to alleviate salinity: Bacterial inoculants developed to alleviate harmful effects of salinity for enhanced growth and yield of wheat, identified through sequencing of 16S rDNA, are *Bacillus pumilus* EU 927407, *B. aquimaris* EU 927408, *B. arsenicus* EU 927409, *Arthrobacter* sp. EU 927410, *Bacillus cereus* EU 927411, *Pseudomonas medicona* EU 927412, *Bacillus subtilis* EU 927413, *Bacillus pumilus* EU 927414 and *Bacillus aquimaris* EU 927415. These were submitted to NCBI Gene bank and accession numbers were obtained.

Potent biocontrol agent against *Fusarium*: Of the 23 isolates of *Trichoderma* obtained from the Uttarakhand soil samples, 10 showed more than 40% inhibition in all the assays against *Fusarium melonis, F. cucumerinum* and *F. lycopersici*. PCR amplification using primers, internal transcribed spacers, ITS-1 and ITS-4, followed by RFLP analysis with restriction endoncuclease *Hind III*, could cluster 10 isolates into 8 groups. RAPD analysis with oligonucleotide primer OPV 14 revealed significant level of polymorphism among the isolates.

Microbial shift in soils: The community-level physiological profiling of soil microbes using BIOLOG showed significant shift in C utilization pattern of the effluent-irrigated soils over the control soils.

Fast-growing actinomycetes strains isolated from the effluent-contaminated sites were characterized at the molecular level and their 16S rDNA and PCR-RFLP analysis using restricition enconucleases *Mbo*I and *Taq*I, grouped these 45 isolates into 12 clusters, of which 6 clusters were unique isolates from the effluent-irrigated soils, and 2 were unique isolates from the control soils. These isolates were able to produce xylanase and cellulose at 85-290 and 28-70 IU/ml/min.

Bacteria and fungi identified: From salt lake of Sambhar, Rajasthan, bacteria capable of growing at 20% NaCl and at pH of 12 were isolated. Molecular diversity clustered bacteria into 29 groups- and sequencing of 16S rDNA led to identification of *Halomonas* sp., *Marinobacter alkaliphilus, Marinobacter hydrocarbonoelasticus, Halomonas variabilis, Altermonadales, Nitrinicola lacisaponesis, Bacillus thuringiensis, Chromohalobacter salexigens, Marinobacter aquaeolei*. From Leh region, psychrophilic fungi growing at 4° C or lower temperature were isolated and identified as *Asordaria sibutii, Gemocyes* sp. *Penicillium* sp., *Ulocladium consortiale, Thelebolaceae* sp. and *Ulocladium* sp.

PESTS AND NATURAL ENEMIES

Biosystematics: Field surveys in 20 states/union territories led to collection of 98,122 insects and mites belonging to economically important group. Taxonomic keys have been developed for the genera and the species of Largidae, Pyrrocoridae and Cercopidae. Two new species of Eriophyiidae have been identified and described.

Eucalyptus pest identified

There was an epidemic of an invasive pest, gall wasp, in eucalyptus that is used commercially for pulp production and for other raw materials for paper industry in the different parts of India. This pest was found to be occurring as a regular and serious pest in eucalyptus nurseries and plantations not only in Andhra Pradesh, Karnataka and Tamil Nadu, but also in Delhi, Uttar Pradesh, Haryana, Rajasthan and Madhya Pradesh. This has now been identified as *Leptocybe invasa* (Eulophidae: Hymenoptera), and details of its ecology and bionomics have been worked out.

Genetic diversity of Trichogrammatids: Internal transcribed spacer, ITS-2, and RFLP analysis enabled molecular differentiation of 12 species of trichogrammatid egg parasitoids. Microbial symbionts that influence sex ratio of these egg parasitoids provide clue on the influence of *Trichogramma* female.

Rodent surveys: In Punjab dominance of *Bandicota bengalensis* was noticed, followed by *Tatera indica*, *Mus* spp. and *Golunda ellioti*.

Distribution pattern of rodent-pest complexes in crop fields in Karnataka

Crops	Pest species complex	Live-burrow density/ha
Irrigated rice	*B. bengalensis> Mus booduga*	73
Ragi	*T. indica>B. bengalensis> M. booduga*	40–50
Maize	*B. bengalensis> T. indica> M. booduga*	6–20
Pearl millet	*B. bengalensis*	8–10
Wheat	*B. bengalensis*	26–30
Pigeonpea	*T. indica > B. bengalensis > M. booduga*	20–25
Cowpea and mungbean	*T. indica > B. bengalensis > M. booduga*	8–30
Soybean	*B. bengalensis > T. indica > M. booduga*	24–29
Sunflower	*T. indica, M. booduga* and *Mus platythrix*	12–30
Sugarcane	*B. bengalensis > M. booduga*	10–25
Tuberose (a flower crop)	*B. bengalensis > M. booduga> Milardia meltada*	47

Mitigating desert locust outbreak in Rajasthan and Gujarat

There was an outbreak of the desert locust in six villages of Jalore district of western Rajasthan and adjoining localities in Gujarat during *kharif*. In all, 81 hectares and 129 farmers had been affected in the villages Partappur, Paladsar, Luniasar, Barsam and Mekhpura in Sanchore tehsil and Vanse in Bilmal tehsil. The project aided diagnostics of the locust, and paved way for clearing the confusion of whether it is the same migratory locust, which occurred in epidemic in Leh of Ladakh in Jammu and Kashmir in 2006. Taxonomic studies confirmed it to be the desert locust *Schistocerca gregaria*; characterized by the presence of prosternal tubercle. This facilitated quick and timely management of the locust by the plant-protection agencies.

Highest trap index of *B. bengalensis* was 56.25 from fodder crops in October. In Andhra Pradesh, the rodent population in terms of active live-burrows was high in rice-sugarcane cropping system compared to rice-rice-pulse or rice-rice cropping systems. In rice-rice cropping system, burrow infestation was low to medium in *kharif* and low in *rabi*. In arid Rajasthan, a complex of two gerbils, *Tatera indica* and *Meriones hurrianae*, was predominant in *bajra*-mungbean-mothbean in *kharif*.

Lesser bandicoot rat in the arid region: In recent years, lesser bandicoot rat *B.bengalensis* population remained almost constant throughout the year in Jodhpur with a trap index up to14.0. Average daily intake of pearl millet grains by *B. bengalensis* was 13.57 g/day as compared to 6.19 and 5.24 g/day by *Rattus rattus and Tatera indica*, indicating more than two times higher potential losses to stored grains, besides other damages and contaminations caused to stored commodities.

HORTICULTURE

Mango: Mango accessions, 11 at RFRS, Vengurle, 15 at Periyakulam, 10 at FRS, Sangareddy and 4 at AES, Paria were added. Two clones of Alphonso and one of Bangalora were added in the germplasm. Bangalora was the highest-yielding cultivar followed by Dholikothi Maldah at RAC, Sabour Campus, while Mallika gave higher fruit yield at Pantnagar. Seedling selection, Peddapur 16 and Pargi 16, recorded the maximum yield at FRS, Sangareddy, while seedling No.7/80 and 10/85 at Sabour and Latif Aliwala, Surkhroo 1 and Surkhroo 2 at Pantnagar. Clone Rati Banganpalli showed cluster-bearing habit while Benishan early maturity; Pedda Benishan and Allahabad Benishan with bigger-size fruits than Benishan. At FRS, Rewa, a clone of Chausa

(Chausa No. 2) was found promising.

Guava: Six new accessions of guava three each at FRS, Sangareddy and FRS, Rewa were collected. Cultivar Sardar gave the highest yield followed by Pant Prabhat at Pantnagar, while Guthneewala, Safeda (J 2) and Portugal gave higher yield at FRS, Rewa. At FRS, Sangareddy, cv. Kohir Safeda performed better followed by Allahabad Safeda, while Sardar , MPUA&T- S 1 and MPUA&T-S 2 at RCA, Udaipur and Allahabad Safeda and Safed Jam at BAC, Sabour.

Litchi: Two clones of Bombai litchi were collected by BCKV, Mohanpur. Litchi cultivar Rose Scented outyielded at Pantnagar, Shahi and Late Bedana at RAU, Pusa and Bombai and Muzaffarpur at BCKV, Mohanpur.

Tropical fruits: Under All-India Co-ordinated Research Project on Tropical Fruits, genetic resources of varieties/species of tropical fruits were maintained and evaluated at different centres. Nine sweet orange clones, 21 accessions in banana, 1 in sapota and 2 in jackfruit were added to the germplasm collection. At Kannara, two introduced hybrids (TMB 5295-1 and SH 3640) are under multilocational trial. Acid lime selections 2 and 5 and mandarin selections 5 and 4 continue to record higher yield under Akola conditions. An elite clone of acid lime has been identified from Vaigai Dam, Tamil Nadu. In banana, Acc. No. 73 - 9 has been identified as a promising genotype. At Coimbatore, a field tolerant papaya genotype against PRSV was identified which is under multiplication.

Citrus: Two clones, one early maturing (N2) and another less seeded (N4) (less than 3 seeds/ fruit) were identified. Under clonal selection programme, 49 exotic germplasm comprising 31 Scion (14 mandarin, 9 sweet orange, 7 grapefruit and pummelo from USA, France, Japan), 19 rootstock (mostly from USA, a few from Australia) and 532 indigenous collection have been collected and maintained at NRCC, Nagpur. Besides, 55 superior clones of Nagpur mandarin, 13 of acid lime and 13 of Mosambi were also collected. More than 215 genotypes/accessions of pomegranate were collected from Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Maharashtra and Karnataka. At present, over 160 germplasm accessions were maintained.

Arid fruits: Tikadi , Khavaspura and Sanaur 5 cultivars of ber were found tolerant to low temperature (-1 °C), while Sanaur 1 , Jogia and Kathaphal were moderately tolerant. Early doka stage was observed in cultivars, Khuneizi , Muscat and Tayer of date palm. Two new germplasm of wood apple have been added. Promising genotypes of aonla, Narendra Aonla 27, Narendra Aonla 28 and Narendra Aonla 29 were identified. Pomegranate anardana types (05) were collected from Shimla. Out of 16 different types of Bhagawa in Maharashtra, Sel 4 was found superior in yield and quality parameters. In bael, two genotypes, viz. a Narendra Bael 19 and Narendra Bael 20, were significant. Higher fruit yield/plant was recorded in Singapur seedling and Red tamarind. Custard apple accession AS 1(APK (Ca)1 showed yield of 12.50 kg/ tree. At Rahuri, evaluation of germplasm of Bullock Heart (*Annona atemoya*), Island Gem (*Annona atemoya*) and Annona Hy. No. 2 (*Annona squamosa* × *Annona cherimoya*) indicated superiority for fruit quality.

Cashew: Four germplasm accessions were added to National Cashew Field Gene Bank (NCFGB), raising the total germplasm to 513. At various Regional Cashew Field Gene Banks (RCFGBs) at different AICRP-Cashew Centres, 1,272 accessions have been conserved.

Vegetable crops: Out of 161 germplasm lines in chilli, GP 276 for high capsaicin content (0.581%), GP 89 for high oleoresin content (14.51) and GP299 for high capsanthin (53375EOA); okra (IIVR 402 for resistance to YVMV); early cauliflower (Kuwari 23/42 for earliness and heat tolerance); late cauliflower (RSK 1301 for resistance to downy mildew; cabbage (Ac 208 for bluish green colour and resistance to black rot); lablab bean (IS 21 for earliness) and ivy gourd (CG 84 for resistance to mosaic) were found promising.

Mushroom: About 302 wild mushrooms of Termitomyces, Lepista, Chlorophyllum, Agrocybe, Leucocoprinus and *Mycena* spp. were collected. The DNA sequence from *Tricholomella constricta* has been deposited. This is second DNA sequence data from the world and first of this species from India. DNA sequence of two new *Volvariella* spp. has also been deposited. Two new species of *Volvariella* were identified. Genomic DNA from 12 strains of *A. bisporus* and *C. indica* were isolated and purified. DNA fingerprints were developed using 4 random primers. Seven new strains/SSI of paddy straw mushroom (*Volvariella volvacea*) were evaluated for their mushroom yield and quality. Strain bbsr-007 gave highest mushroom yield of 31% on a 1:1 mixture of paddy straw + cotton waste in 2 weeks of cropping. A total of 130 specimens of wild fleshy fungi were collected from the forest areas of different regions. The important collected species were *Ganoderma* spp., *Agaricus bisporus*, *Schizophyllum commune*, *Polyporus* spp., *Termitomyces* spp., *Auricularia polytricha*, *Rassula* spp., *Cantharellus* spp., *Calocybe* spp., *Pleurotus* spp., *Phellorinia inguinans*, *Podaxis pistillaris*, *Daldania concentrica*, *Ramaria* spp., *Tricholoma* spp., *Hericium erinaceusm*, *Lapiota procera*, *Lycoperdon*

spp., *Mycena* spp. and *Volvariella volvacea*.

Oil palm: Seeds of 12 promising oil palms, viz. Baratang (2 nos.), Theni (5 nos.), Nellore, (4 nos.), Sulia, Mangalore (5 nos of Nigerian source), were collected from commercial plantations of Little Andaman. One high-yielding virescence dura, was collected. One dwarf Surinam palm was identified at Palode. One more dwarf Nigerian sterile pisifera was identified in OPIL estate. Two high-yielding viresence type dwarf palms were identified at PCKL, Athirapalli. One dwarf tenera of Costarican origin was collected from a plantation in Andhra Pradesh.

Spices: A total of 585 black pepper germplasm have been maintained under different AICRPS centres. The characterization resulted in identification of high-yielding accessions, viz. Karimunda II with a maximum green berry yield of 5.60 kg/vine followed by Valiyaramundi (3.45 kg/vine) and TMB IV (1.80 kg/vine). In cardamom, 305 germplasm have been maintained. Ginger (660 accessions) and turmeric (1,280 accessions) have been maintained under AICRPS centres. Out of the 265 turmeric germplasm accessions screened for resistance against leaf spot and leaf blotch diseases, the turmeric germplasm accessions, viz. CL 1, CL 2, CL 3, CL 6, CL 14, CL 22, CL 25, CL 31, CL 32, CL 33, CL 53, CL 54, CL 148, CL 153 and CL 230 were resistant to leaf spot (8 – 10 PDI) and leaf blotch. In tree spices, a total of 37 clove, 119 nutmeg, 39 cinnamon and 6 cassia accessions have been maintained. In coriander 1,809, in cumin 623, in fennel 670 and in fenugreek 976 accessions were maintained.

Flowers: At Bhubaneshwar, five new cultivars of rose were added to the existing germplasm of 324 cultivars including 201 HT, 73 floribunda, 42 miniature and 8 climbing roses.

Orchids: A total of 3,130 orchid accessions maintained at NRC for Orchids, Pakyang, Sikkim. Two orchid species, Euranthes and Ione, have been collected and enriched germplasm collection.

Betelvine: The cultivar, Vasanaa Kapoori, performed better than others in respect to leaf yield, 20% more than the control. GN 1 hybrid (Ghodi Bangla × Kapoori Nasik) exhibited normal vigour. Even in GN hybrid, yield was much below than the local check variety. The hybrids could not establish at BCKV centre.

Tuber crops: In tuber crops, four early-maturing hybrids and 12 others suitable for table purpose were identified. The 164 SSR marker-tested cassava mosaic resistant clones received from CIAT were evaluated. Flour clones, viz. CR 43-11, CR 43-7, CR 54A-3 and CR 59-8, had high yield (>40 tonnes/ha) coupled with CMD resistance. Out of 1,820 first clonal hybrids evaluated for identifying TLB tolerant clones, 12 were symptom-free and being evaluated along with Mukhtakeshi. Also hybrid seeds were generated incorporating TLB-free wild taro as one of the parents (seven crosses) to produce TLB-resistant taro hybrids. Fifteen high-yielding hybrids were identified from the replicated trial and being evaluated to confirm the performance. About 118 hybrids were evaluated for isolation of high-yielding good cooking types.

In cassava, ME 833 gave higher yield at Yethapur and CM 9905 at Thiruvananthapuram. H 740/92 recorded significantly higher yield at Yethapur and Peddapuram. Three clonal selections, PDP 5, PDP 6 and PDP 7, obtained from crosses Ambakadan × Sree Prabha (TCH 2) and Ambakadan × H 165 showed high degree of resistance to cassava mosaic virus with high yield potential.

In sweet potato, two selections, viz. CARI – SP1 and CARI-SP2, from Port Blair with consistent higher yield under Island ecosystem were identified for Andaman and Nicobar Islands. IGSP 14, CO 3-4, SV 280, DOP 93-19 and ST 10 were identified as good yielders at different centres. Among orange fleshed sweet potato entries, Kamalasundari, 440038, CIPSWA 2, ST 14, IGSPC 15, 362-7 and SV 98 showed better performance in different states.

Yam bean RM 1, DPH 101, DPH 88 and DPH 70 were the maximum tuber yielders at different centres. Among the collection of *Colocasia*, *C. esculenta* var. *antiquorum*, taro collections, ML 1 and ML 9 were good yielders in Meghalaya. JCC 25, IG Col 4 and BCC 17 in taro were identified as good yielders for Asom, Chhattisgarh and West Bengal.

ANIMALS

Livestock information management

Individual assignment using genetic algorithm: A computational methodology based on genetic algorithm was developed to solve the individual assignment problem using microsatellite data. Its results were compared, and accuracy of assignment was also tested. Performance using genetic algorithm methodology is comparable with that of existing methods with the data generated from actual allelic frequency values of Red Kandhari, Deoni, Hariana and Sahiwal cattlebreeds.

Phenotypic characterization

Bargur cattle: Bargur cows are distributed in and around Bargur hills in Bhavani Taluk of Erode district, and also in Kolathur Taluk of Salem district especially the regions adjoining the Bargur hills. Bargur village (34 hamlets) has 10,102 cattle of which 90% conform to breed characteristics of Bargur cattle. The animals are maintained in low

Evaluation of indigenous pig germplasm

Indigenous pig herds of three strains, were established at the NRC Pig for genetic evaluation, improvement and conservation. Unrelated pigs of Nagaland, Megahlaya and Northern West Bengal (Ghungroo) were directly procured from farmers' field and the founder stock was established at the institute. The litter size at birth in indigenous pigs from north Bengal (Ghungroo) was on an average 12 piglets in comparison to seven in Meghalaya and five in Nagaland. The weaning weight is about 12 kg in Ghunguroo in comparison to Megahalaya local (5.25 kg) and Nagaland local (4.5 kg).Gunghroo has the potential to be developed as the Indian Meishan pig in the future.

Ghungroo pig with litter

Sex identification of meat

Method for identification of sex from meat was standardized. It involves PCR amplification of Amelogenin XY gene. In males amino acid coding region of the Amelogenin gene on the Y chromosome (AMELY) is shorter than its X chromosome counterpart i.e. it is having a deletion region. Hence PCR amplification of AMEL gene gives amplicons of two sizes (217, 280 bp) in male and only amplicon of single size (280 bp) in female DNA samples. Repeatability of the assay was confirmed by testing in different field samples.

input system by grazing animals in deep thick forests. *Patti* system is practiced, whereby herdsmen keep animals in *pattis* during night. Animals are small; brown colour with white patches. The average body length, height at wither, heart girth, paunch girth, face length, face width, horn length, ear length and tail length without switch in cows were 99, 108, 139, 144, 42, 14, 35, 17 and 62cm, respectively. The birth weight varied between 15 and 18 kg. Cows are poor milkers; average daily yield is 1.14 kg. Age at first calving varies from 36 to 60 months with an average of 48 months. Calving interval varies from 16 to 18 months, lactation length 180 days to 240 days, service period 120 to 180 days, and dry period from 150 to 210 days.

Malnad Gidda cattle: Malnad Gidda, a dwarf cattle is mainly distributed in Shimoga, Chickmagalur, North and South Kannada, and Belgaum districts of Karnataka. The breed population has declined especially in last two decades. The animals are kept under low input system of management. There are five major coat colours in the breed (black, brown, red, fawn, white and sometimes mixture of any two). The average body length and height at withers were 87.04±0.65 cm and 90.29±0.46 cm, respectively, for cows, and 86.53±1.93 cm and 91±1.47 cm, respectively, for adult males. The average chest girth and paunch girth were 118.36±0.67 and 121.39±0.82 cm for cows and 118.47±3.93 and 118.67±3.90 cm for adult males. Birth weight, weight at maturity, age at first calving, age at first service in males, calving interval, service period and number of services/conception were 8.56 ± 0.44 kg, 87.29±2.95 kg, 45.41± 1.22 months, 38.06 ± 1.24 months, 17.02 ± 0.68 months, 8.38 months, and 1.48, respectively. About 15% cows are producing more than 2 kg milk/day. In elite cows, the lactation period, dry period, average daily milk yield, peak yield, lactation milk yield were estimated as 8.95 months, 7.17 months, 2.11 kg, 3.09 kg, 569.13 kg, respectively.

Balangir sheep: The Balangir sheep is distributed in Balangir, Kalahandi Baudh and Angul districts of Orissa. Animals are small; average body weight, body length, height at withers and chest girth were 23.0±0.74kg, 57.6±0.84cm, 62.1±0.74cm and 69.7±0.84cm in rams and 20.4±0.17kg, 55.6±0.22cm, 59.6±0.18cm and 67.2±0.22cm in ewes, respectively. Coat colour ranged from light to dark brown or patches of white and brown. Males are horned and females are polled. Body is covered with coarse, open and colour fleece. Face, belly and legs are devoid of wool. In males, age at first breeding was 8-12 months with a breeding life of 1-3 years. Lambing rate was 70-100%. Balangir sheep are primarily maintained for mutton.

Surti goat: Surti goats are found in Bharuch, Narbada, Navsari, Valsad and Vadodara districts of Gujarat. Animals are of medium size with varied colour patterns, viz. white, black tan, and grayish. Mottled animals are also found. Surti goats are good milch animals with well developed funnel/ bowl shaped udder. The milk production ranged from 1.5 to 4 kg/day. Surti goats are good breeders showing first oestrous at an age of 6-8 months and kid at 13-14 months of age. Twins are born to majority of does (50-60%), and triplets are rare (5%). Males also show sexual maturity at the age of 6-7 months. The major breeding season is March-April and minor is October-November. The average body weight of adult male and female is 29.03 and 31.06 kg, respectively.

Busra chicken: Busra birds are found in Navapur taluk of Nandurbar and Sakri taluk of Dule districts of Maharashtra, and Songadh and Uchchal taluks of Surat district of Gujarat. These birds are reared for home consumption as well as for sale of live birds and eggs. Birds are kept in

the free range system. Flock size varied from 2 to 25 with an average of 8.6. Plumage is mostly white mixed with black feathers on neck, back, tail, and reddish brown feathers on shoulders and wings. Comb is red, single, small to medium in size, stands erect; beak yellow; wattles red, small to medium size; and shank, yellow. Weight of cock ranged from 0.85 to 1.25kg (average 1.11±0.06 kg) and of hen from 0.8 to 1.2 kg (average 0.98±0.06 kg). Age at first egg ranged from 5-7 months (average of about 6 months). Annual egg production ranged from 40 to 55. Hatchability on total egg basis ranged from 60 to 85%. Dressing percentage is about 65 – 70%. Eggs are small weighing about 28-38g (average 31.56±1.40g). Shell colour is mostly light brown. Egg shell is mostly strong with an average thickness of 37.73±1.47µ. Albumen index, yolk index and haugh unit were 0.059±0.007, 0.352±0.012 and 73.66±4.04, respectively.

Busra birds are kept for home consumption and sale of live birds

Genetic characterization

Cytogenetic status of Assamese buffalo: All the non-descript buffaloes found in Assam resemble swamp buffaloes in external features. They are of small body size, low milk yield and are classified as swamp buffaloes (Assamese swamp buffaloes). Distinctive karyotypic features of swamp and river buffaloes were exploited to explicitly ascertain their riverine or swamp status. Majority of the animals investigated–picked from different parts of Assam–were riverine type, which is in contradiction to the general classification of Assamese buffaloes as swamp type.

Only four animals had a diploid count of 49 chromosomes, with one large size metacentric chromosome characteristic of swamp buffaloes. These four animals were thus crosses of River × Swamp type indicating the presence of swamp type buffaloes also in the vicinity, probably of the wild type.

Buffalo lactoferrin gene: Lactoferrin is a potential candidate gene in dairy cattle breeding for increasing resistance against infections especially in mammary gland. Polymorphism in this gene was studied by analyzing the 5' flanking region of lactoferrin gene in Murrah, Jaffarabadi, Marathwada, Toda and Pandharpuri buffalo breeds. Ten distinct SSCP (single strand conformation polymorphism patterns) were observed, which further revealed 13 polymorphisms with 8 transitions, 4 trans-versions and one deletion mutation upon sequence analysis. Sequencing indicated homology with *Bos taurus* (96%), *Bos indicus* (95%), *Capra hircus* (91%), *Ovis aries* (92%), *Sus scrofa* (57%) and *Homo sapiens* (28%). Sequence analysis of SSCP variants revealed 34 nucleotide changes in bubaline lactoferrin gene from that of *Bos taurus* across

Comparative Genetic resistance to H5N1

Genetic resistance of indigenous stock — Kadaknath and Aseel Peela vis a vis high yielding SDL-IC (Synthetic Dam Line-Immunocompetent)—broilers against induced infection of H5N1 was evaluated.

The birds were subjected to induced-infection intra-nasally with a dose of 1,000 EID 50 (determined by a prior experiment) of H5N1 (narapur/7972 strain). The overall survivability percentages were 8, 2 and 0% in SDL-IC broilers, Aseel and Kadaknath, respectively. The MDT (mean death time) was highest in SDL-IC (6.96 days) followed by Aseel (5.92 days) and Kadaknath (3.12 days). The day-wise and cumulative mortality percentages and MDT were significantly different among genetic groups. So far, no report is available in literature on survival of chicken after induced challenge of H5N1 whereas, for the first time, in present case 1 out of 50 Aseel and 4 out of 50 SDL-IC broilers survived for 10 days experimental period after H5N1 induced infection at higher dose than reported in literature. The four surviving SDL-IC broilers did not show any clinical sign and were apparently healthy whereas the Aseel was depressed.

The overall severity of clinical signs was less with delayed onset of symptoms in SDL-IC broilers as compared to other two genetic groups. The overall severity of gross PM lesions was less in Kadaknath followed by Aseel and SDL-IC broilers, which might be due to the least MDT in Kadaknath as compared to other genetic groups. During early as well as late phases of H5N1 infection, lungs were most severely affected followed by brain in all the 3 genetic groups.

The expression profiles of genes indicated better genetic resistance in SDL-IC broilers as compared to Aseel and Kadaknath against H5N1 infection, which was in agreement with results of challenge trial. Nucleotide analysis of differentially expressing genes also revealed variation (transitions, transversion and insertion/deletion) in both exon and intron regions among the three genetic groups.

different exonic regions. Analysis of different intronic regions revealed 38 nucleotide changes. Further, analysis of sequence data revealed five novel SNPs in intronic region and two SNPs in exonic region of bubaline lactoferrin gene. The SNPs identified in the lactoferrin promoter, exonic and intronic regions may serve as potential candidate marker(s) in buffaloes.

Phylogenetic relationship among bovine species: RAPD analysis on five bovine species under the genus *Bos* (Bovis), viz. yak (*Pheophagus grunniens*), mithun (*Bos frontalis*), *Bos indicus*, *Bos taurus* and buffalo (*Bubalus bubalis*) showed that yak shares highest genetic similarity with mithun (42%) followed by exotic cattle (27%), indigenous cattle (29%) and buffalo (16%). In comparison with yak, mithun was slightly closer to both the cattle species. Among the five species studied, buffalo seemed to be the most distinct from others. These results suggested that during the course of evolution, chromosomal rearrangement might have played little role in the diversification of bovines.

Molecular genetic characterization

Sheep and goat: Microsatellite based genotyping of Patanwadi, Marwari and Dumba Sheep breeds revealed genetic distance of 0.033 between Patanwadi and Marwari, 0.049 between Patanwadi and Dumba, and 0.066 between Marwari and Dumba, indicating less genetic distance between Patanwadi and Marwari sheep breeds.

Microsatellite based genotyping was completed for Coimbatore sheep, Barghur cattle, Salem Black and Tellicherry goat at Core lab, TANVASU, Chennai, and diversity analysis for Bachaur cattle, Shahbadi and Ganjam sheep breeds at Core lab, NBAGR, Karnal. Diversity analysis indicated existence of substantial genetic variability and had no recent bottleneck in the populations investigated. Under trait-specific gene characterization, polymorphism at the *DGAT1* locus was also investigated by PCR-SSCP assay in native goat breeds.

Calpastatin gene, responsible for meat tenderness, was genotyped in Deccani, Nellore, Sonadi, Malpura, Nali, Ganjam, Chokla and Garole sheep breeds. Nellore sheep revealed the highest polymorphism in the calpastatin gene. Nellore and Malpura sheep are closer in terms of meat tenderness.

Layer and broiler germplasm: Genetic diversity analysis of 6 genetic groups of a diallel cross was carried out by 14 microsatellite markers. The genotypes showed varied genetic identity/ diversity. In a study using 14 microsatellite markers located on different chromosomes, the markers *ADL023*, *MCW041*, *ADL210* and *MCW110* were significantly associated with egg production up to 28, 64 and 72 weeks of age. *MCW007*, *ADL020*, *ADL023* and *ADL176* microsatellites correlated significantly with age at sexual maturity. The genotypes of *MCW007* microsatellite were associated with body weight.

Genetic manipulation through introgression of major gene, transgenesis and reconstitution of poultry species: Two pure broiler strains (NNWP and NNCP) having specific introgressed naked neck gene, have undergone specialized selection programme over thirteen generations. The naked neck birds showed consistently relative superiority over normal for array of broiler traits. Presently, CARIBRO-Mritunjai is the only proven commercial (Naked Neck) broiler to perform exceedingly well in hot and humid conditions (tropical climate). To improve the general immunocompetence, the male and female progeny of NNCP population were selected for high 5-week body weight and high response to HI titre, and in NNWP population only male progeny was selected for high 5-week body weight and high response to HI titre.

Role of apoptotic genes during forced moulting: Apoptotic genes, viz. Caspase-1, Caspase-2, Caspase-3, Caspase-6, Caspase-8, Caspase-9, p53, Bcl-2 and Bcl-xL, were studied in the regressing reproductive tissue of force moulted White Leghorn hens. The mRNAs of all caspases under study except Caspase-6 were found in the regressing ovarian and oviduct (magnum and uterus) tissues. The involvement of apoptotic genes of intrinsic pathway (p53, bcl-2, bcl-xL) was also found in the ovary, magnum, and uterus of the moulted birds. The present investigation clearly indicated that apoptotic genes involved in both extrinsic and intrinsic pathways control reproductive regression in moulting birds.

Isolation and molecular characterization of methanogenic archaea: The methanogenic archaea

Genetic characterization of predominant *Salmonella* serovar in seafood

PCR ribotyping and band pattern analysis of *Salmonella* Weltevreden and *Salmonella* Rissen isolates, the most common isolates from different seafood revealed three ribotype profiles in *Salmonella* Rissen and four major ribotype patterns in *Salmonella* Weltevreden strains indicating distinct genetic diversity among them. Studies on the genetic variations among *Salmonella* Typhi isolates by PFGE and VNTR showed similar genetic homology among *Salmonella* Typhi strains isolated from different seafoods. These molecular fingerprinting techniques showed that there were intra-serovar genetic variations among predominant *Salmonella* serovars in seafood.

were isolated from the rumen of small and large ruminants. Uncultured archaeal sequences were also characterized from the metagenomic library constructed with rumen content. Archaeal isolates *Methanobrevibacter* and *Methanosarcina* were isolated. An organism with 94% sequence similarity with *Methaniculleus marisnigri* was recorded for the first time in India.

Network Project on Animal Genetic Resources

***In-situ* conservation:** At the *in-situ* Conservation Unit of Beetal goat, 173 Beetal does were registered and their performance data recorded. Male kids were selected, tagged and registered, and their body weights were recorded up to 12 months of age. The awareness for pure breeding of Beetal was created among the selected farmers, which resulted in an increase of flock size by 5-7. This was also attributed to the culling of non-Beetal goats and sheep in flocks.At Navsari, 150 Surti goats were registered in 11 villages of Bharuch, Surat and Navsari districts. The male kids were born with slightly higher birth weight than female kids. The daily weight gain up to the age of 3 months was approximately 75.88g for male and 74.11g for female kids.

At Kilakarsel sheep *in-situ* Conservation Unit, 358 animals of Kilakarsel (1.5%) were identified by surveying 23,621 sheep in five districts. The number of pure Kilakarsel sheep was very less, therefore it was categorized as a threatened breed. Purebred Kilakarsel sheep are being reared to produce 50 rams for distribution in field.

***Ex-situ* conservation:** At BAIF, Pune, bull calves of Krishna Valley cattle were reared at germplasm unit in individual bull-pens. The bull calves, weighing at least 260 kg were used for semen collection, and 7,000 semen doses were stored. On an average 1,000 semen doses per Jaffarabadi bull were produced and stored. At the UPLDB Lucknow, 12 male calves of Ponwar cattle and 11 male calves of Kherigarh cattle are being trained for semen donation.

FISH

Coldwater fisheries: The coldwater fish genetic stocks of the Kumaon region, Uttarakhand, were surveyed in river Kosi, Ramnagar, Gola and Chirapani stream and *Tor putitora*, *Schizothorax richardsonii*, *Barilius* species, *Garra* species and *Riamas bola* were recorded. The cyprinid family fish species were assessed for their molecular systematics at subfamily level and the sequence was submitted to NCBI database with the accession numbers of AM778102 to 06 and AM950230. They indicated the possible occurrence of subfamilies Schizothoracinae, Cyprininae and Rasborinae.

Development of microsatellite markers in *Macrobrachium rosenbergii*: With regard to development of microsatellite markers in giant freshwater prawn, *Macrobrachium rosenbergii*, over 3,000 colonies from a partial genomic library were screened. A total of 92 positive colonies were detected and 30 colonies were selected on the basis of signals strength of which 12 could be sequenced. Eight loci were polymorphic and all the loci except one were in the agreement with HWE. No significant pair-wise linkage disequilibrium was found among the loci. These markers may prove useful for characterization of natural population as well as brood stock management of this species.

Genetic linkage mapping in Indian major carps: Marker to marker linkage study was initiated in rohu, the first attempt of its kind in Indian fish species. Rohu and kalbasu (*Labeo calbasu*) have 25 pairs of chromosomes and produce viable F1 hybrids. Pair-wise recombination estimation using LINKMFEX software showed eight loci to be linked with a minimum LOD score of 3.0 forming three linkage group in male parent spanning 67.29 cM.

Gene banking of Indian catfish *Horabagrus nigricollaris*: *Horabagrus nigricollaris*, an endemic, cultivable yellow catfish, is found only in one river (Chalakkudy River, Kerala) originating from southern part of the biodiversity hotspot – the Western Ghats, South India. This species enjoys a good market value as a food and ornamental fish. The species was categorized as critically endangered due to its highly restricted distribution, loss of habitat, over exploitation, destructive fishing practices and trade. Hence, captive breeding and milt cryopreservation techniques were developed for the species.

DNA barcoding of Indian fishes: A comprehensive programme on DNA barcoding of fishes of India is being carried out at the NBFGR, Lucknow. The total DNA was isolated for 1,427 samples of 410 species and PCR amplification was done for 733 samples of 280 species. DNA sequencing was done in 540 samples of 182 species. DNA barcodes were prepared for 180 species. A total of 395 DNA sequences of 110 species were submitted to BOLD.

Species-specific DNA - based diagnostic assay for *Gyrodactylus elegans*: A standardized DNA based-diagnostic technique for species-specific identification of the trematode, *Gyrodactylus elegans* was developed. This is the first attempt in the country, towards molecular detection of fish parasites.

6

Crop Improvement

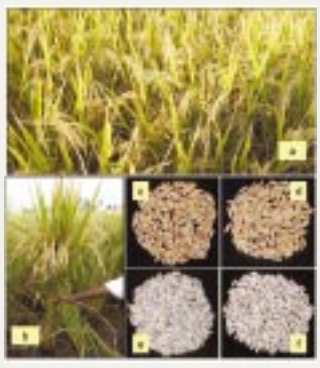
IMPROVEMENT

Rice: Eighteen hybrids/varieties have been released for various agro-ecologies.

Rice varieties/hybrids released

Variety	Ecosystem	Resistant to pests/diseases	Recommended
Central Releases			
Hybrid 6129*	Irrigated	Blast, brown spot, brown plant hopper (BPH), white backed plant hopper (WBPH)	Irrigated areas of Punjab, Tamil Nadu
Improved Pusa Basmati 1	Basmati	Blast	Basmati-growing areas of Delhi, Punjab, Jammu and Kashmir, Uttarakhand
Improved Samba Mahsuri	Rainfed shallow lands	Blast, bacterial blight	Irrigated/shallow lowlands of Andhra Pradesh, Chhattisgarh, Jharkhand, Orissa, Bihar, Gujarat, Maharashtra
State Releases			
Chandrama	Shallow lowland/ boro	Blast, bacterial blight, rice tungro virus (RTV), sheath blight, BPH, WBPH	Shallow lowlands/boro areas of Assam
Madhuri	Rainfed lowlands	Blast sheath rot, bacterial blight	Lowlands of Karnataka
Karma Mahsuri	Irrigated	Blast, brown spot, gall midge	Irrigated areas of Chhattisgarh
Varun Dhan	Irrigated hill	Blast	Irrigated hills of Himachal Pradesh
MAS 946-1	Aerobic	Bacterial blight	Limited water environments of eastern dry zone in Karnataka
MAS 26	Aerobic		Limited water environments of eastern and central dry zones in Karnataka
Annalakshmi	Irrigated	Bacterial blight, RTV, brown spot	Irrigated areas of Pudducherry
CO (R) 48	Irrigated		Irrigated areas of Tamil Nadu
RMD (R) 1	Irrigated	Moderately resistant to shoot-borer and leaf folder	Irrigated areas of Tamil Nadu
Karjat 7	Irrigated	Neck blast, leaf folder	Irrigated areas of Maharashtra
Satya Krishna	Irrigated and rainfed shallow lowlands	BPH, blast, bacterial blast	Irrigated and rainfed lowlands of Orissa
Nua Kalajeera	Rainfed shallow lowlands		Shallow lowlands of Orissa
Nua Dhusara	Rainfed shallow lowlands		Shallow lowlands of Orissa
Hanseswari	Semi-deep water ecology		Semi-deep lowlands of Orissa
Chandan	Boro ecology		Boro irrigated areas of Orissa

*Hybrid rice



Improved Samba Mahsuri has good agro-morphological features (a,b) and excellent grain quality (d,f) similar to Samba Mahsuri (c,e)

Wheat: Seven varieties of wheat have been released and notified.

Wheat varieties released

Variety	Area of adaptation	Production conditions	Remarks
		Bread Wheat	
VL 892	Hills of Himachal Pradesh and Uttarakhand	Late sown, medium fertility restricted irrigation conditions	Yielded more than check varieties
HPW 251	Hills of Himachal Pradesh and Uttarakhand	Early sown, low fertility rainfed conditions	Gave high yield over check varieties. In addition to being resistant to brown rust, it showed better resistance than checks against yellow rust. It also showed high degree of resistance to Karnal Bunt and immunity against flag smut
PBW 550	Punjab, Haryana, west Uttar Pradesh (except Jhansi division), Delhi, Rajasthan (excluding Kota and Udaipur divisions), *Tarai* of Uttarakhand, Paonta Valley and Una district of Himachal Pradesh	Timely sown, high fertility irrigated conditions	Possessed higher degree of resistance to yellow and brown rusts and flag smut in comparison to checks. And found resistant to 78S84 race of yellow rust to which PBW 343 has now become susceptible
WH 1021	Punjab, Haryana, west Uttar Pradesh, Delhi, Rajasthan, (excluding Kota and Udaipur divisions), *Tarai* of Uttarakhand, Paonta Valley and Una district of Himachal Pradesh	Late sown, medium fertility irrigated conditions	Yielded higher than UP 2425, PBW 373 and Raj 3765. It has more protein content, higher loaf volume (12.21%), (572cc) and much better bread-making quality. Besides better nutritional quality, showed high degree of resistance to yellow rust, brown rust and flag smut
HI 1544	Madhya Pradesh, Rajasthan (Kota and Udaipur divisions) and Gujarat	Timely sown, high fertility irrigated conditions	Yielded higher than Lok 1. It showed resistance to leaf and stem rusts
HD 2932	Madhya Pradesh, Chhattisgarh, Rajasthan (Kota and Udaipur divisions), Gujarat, Maharashtra and Karnataka	Late sown, medium fertility irrigated conditions	It out-yielded all check varieties in the central parts of the country. It exhibited high magnitude of adult plant resistance to leaf and stem rusts. It is an early-maturing variety with acceptable grain quality
HI 8663(d)	Maharashtra and Karnataka	Timely sown, high fertility irrigated conditions	It exhibited high beta-carotene content, high protein content, high sedimentation value (35ml), and high contents of iron, manganese, copper and zinc to make it a very good durum wheat. It showed desirable pasta cooking quality. It maintained high degree of field resistance to leaf and stem rusts and foot rot

Wheat varieties identified

Variety	Area of adoption	Salient features
HS 490	North Hills Zone (Hills of Jammu and Kashmir except Jammu and Kathua districts), Himachal Pradesh (except Paonta Valley and Una district), Uttarakhand (excluding *Tarai* region), Sikkim and hills of West Bengal and north-eastern states. Late sown, restricted irrigation	Good biscuit quality
PBW 590	North Western Plains Zone (Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), west Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh and *Tarai* region of Uttarakhand. Late sown, irrigated conditions	Tolerance to terminal heat stress and good bread quality
CBW 38	North Eastern Plains Zone (East Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Orissa, Assam and plains of north-eastern states. Timely sown, irrigated conditions	Resistance to leaf blight and leaf rust, high sedimentation value (58cc), bread quality and grain nutritional characteristics
RAJ 4120	North Eastern Plains Zone. Timely sown, irrigated conditions	Resistant to Ug99, superiority in leaf rust resistance and good chapati quality
MP 1203	Central Zone (Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur division of Rajasthan and Jhansi division of Uttar Pradesh). Late sown, irrigated conditions	High protein (13%) and extraction rate (70%), good bread quality and grain appearance
UAS 415	Plains Zone (Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu). Timely sown, irrigated conditions	Durum for superior pasta quality
PBW 596	Plains Zone, Timely sown, irrigated conditions	Goof for limited irrigations
MACS 2971	Plains Zone, Timely sown, irrigated conditions	Dicoccum variety
RD 2715	Central Zone, Timely sown, irrigated conditions	Dual-purpose variety for green fodder and grains

Registration of genetic stocks. Ten new genetic stocks of wheat have been registered by the Plant Germplasm Registration Committee.

Wheat genetic stocks registered

Name	Reg. No.	I.D. No.	Developed by	Traits(s)
FLW 28	INGR 08001	IC 553913	DWR, Shimla	Resistant to brown and yellow rusts
FLW 29	INGR 08002	IC 553914	DWR, Shimla	Resistant to all rusts
FLW 30	INGR 08003	IC 553915	DWR, Shimla	Resistant to all rusts
GW 2002 18	INGR 08004	IC 553917	WRS, SDAU, Gujarat	High tillering
GW 2002 51	INGR 08005	IC 553919	WRS, SDAU, Gujarat	High grain weight in durum wheat
HS 424	INGR 08006	IC 557719	IARI, RS Shimla	Resistant to leaf and stem rusts
HS 431	INGR 08007	IC 557720	IARI, RS Shimla	Resistant to leaf and stem rusts
LBRL 4	INGR 08056	IC 549912	DWR, Karnal	Leaf blight resistance
LBRL 6	INGR 08057	IC 549913	DWR, Karnal	Leaf blight resistance
LBRL 1	INGR 08058	IC 549914	DWR, Karnal	Leaf blight resistance

To mitigate the threat posed by the stem rust virulence Ug99, 318 wheat varieties were screened at its hot spot Njoro (Kenya). The screening revealed that 78 genotypes were resistant to Ug 99. Four wheat varieties HD 2781, DL 153-2, NI 5439 and HI 8498(d) have been reconfirmed for their resistance to Ug 99.

Barley: Dual-purpose barley RD 2715 has been identified for release in Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur division of Rajasthan and Jhansi division of Uttar Pradesh for timely sown, irrigated conditions. This showed resistance to yellow rust.

Maize: Five hybrids, four composites and two quality protein maize (QPM) hybrids have been released for different agro-ecological zones of the country.

Sorghum: A new multicut forage sorghum hybrid CSH 24MF (UTMCH 1302) has been identified for release in all forage zones of India. It has lower HCN content (90-100 ppm), and is resistant to anthracnose, zonate leaf spot and grey leaf spot, and is tolerant to stem borer and shoot-fly.

Dual-purpose hybrid sorghum CSH 25 has been identified for cultivation in *kharif* in Maharashtra,

Maize hybrids/composites released

Hybrids/ composites	Area of adaptation	Characterization
Hybrids		
PMH 3	Delhi, Punjab, Haryana and western Uttar Pradesh	Late-maturing, orange flint grains, single-cross hybrid
HM 10	Delhi, Punjab, Haryana, western Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka	Late-maturing, yellow grains, single-cross hybrid; resistant to *Sesamia inferens*; released for winter
HM 8	Punjab, Haryana, western Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra (*rabi* and *kharif*)	Medium-to-late maturing single-cross hybrid, orange grains; suitable for *kharif* and *rabi*
PRO 368	Rajasthan, Gujarat and Madhya Pradesh	Double-cross hybrid, yellow grains
Vivek maize hybrid 33	Uttarakhand, Jammu and Kashmir	Extra-early maturing hybrid; orange dent grains
Composites		
Pant Sankul Makka3	Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Rajasthan, Gujarat and Madhya Pradesh	Yellow grains
Bajaura Makka	Uttarakhand and Himachal Pradesh	Orange grains
Chandramani	Andhra Pradesh, Karnataka, Maharashtra	Composite with yellow to orange grains
Pratap Kanchan	Tamil Nadu, Jammu and Kashmir and Uttarakhand	Yellow grains, moderately resistant to stem borers and major diseases
QPM Hybrids		
HQPM 7	Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Yellow grains quality protein single-cross hybrid, medium-to-late maturing
Vivek 9 QPM	Jammu and Kashmir, Himachal Pradesh, Uttarakhand ,Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Extra-early maturing yellow grains; developed by SSR marker-assisted selection; semi-dent QPM single-cross hybrid

Andhra Pradesh, Karnataka, Madhya Pradesh and Gujarat. It is tolerant to grain mold.

Pearl millet: Four hybrids MH 1340,MH1385, MH1351 and MH1352 and an open-pollinated variety MP 443 have been identified for release.

Small millets: Proso millet TNAU 151 and barnyard millet VL Madira 207 have been identified for release in Tamil Nadu,Andhra Pradesh, Bihar, Karnataka, Uttarakhand and across the country, excepting Gujarat and Tamil Nadu.

Forage crops: *Oat JHO 991 (Bundel Jai 991)***.** Its seed-to-seed maturity period is 150-155 days and seed-to-flowering is 120-125 days. It is moderate to highly resistant to leaf blight and moderately resistant to nematodes, and resistant to highly resistant to grasshoppers and aphids. It contains crude proteins 9.7%, acid digest fibres 46.7%, neutral digestible fibres 63.5% and its *in-vitro* dry matter digestibility is 57.4%. This variety has been released for cultivation in the hilly zone under single-cut system.

Forage crop varieties identified and released

Forage crops	Variety	Adaptation region/ Agro-ecology
Maize	Pratap Makka Chari EC 3135	North West Zone covering Punjab, Haryana, Rajasthan, western parts of Uttar Pradesh and Uttarakhand
Cowpea	UPC 625	Cowpea-growing areas in North West, Central and North East Zones
Pearl millet	BAIF *bajra 1*	Pearl-millet growing areas in North West and Central Zones
	JHPM 05 02	All pearl-millet growing areas except South Zone
	NDFB 2	Pearl-millet growing areas in North East Zone under salt-affected soils

Underutilized crops: Grain-amaranth RM 4 and GA 3 have been identified for release for cultivation in *rabi* in Rajasthan, Orissa, Jharkhand and Gujarat.

Phytochemical characterization was done of promising genotypes identified in Grain-amaranth IC 35399, for protein content and lysine content (6.4 %), and in faba bean HB 502 for protein (26.30%), and HB 30 for low vicine-convicine content (0.82%).

Groundnut: Two varieties have been released and notified, and 3 have been recommended for release.

Groundnut varieties

Variety	State(s) area of adaptation	Special features
Released and notified		
Girnar 2 (PBS 24030)	Uttar Pradesh, Punjab, northern Rajasthan	Virginia bunch type with 'stay green' leaves and bold seeded. Tolerant to rust, leaf spot, peanut stem necrosis disease (PSND) and sucking pests
AK 265	Southern Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu	Drought tolerant, suitable for rainfed areas, resistant to foliar fungal diseases
Identified for release		
R 2001-2	Orissa, Jharkhand, West Bengal and north-eastern states	High yielding than JL 24 and tolerant to foliar diseases and sucking pests
VG 9816	Tamil Nadu, Andhra Pradesh, Karnataka and southern Maharashtra	Tolerant to foliar diseases and consistency in yield performance
ICR 48	Rajasthan and Gujarat	Identified for terminal drought areas

Rapeseed-mustard: Two hybrids of Indian mustard NRCHB 506 and DMH 1 have been

Grain-amaranth has been identified for release in *rabi* in Rajasthan, Orissa, Jharkhand and Gujarat

NRCHB 506 Indian mustard hybrid

NRCYS 05-02 yellow sarson variety

Castor 48-1 is resistant to wilt, capsule borer, and is tolerant to jassids

identified for release. Similarly, 7 varieties of rapeseed-mustard have been identified for release for various agro-ecologies of the country. These are ONK 1 (Gobhi sarson), NRCYS 05-02 and YSH 0401 (Yellow sarson), RB 50, RGN 145, NRCHB 101 and LESI 27.

Soybean: Three improved varieties, VLS 59, VLS 63 for Northern Hill Zone and JS 97-52 for Central Zone have been identified for release.

Safflower: NARI 38 and AKS 207 with wilt resistance and yield advantage have been released and notified for the safflower-growing areas of the country and Vidarbha region of Maharashtra. And SSF 658 superior to NARI 6 and JSI 7 in yield with resistance to wilt has been identified for all safflower-growing areas.

TAS 82 sunflower has been notified for Maharashtra

Sunflower: DRSF 113 has been released and notified. It is suitable for *kharif* and *rabi*, and is recommended for Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra; and TAS 82 for Maharashtra and CO (SFV) 5 for Tamil Nadu have been notified.

Castor: 48-1, exhibiting distinct superiority over the checks in seed (15-30%) and oil yields (19.9-50.2%), has been released for castor-growing areas. It is resistant to wilt and capsule borer, and is tolerant to jassid.

Sesame: Two varieties of sesame RT 346 and SWB 32-10-1 have been identified for release and notification. RT 346 having 20% superiority over the check with higher oil percentage has been identified for Rajasthan, Haryana, Gujarat and parts of Maharashtra and Uttar Pradesh. SWB 32-10-1 having 15% yield superiority has been identified for summer in coastal ecosystem of Andhra Pradesh, Karnataka and Orissa.

Niger: BNS 10 has been recommended for release in niger-growing areas, and KBN1 has been released for Karnataka.

Pulses: Five varieties have been identified in pulse crops.

Pulse varieties identified

Crop	Variety	Special features	Area of adoption
Chickpea (Kabuli)	IPCK 2002-29	Extra large seeds (33.8 g/100 seeds)	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, southern Rajasthan, Maharashtra, Chhattisgarh, Gujarat
Pigeonpea	TJT 501	Tolerant to pod borer and pod fly	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, southern Rajasthan, Maharashtra, Chhattisgarh, Gujarat
	GTH 1	Resistant to SMD and wilt	First CMS-based hybrid notified for Gujarat and identified for Madhya Pradesh, Bundelkhand region of Uttar Pradesh, southern Rajasthan, Maharashtra, Chhattisgarh, Gujarat
Mungbean	KM 2241	Resistant to MYMV	Jammu and Kashmir, Himachal Pradesh, Uttarakhand
Urdbean	IPU 02-43	Resistant to MYMV and powdery mildew	Andhra Pradesh, Karnataka, Tamil Nadu, Orissa
	NDU 5-7	Resistant to MYMV	Punjab, Haryana, western Uttar Pradesh, north Rajasthan
	Vallabh Urd 1	Resistant to MYMV	Punjab, Haryana, western Uttar Pradesh, north Rajasthan
Lentil	WBL 77	Resistant to rust, small seeds	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam

Arid legumes: Guar VLG 15 and HG 2-20 have been identified for release and notification. VLG 15 having advantage of higher grain yield and tolerance to diseases has been identified for Northern and Central Zones. HG 2-20 identified for Northern Zone is moderately resistant to foliar diseases with 31.14% gum content.

Sugarcane: Among red-fleshed clones, NG 77 75 recorded appreciably higher antioxidants than the other tested clones.

CoLk 94184 (Birendra) has been recommended for commercial cultivation. It withstands moisture stress and waterlogging in eastern Uttar Pradesh and Bihar

Two new improved sugarcane varieties, resistant to red rot and smut and tolerant to drought and salinity Co 2001-13 and Co 2001-15 were identified for cultivation in Peninsular Zone. They showed significant improvement over standard varieties.

A high sugar-yielding cane variety CoLk 94184 (Birendra) has been recommended for commercial cultivation. This is early maturing and withstands moisture stress and waterlogged conditions in eastern Uttar Pradesh and Bihar.

Jute: JRO 2003 H (IRA) has been recommended for entire *tossa* jute-growing belt of the country for cultivation during mid-March to last week of April. Its yield was 10-15% higher than JRO 524 and JRO 8432, i.e. the check varieties. The variety showed better resistance to biotic stress and also had less body defects and root content as compared to national checks.

JRO 204 (Suren) has been notified for the entire jute-growing tracts of India. It is a high-yielding *tossa* jute variety, showing better fibre quality. As the variety is highly resistant to premature flowering, it can be sown from the first week of March, and can be easily accommodated in multiple cropping systems in Assam, Bihar, Orissa and West Bengal. It is least affected by major pests and diseases as compared to widely cultivated *tossa* jute varieties. It produced finer quality fibres (2.3-2.4 tex), which were 21% and 15% finer than JRO 524 and JRO 8432. The fibre of JRO 204 is free from body defects and root content.

AAU OJ-I (Tarun) has been notified for the entire jute-growing tracts in India. The variety fibre yield surpassed national check JRO 524 by 7% at the all-India level. It showed better biotic stress resistance.

C. capsularis entries C 517 and C 532 and one of mesta JMB 2004D have been recommended for release at the national level.

Tobacco: Sangami variety was released for cultivation in Bhavani, Anthijur and Kurichi areas of Erode district and Edapady area of Salem district of Tamil Nadu. This is a narrow-leaf country cheroot tobacco variety. It showed an increase of 22.4% in average cured leaf yield over the ruling variety I-737, coupled with good smoking quality. The variety showed less susceptibility to tobacco mosaic virus, black shank and leaf curl.Torsa, new motihari tobacco variety, has been approved for release. It recorded significantly higher cured leaf yield.

Tobacco as oilseed crop

Oil content in seed was estimated in 108 tobacco germplasm accessions of various tobacco types. Among the 43 germplasm accessions of exotic air-cured type, the seed oil content varied between 33.06 (EAC 145) and 44.94% (EAC 101). Among the Burley tobacco accessions, the seed oil content varied from 23.09 (BGP 33) to 45.61% (BGP 35). The peroxide value increased from 8.24 to 84.24 me peroxide/kg within 90 days from the date of extraction; in sunflower oil, it varied from 6.24 to 50.12 me peroxide/kg within 90 days.

Horticulture

Mango:A new mango hybrid, Arunika, was released. A cross between Amrapali and Vanraj, it has regular bearing and good fruit qualities. Twelve STMS primers, modified with fluorochromes for high resolution genomic analysis were utilized for molecular characterization of 150 cultivars of mango. In general, fluorescent-based analysis revealed single main peak in homozygotes and two different size allelic peaks in heterozygotes. Polymorphic information content (PIC) values ranged from 0.630 to 0.855. A total of 149 alleles were amplified. The number of alleles detected per locus ranged from 7 to 21. Four set of primer pairs were found sufficient to identify the accessions. In mango, Hybrid 311 (Alphonso x Neelum) having good yield and quality and freeness from spongy tissue were found promising at RFRS, Vengurle. At IARI, New Delhi, five hybrids, viz. H 1-1 (Amrapali × Lal Sundari), H 1-6 (Amrapali × Sensation) and H 2-6 (Amrapali × Sensation), H 4-12 (Dashehari × Sensation) and

H 8-11 (Amrapali × Sensation) were found promising.

Grape: In grape, two hybrid seedlings of Thompson Seedless × Sevye Villard showed tolerance to powdery mildew (12/6 and 15/2), anthracnose (10/4 and 11/3) and rust (7/5, 11/4 and 15/3). A mother block of quality planting material comprising 12 table/raisin varieties, 6 wine varieties and 9 rootstocks was established. About 150 varieties including 28 wine/juice and 25 crosses were evaluated for their various desirable attributes. The F_1 hybrids, Flame Seedless × Sevye Villard and Thompson Seedless × Sevye Villard were maintained in the greenhouse and some progenies were transferred to the field. *In-vitro* screening of these available hybrids was also done against *Plasmopara viticola*. DNA from 41 hybrids was analysed with 32 microsatellite primers.

Sapota: In sapota, plant spacing of 8 m × 4 m (312 trees/ha) registered highest yield/ha (24.96 tonnes/ha) while number of fruits (1,650) and yield of fruits/tree (95.00 kg) were more in 8 m × 8 m spacing in PKM 1 sapota at Periyakulam.

Citrus: Seven citrus genotype (NRCC Pummelo 1, NRCC Pummelo 2, NRCC Pummelo 3, NRCC Pummelo 4, NRCC Pummelo 5, NRCC Pummlo Galgal 1 and NRCC sweet lime 1) were promising. About 61,200 disease-free plants of Nagpur mandarin, Mosambi, acid lime and rootstocks were sold to different government departments and farmers. And 46,000 certified elite STG derived disease-free planting stock were released to citrus growers of Maharashtra, Andhra Pradesh and Madhya Pradesh.

Banana: Fourteen accessions of banana were collected, which include 3 wild accessions and 11 landraces. A high-yielding Cheeni Champa clone with better fruit quality was collected. Cryobanking of Musa germplasm was initiated with the transfer of 210 accessions as *in-vitro* to NBPGR, New Delhi.

Sweet orange: At Rahuri, Sweet orange selection 4 was released as Phule Mosambi and acid lime line, RHR-L 124, as Phule Sharbati. The rootstock Rough lemon 14-19-13 recorded highest yield, whereas Rough lemon Nematanga Assam and Rangpur lime Brazilian showed seedling resistance to root rot.

Cashew: In cashew, five collections having compact canopy and bunch bearing were collected from Ansurli which had bold nut character (> 8.0 g). The hybrids, H 66, H 68 and H 43, yielded 5.4, 4.9 and 5.4 kg/tree in fourth harvesting with a cumulative nut yield of 19.9, 18.8 and 19.5 kg/tree respectively. Hybrids, H 125 and H 126, of cross combination NRCC Sel 2 × Bhedasi gave a yield of 5.6 and 5.0 kg/tree in the fourth harvesting and a cumulative yield of 19.5 and 17.8 kg/tree respectively. The cumulative yield of 14 years was higher in cashew JGM 34/7 (276.64 kg/tree), followed by JGM 70/2 (211.56 kg/tree), and JGM 48/1 (174.72 kg/tree).

Acid lime: In acid lime, intermediate hybrids of the cross Kagzi lime × Nepali round and Kagzi lime × Nepali oblong were found resistant to citrus bacterial canker. The hybrids had lemon like character.

Apricot: Ten promising apricot genotypes were evaluated under medium-density accommodating 400 trees/ha. Four varieties were found promising under Kashmir conditions. CITH selection KS 1 (8.0 tonnes/ha) gave the maximum yield followed by Harcot, AS 1 and AS 2. The TSS of these elite varieties ranged from 13.87 to 15.98° Brix, indicating their suitability for table purpose.

KS-1, a promising apricot

Underutilized fruits: In ber, phylogenetic relationships revealed that the pooled chromatogram of eight cultivars possessed a total of 28 flavonoid spots. Spot No. 3 and 12 were encountered only in single taxon and hence, they proved to be marker spots for respective cultivars. In pomegranate, number of spots varied from 12 to 17 in different genotypes, maximum in cv. Mridula and minimum in cvs. Kabul and Jalore Seedless. Regeneration protocol for genetic transformation of pomegranate Bhagwa with nodal blight resistant gene was standardized. In pomegranate, seeds of Bhagwa and Ganesh were irradiated with 0-30 kR gamma rays and sown in polythene bags. Branching was more at lower doses of gamma irradiation (0-6 kR) and there was decreasing trend in branching habit with increase in irradiation doses beyond 6kR in Ganesh. In contrary, higher doses (beyond 6kR) of gamma irradiation increased branching in seedlings of Bhagwa. The plant height in Ganesh and Bhagwa was not influenced by irradiation treatments at 0-9 kR and 0-18kR respectively. But higher doses

of gamma irradiation induced dwarfing effects at 27 and 30 kR in Ganesh and Bhagwa. Wedge grafting on 30th January was found optimum for grafting. Pomegranate, viz. Dholka, Bedana and Kandhari, planted under 2.5 m × 2.5 m spacing were found promising under Karewa conditions of Kashmir. The maximum yield was recorded in Dholka (11.52 tonnes/ha) followed by Bedana and Kandhari. The number of spots in date palm varied from 6 to 9 in different genotypes. In date palm Halawy, axilary bud formation in shoot tip was achieved. Direct morphogenesis of shoot and root formation was achieved in lasoda *(Cordia myxa)*, mulbery *(Morus alba)* and citrus *(Citrus aurantifolia)*.

Vegetable crops: A total of 10 varieties / hybrids including six open-pollinated varieties and 4 hybrids were identified for release. They are Pusa Santushti (bottle gourd), IIVR MC 12 and DC 76 (cauliflower), VR 5 and Swarna Harita (cowpea), GMM 3 (muskmelon), JNDOH 02-22 (okra), HATH 5 and ARTH 734 (tomato) and Vivek bitter gourd. Two promising gourd varieties, CHTG 2 (teasel gourd) and CHSG 28 (spine gourd), were selected at Central Horticultural Experiment Station for yield and quality. Kashi Agahani, a mid-late maturity group (December-January) cauliflower was developed.

In muskmelon *(Cucumis melo)*, line AHMM 17, AHMM 26, AHM 32, AHM 46 and CIAH Selection 1, showed potential for better fruit quality and yield attributes under high temperature conditions, while in bottle gourd, line AHLS 11 and AHLS 24 exhibited better fruit quality and high yield potential. In varietal trial, advanced lines of Indian bean (AHDB 16) exhibited superiority for earliness under high temperature conditions. In Luffa gourds, purified genetic material of AHSG 4 was found to be superior for uniform harvesting and early marketing.

Mushroom: Out of 7 strains/SSI of paddy straw mushroom evaluated, OE 274, BBH and BBH 5 and SSI-OE 55-0% gave more than 25% mushroom yield in first flush. However, in overall yield OE 274 and BBH outyielded other strains/SSI. Button mushroom strains CM 3, CM 7 and CM 9 gave higher yield. Out of 53 hybrid strains of *Pleurotus sajor-caju* developed for fructification, mycelial growth in 33 strains was observed. Three strains gave significantly higher yield on wheat straw. Of the six strains of *Agaricus bisporus* evaluated, CM 13 and CM 16 gave higher yield. In paddy straw mushroom *(Volvariella volvacea)*, strains Vv 09, Vv 11 and Vv 12 gave higher yield and milky mushroom *(Calocybe indica)* strain C 1-6 gave higher yield. The hybrids, PSc 1 of *Pleurotus sajor-caju* and PF 01 of *P. florida* gave higher mushroom yield than their parents and other hybrid strains.

Potato: A new potato variety Kufri Sadabahar was released for cultivation in Uttar Pradesh. It gives an average yield of 35 tonnes/ha and has dry-matter content of 19-20%. Late blight resistant variety Kufri Girdhari , was released for hills. Hybrid, J. 93-86, an early bulking potato line for fitting in rice-wheat system was also identified. This hybrid is likely to be a good replacement of Kufri Ashoka and Kufri Chandramukhi for cultivation in the plains specifically for Haryana, Punjab, Rajasthan, Uttar Pradesh, Gujarat, Bihar, Madhya Pradesh and West Bengal.

Advance hybrid for French fry developed

An advanced hybrid, MP/98-71, suitable for making French Fries was developed for cultivation in the Indo Gangetic plains. Promising hybrids of Kufri Bahar/Kufri Jyoti x RB-transgenic Katahdin were identified. Similarly, putative transgenic lines of Kufri Jyoti and Kufri Chipsona 1 with reduced cold-induced sweetening developed.

MP/98-71: a potato hybrid for French fry

Coconut: Three coconut varieties, viz. Kalpa Dhenu, Kalpa Mitra and Kalpa Pratibha, were released for commercial cultivation. A new coconut variety, Kalparaksha was recommended for release as a high-yielding and resistant (field resistance) to root (wilt) disease. Three coconut ecotypes, viz. Bedakam type in Kasaragod district, Anjarakandy type from Kannur district and Kuttiadi type from Kozhikode district, were identified for *in-situ* characterization. Putative *in-situ* drought-tolerant coconut palms were identified in Sivaganga district of Tamil Nadu. Coconut, Kalyani Coconut 1, was released for West Bengal. Coconut IND 003 S is a high-yielding coconut variety (12,813 nuts/ha/annum) with sweet taste of nut water (sugar content 6.40 g/100 ml) with a very high quantity of nut water (446 ml) and high potassium content (2035 ppm). It was released for Andhra Pradesh, Tamil Nadu and Maharashtra. It was named as Gauthami Ganga. Coconut hybrid, Konkan Bhatye Coconut Hybrid 1, was released for the Konkan coastal region. Varieties Kalpa Dhenu, Kera Keralam, Kera Bastar, Kalpa Prathiba, Kalpa Mitra, and hybrid Kahikuchi of Coconut Hybrid 1, were released.

Oil palm: Eleven oil palm hybrids, 4 from ASD Costa Rica, 4 from Palode, India, 2 from Ivory coast and 1 from Papua New Guinea were evaluated. In Dura mother palms, maximum germination (97.6%) occurred when fruit reached Stage 4 (165/days after anthesis-DAA) where least moisture content was recorded. At Stage 5 (180 DAA), decline in germination (94%) was noticed. High dry-matter accumulation and low moisture content were recorded in both the stages. Seedlings obtained from Stage 4 showed superior quality. Oil formation initiated (6.62%) at Stage 1 (75 DAA) and highest content (74.93%) was recorded at Stage 5. The virescense palms showed early maturity and germination than normal nigrescense palms.

Black pepper: In black pepper, Cul 5489 showed highest spike length (13.34 cm) followed by Cul 5308 and Panniyur 1. At Panniyur, maximum yield/vine was recorded in Cul. 5489 (1.847 green berry kg/vine) and was on par with Karimunda OP, Cul.5308, Panniyur 1, Karimunda and Coll. 1041. Hybrid P 6 × P 5 was promising with a fresh yield of 3.54 kg/vine.

Ginger: In ginger, there was maximum yield in V1E 4 -5 (29.21 tonnes/ha), followed by V2E 5-2 (28.29 tonnes/ha) with 32.29 and 28.12% higher yield over the control Suprabha. The genotypes, viz. SG 27/04, SG 45/04, SG 896 707, SG 827, SG 716, SG 682 and 51/04, were identified as high-yielding and high-quality lines.

Coriander: Coriander entries, DH 220 and DH 233, were identified as high-yielding in IET at Hisar. The CVT trials at Coimbatore identified LCC 170 and UD 206 as high-yielding with a yield potential of 928.33 and 923.33 kg/ha respectively. Three entries, COR 5 (1913 kg/ha), COR 4 (1825 kg/ha) and COR 2 (1670 kg/ha) were identified as high yielders from Hisar. LCC 244 (18.9 tonnes/ha), LCC 233 (18.5 tonnes/ha) and LCC 234 (18.0 tonnes/ha) were identified as good leafy types at Coimbatore. COR 4, COR 10, COR 11, COR 12, COR 13, COR 14 and COR 15 were identified as early-maturing types at Dholi. At Kumarganj, COR 9 (1.99 tonnes/ha) and COR 8 (1.94 tonnes/ha) were identified as high-yielding.

Cumin: Of the 10 entries in IET tested against wilt, blight and powdery mildew, UC 331 and UC 225 were found resistant to wilt, blight and powdery mildew at Jobner.

Fennel: Fennel, HF 131 and HF 143, from Hisar and NS 63, NS 46, RF 125 and RF 101 from Jobner were identified as promising. The maximum volatile oil (2.47%) was found in FNL 17, followed by FNL 15, FNL 20 and FNL 14. The FNL 15 ranked first in volatile oil yield (41.36 litres/ha), followed by FNL 16 (40.04 litres/ha), RF 125 check (34.36 litres/ha), FNL 17 (32.93 litres/ha) and FNL 14 (28.52 litres/ha).

Fenugreek: In fenugreek, JF 270 recorded higher yield (573 kg/ha) which was at par with Rmt 303 (543.33 kg/ha) from Coimbatore. FGK 14 was identified promising from Dholi centre with a yield of 2.18 tonnes/ha. HM 348 and HM 355 were identified as promising at Hisar.

Flowers: Two carnation interspecific hybrids, IIHRIS 1 and IIHRIS 2, were found potential for commercial exploitation. Crossandra, F_1 Hybrid IIHR 2004-9, was characterized by large-sized flowers, novel orange colour. In gladiolus, two hybrids each from the IARI, New Delhi and MPKV, Pune; 6 new varieties in chrysanthemum from PAU, Ludhiana, are under multilocational testing. Two promising gerbera hybrids IIHR 99-1 and IIHR 99-2, were identified for open cultivation. They were tolerant to thrips and leaf spot with double flowers having deep orange and yellow florelts.

In orchids, random amplified polymorphic DNA (RAPD) markers were used to study the genetic diversity of 10 cymbidium species. Newly-developed hybrids NRCO 42 *(Dendrobium whitae* × *Dendrobium pompadour)* and H × B (Cymbidium cross) were good for flowering and other floral traits.

Betelvine: Flowering was observed for the first time in 11 female and 9 male accessions. A total of 141 different cross-combinations were carried out using 1,713 catkins involving 25 female and 21 male clones. A total of 480 fruits were harvested from 83 crosses. The germination varied from 2.2 to 67.2% among the crosses. Maximum number of hybrid seedlings was raised in the cross SGM1/ Vasani Kapoori (169) followed by SGM1/ Tellaku Ponnuru (140). Wide variability was observed for many morphological traits like plant vigour, leaf size, leaf shape, leaf colour, petiole length, internodal length and stem pigmentation.

Cassava: In cassava, Hybrid 6-6 was superior with a mean tuber yield of 40.5 tonnes/ha and 31.0% extractable starch. The 164 SSR marker-tested cassava mosaic resistant clones were evaluated for four years. Flour clones, CR 43-11, CR 43-7, CR 54A-3 and CR 59-8 had high yield (>40 tonnes/ha) coupled with resistance to CMD.

Taro: In taro, out of 1,820 first clonal hybrids evaluated, 12 were symptom-free and being evaluated along with Mukhtakeshi. The hybrid seeds were also generated incorporating TLB-free wild taro as one of the parents (seven crosses) to produce TLB resistant hybrids. Fifteen high-yielding hybrids (17.0-22.5 tonnes/ha) were identified from the replicated trial and being evaluated to confirm the performance.

Region-wise recommended entries/varieties for release

Crop	Entry	Region/state for which it is recommended	Average yield (tonnes/ha)
Cassava	IGT 1	Bihar	31.40
		Chhattisgarh	34.50
Sweet potato	Kamalasundari (rich in ß carotene)	West Bengal	29.00
		Orissa	20.00
Taro	JCC 25KCS 2	Assam	18.10
		Andhra Pradesh	28.90
Elephant-foot yam	Sree Padma	Assam	20.00
	Gajendra	Bihar	30.70
Bunda	NDB 1	Assam	18.50
		Jharkhand	11.30
Swamp taro	BCST 5	Assam	14.00

Elephant-foot yam: In elephant-foot yam, 118 hybrids were evaluated. Of them, 52 were high-yielding.

BIOTECHNOLOGY

Rice: Two varieties released, Improved Pusa Basmati (IET 18990) and Improved Samba Mahsuri (IET 19046), are the first products of biotechnology. Both were developed through marker-assisted selection (MAS) for pyramiding three bacterial blight resistant genes in the background of the most popular aromatic variety Pusa Basmati and the popular and widely cultivated variety Samba Mahsuri.

Sorghum: Sorghum transgenics with *Cry1B* gene that can control stem borer were produced and tested with 10 artificially reared borer larvae till four generations. Transgenics from two independent events were very effective. *Bt* protein level in the leaves was as high as 3 □g/g of leaf tissue (comparable to commercial *Bt* cotton).

Quantitative trait loci (QTL) resistant to target leaf spot, zonate leaf spot and *Dreschlera* leaf blight were located in sorghum (genomic) chromosome SBI-06. This genomic region is syntenic with regions on rice chromosome 4, and maize chromosome 2.

Reduced feeding and reduction in stem borer larval growth on sorghum transgenic plants in insect bioassay. (A) Control leaf fully damaged with stem-borer larvae; (B) Minor nibbling marks on transgenic leaves (arrows indicate the dead larvae on transgenic leaves); (C) Larvae survived in non-transgenic control; (D) Dead larvae in transgenic plants

HH 67 (new), which was bred using DNA markers for downy-mildew resistance, has significantly arrested spread of the disease in the country. Both the parents of three most popular hybrids RHB 121 in Rajasthan, GHB 538 in Gujarat, and HHB 117 in Haryana have been converted into downy-mildew resistant using markers, and are in the final stage of testing.

Forage crops: *Reproductive pathways in apomictic guinea-grass*. Three components of apomixis, apomeiosis (formation of unreduced embryo sac formation), parthenogenesis (fertilization-independent embryogenesis) and functional endosperm development, were found to be frequently recombining in the germplasm lines. Reconstruction of reproductive pathways yielded a total of 8 different pathways of seed development.

Hybridization-supplemented apomixis components partitioning approach (HAPA) for ploidy manipulations. Apomeiosis and parthenogenesis when partitioned (following recombination, expressivity or modifying effects) yielded high frequency of triploids and haploids. Utilizing this hybridization-supplemented apomixis-components partitioning approach (HAPA),the largest ploidy

Pyramiding additional bacterial blight resistance genes in basmati rice background

Background analysis revealed that Improved Pusa Basmati inherited most of the regions from Pusa Basmati 1, which are linked to Basmati quality traits. Possibility of linkage drag was also minimum in respect of chromosomes 8 and 11, carrying genes *Xa 13* and *Xa 21* for BB resistance respectively. Marker-based analysis suggested that this variety can be used as a combiner in Basmati hybrid-breeding programme. With the objective of adding more BB resistance genes in the Basmati background, a large segregating population was generated using Basmati 370 and IRBB 60, a non-Basmati rice line, carrying four genes *Xa4*, *xa5*, *xa13* and *Xa21*. This population will now be screened for identification of suitable recombinants possessing all the 4 BB resistance genes and Basmati traits.

Transgenic rice for blast resistance

From rice line Tetep blast resistance gene *Pi-k*^{h} has been fine mapped and cloned. Blast susceptible line Taipei 309 (TP309) has already been genetically transformed with cloned rice blast resistance gene *Pi-k*^{h}. Further evaluation of the transgenic lines containing *Pi-k*^{h} genes with same isolate of *Magnaporthe grisea* in T2 generation was carried out.

series in a crop-plant from a single progenitor in guinea-grass was generated.

Molecular markers. A RAPD primer (10-mers, Operon Series) showed differential pattern in apomictic and sexual guinea-grass; yielding a band of about 300bp, exclusively represented in apomictic genotypes and absent in sexual forms.

Tissue-cultured lucerne. Multiple shoot induction from apical meristematic axis on MS medium supplemented with BAP and kinetin showed high frequency of plantlets regeneration in lucerne.

Tissue-cultured lucerne

Oilseeds: *Castor.* Whole plant bioassays were done for 69 transgenic castor lines derived from 20 independent transformation events showing tolerance to *Spodoptera* and semilooper. Among the tested events, PCP202 AMT18 conferred maximum resistance to both the target pests. The transgenic castor plants PCP 202 AMT 1, 9, 11, 18, 37 with *Cry-1 EC* gene showed less than 20% defoliation due to semilooper and *Spodoptera*.

Safflower. Delta 6-desaturase gene isolated from borage was developed into a cassette, and the construct cloned into binary vector is being used for developing transgenic safflower plants with gamma linolenic acid in seed oil.

Soybean. Fifteen putative transgenics with replicase gene were developed. Genomic DNA was isolated from the leaves of these as well as the control plants. PCR analysis was carried out with replicase specific primers. Presence of an expected amplicon of 566 bp with DNA from putative transgenic plants confirmed the presence of replicase gene. No amplified product was observed in untransformed plants.

Pulses: In-vitro *regenerated fieldpea.* Medium containing MS+B5+4mg/litre BAP+0.6mg/litre NAA produced 16-18 shoots/embryonic axis across the genotypes and media containing MS+B5+2mg/litre BAP+0.4mg/litre NAA produced 20 shoots/cotyledonary node. In rooting medium, 1mg/litre IAA was found better across genotypes.

Commercial crops: *Sugarcane.* Transgenic sugarcane plants with *cry1Ab* gene were produced through particle bombardment as well as by *Agrobacterium*-mediated transformation. Southern analysis was carried out for selected plants, and *cry1Ab* gene integration was confirmed. *In-vitro* bioassay was carried out to study efficacy of different *Bt* toxins Cry1Aa, Cry1Ab and Cry1Ac on sugarcane shoot borer. High larval mortality was observed with Cry1Ab. Eight transgenics expressing Cry1Ab were screened against shoot borer. Plants showing dead hearts varied from 0 to 24 % in transgenics; 50 % of the plants in control showed dead hearts.

Cotton: First public sector transgenic *Bt* cotton variety Bikaneri Narma(BNBt) has been released for commercial cultivation to all cotton-growing areas in *kharif*. The advantage of this variety is that farmers can reuse the seeds year after year.

Male sterility induced in *Arabidopsis thaliana*

A novel mitochondrial gene was identified to be associated with the cytoplasmic male sterility in *Brassica juncea* alloplasmic lines. To test whether it is directly involved in causing male sterility, the coding sequences of this gene were translationally fused with a mitochondrial targeting signal and the fusion construct was cloned downstream to CaMV35 S promoter in a plant transformation vector. Transgenic *Arabidopsis* plants containing the gene were obtained following floral dip transformation and selection of T1 seeds on kanamycin-containing medium. Most of the transgenic plants showed varied degrees of pollen sterility, indicating that the gene is involved in causing cytoplasmic male sterility.

Transgenic *Arabidopsis* expressing male sterility

Pigeonpea genomics initiative

A total of 21 cDNA libraries have been prepared and about 9,776 ESTs sequenced. Pigeonpea varieties Asha, UPAS 1210 and a wild species *Cajanus scaraboides* were used for RNA isolation and cDNA synthesis. Out of the total ESTs produced, 776 sequences have been submitted to the NCBI GenBank and rest of them are under the process of submission. EST database was mined for presence of SSRs, and 28 SSR markers have been developed and are used for polymorphism survey between these two varieties for the creation of first reference genetic map of pigeonpea.

SEED

Breeder seed production: Breeder seeds 9,950.5 tonnes of different field crops were produced; including centrally and state released varieties as per requirement (*see* table on p.40).

Quality seed production: The total quality seed production of field crops was 0.85 lakh tonnes. And production of saplings and tissue-cultured plantlets was 285.33 lakh, and seed production of horticultural and vegetable crops was 1,130.56 tonnes.

Breeder seed production

Production in tonnes

Crop	Centrally released varieties	State released varieties	Total
Cereal crops	3,275.9	1,287.3	4,563.2
Oilseed crops	2,603.8	1,074.1	3,677.9
Pulse crops	1,123.4	387.0	1,510.4
Forage crops	140.2	26.8	167.0
Fibre crops	19.1	12.9	32.0
Total	7,162.4	2,788.1	9,950.5

In the fish component, 1,502.5 lakh spawn of carps, 504.94 lakh fry + fingerlings of carps, 5.1 lakh fry and spawn of catfish, 22.03 lakh larvae of sweet-water prawn, 185.97 lakh larvae of marine prawn, 12.17 lakh seed of ornamental fishes, 12.7 lakh brackishwater fish fry and 848.87 lakh seed of other marine fishes were produced.

In general, 40.91% increase in quality seed production of field crops and almost double fish seed production were observed at various centres.

Mass multiplication of planting material of horticultural crops

Participatory seed production: A total of 5,775 tonnes of seeds were produced under the participatory seed programme at the farmers' fields at the University of Agricultural Sciences, Dharwad, Indira Gandhi Viswa Vidyalaya, Raipur, Narendra Deva University of Agriculture and Technology, Faizabad, Indian Agricultural Research Institute, Regional Station, Karnal, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Mahatma Phule Krishi Vidyapeeth, Rahuri, Rajendra Agricultural University, Dholi, Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Assam Agricultural University, Jorhat, Tamil Nadu Agricultural University, Coimbatore and Punjab Agricultural University, Ludhiana

Seed production technology: Single rice seedlings 12-15 days old transplanted at 25 cm × 25 cm spacing were most suitable under the system of rice intensification for breeder seed production.

Seed processing: Processing damage in soybean seeds could be minimized considerably with the inclined belt conveyor in place of bucket elevator.

Sieve sizes for the unprocessed seeds of safflower, chickpea and pigeonpea have been standardized. Specific gravity separator-based improvement of marginal seed-lots of cotton, soybean and safflower, respectively was attained to the minimum acceptable levels.

Seed treatment. Pre-sowing seed hydration for 17 hr at ambient temperature, followed by dry dusting with Thiram at 0.25% are recommended for rapid and uniform field emergence and plant establishment for better seed yield in sunflower and pigeonpea.

Seed storage: CO_2 provided complete killing of storage insects at 40% (v/v) concentration up to 12 months of storage under ambient conditions at the Coimbatore, and seed germination was above IMSCS (80%) level.

HONEYBEES AND POLLINATION

Apple : Fruit set was 26.2% when four colonies of *Apis mellifera* per hectare were introduced, and fruit set was 16.7% without honeybees colonies.

Radish : For efficient pollination in radish seed-crop, 5 *A. mellifera* colonies each at 10 frames bee-strength per hectare were required.

Cucumber: Fruit set was 74.9% with honeybee pollination and it was 12.2.% in open pollination. And 6 *A. mellifera* colonies produced 21.80 fruits per plant and yielded 10.83 tonnes/ha compared to 8 tonnes/ha in open pollination.

Thai Sac Brood Viral and Sac Brood Viral molecular characterization

Genomic sequences of virus isolates from Himachal Pradesh of Thai Sac Brood Viral disease and Sac Brood Viral disease of honeybees obtained after sequencing of the amplicons with SB 9f/SB 10r and TS3f/TS4r, respectively and phylogenetic analysis have revealed that present SBV isolate of *A. mellifera* is closely related to China and UK SBV strains, and phylogenies of TSBV isolate have showed that it is different from the SBV strains available with gene bank database of the USA.

Litchi : Fruit set recorded was 38.4% in open panicles where honeybees were main pollinators as compared to 0.4% in caged panicles; to exclude insects pollinators.

Champakka *(Eugenia jambos)*: Fruit set in *A. cerana* augmented plants was 43.50% with average fruit weight of 60.61 g, and fruit set in caged plants was only 29.54% with average fruit weight of 46.83 g.

Winged-bean: In *A. cerana* introduced plots, fruit set was 63.96% and in stringless bees, fruit set was 83.16% compared to 22.22% in plots not introduced by bee-colonies.

8

Crop Management

PRODUCTION

Rice: System of Rice Intensification and Integrated Crop Management resulted in increase of grain yield over standard transplanting. Penoxsulam 24 SC at 0.250 kg a.i./ha as pre-emergence or post-emergence effectively controlled broad spectrum of weeds.

Under the irrigated ecology, rice-potato-sesame gave the highest rice equivalent yield of 18.23 tonnes/ha; which was 42 % higher than that obtained with conventional rice-rice-rice sequence cropping. The benefit of mulching with rice-straw in terms of rice equivalent yield was significantly higher for sesame (3.82 tonnes/ha), followed by horsegram (3.01 tonnes/ha) and greengram (2.70 tonnes/ha).

Population densities of culturable iron reducer soil microorganisms ranged from 10^3 to 10^6 per gram, and the Polymerase Chain Reaction Denaturing Gradient Gel Electrophoresis (PCR-DGGE) analysis of the total microbial community DNA from the soils showed that eubacterial microorganisms during peak iron reduction process varied in these soils.

Wheat: Long-term effects of conventional tillage, zero tillage, rotary tillage, strip tillage and bed planting in wheat were evaluated in a fixed plot trial. Eight years' mean yields were 3.04% higher in rotary tillage, and were 7.55% and 12.81% lower in strip tillage and bed planting compared to conventional field preparation. Yields under zero tillage and conventional tillage were similar.

Improving soil-organic C through residue management. Increase in soil-organic C was about 0.1% after two years and about 0.2% after four years with full residue retention or incorporation of rice and/or wheat crops.

Pearl millet: In pearl millet, nitrogen at 60 kg and 40 kg per hectare increased 24.58 and 14.35% grain yield and 18.93 and 12.09% fodder yield over 20 kg N in states having <400 mm rainfall such as north-west Rajasthan, Gujarat, parts of Haryana and Madhya Pradesh.

In summer, grain and fodder yields of pearl millet advance hybrids increased significantly at 120 and 90 kg N/ha over 60 kg N/ha. GHB 558 and MSH 185 responded more to higher doses of nitrogen.

Optimum management of the crop produced 18.94% more grains and 13.24% more fodder compared to low management practices in Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu.

Small millets: Sowing fingermillet and transplanting 40-45 days old pigeonpea seedlings in 8:2 row proportion as intercrop gave 250-270% higher pigeonpea yield over recommended practice of simultaneous sowing of fingermillet and pigeonpea. In terms of fingermillet grain equivalent yield, transplanting of pigeonpea gave yield advantage of 38 and 86% over drilling pigeonpea in intercropping system and farmers' practice of *Akadi*.

Forage crops: In *ex-situ* conservation in rainfed areas, grasses, herbaceous legumes, shrubs and

Culturing fishes in rainfed lowland rice

Breeding and culture of ornamental fishes, introduced first time in the rainfed lowland rice ecology, produced 500 egg-layer species (Blue gourami, Red gourami and Pearl gourami) and 15,000 livebearer species (Guppies and Red sword-tail guppies).

In dry season, 1.03 tonnes of sunflower (KBSH 1), 1.1 tonnes of groundnut (AK12-24), 0.4 tonne of mungbean (PDM 139), 12.5 tonnes of watermelon (Sugar Baby), 8.1 tonnes of pumpkin (Guamal), 5.8 tonnes of cucumber (Chaitali) and 3 tonnes of okra (Hybrid F_1) per hectare were produced.

trees, suited for rangeland/wastelands were evaluated. Mean above ground biomass of *Albizia procera* (12-years old) varied from 27.17 to 42.13 kg/plant. The proportion of the small timber, firewood and fodder was 47, 40 and 13% of the total above-ground biomass.

Groundnut: Groundnut-wheat-greengram cropping system recorded maximum productivity and improved soil-nitrogen and organic-carbon over groundnut-groundnut, groundnut + pigeonpea, groundnut + pearl millet and groundnut-wheat cropping systems.

VG 9902 at Virddhachalam, K 4 at Kadiri, JL 501 at Jalgaon and GG 5 at Junagadh were promising genotypes for late sowing in *kharif* .

Nitrogen 100% to groundnut as basal and 50% nitrogen in 3 splits to intercropped cereal-crop was best fertilizer scheduling for groundnut + cereal intercropping systems at Jalgaon, Junagadh, Chintamani. This saved 50% N to cereal crops.

Polythene mulching on paired-row bed furrows in groundnut with irrigation either at 0.8 or 0.6 IW/CPE ratio and 100 % recommended dose of fertilizers and seed treatment with *Rhizobium* and phosphate-solubilizing bacteria were ideal for water and nutrient management.

For groundnut under rice fallow system, *Rhizobium* strain NRCG 9 or IGR 6 was found suitable at Vriddhachalam and Jagtial.

Sunflower: *Rabi* sorghum succeeding sunflower was adversely affected compared to fallow, in terms of emergence, growth and yield compared to other *rabi* crops, chickpea, coriander and safflower, in scarce rainfall zone of Andhra Pradesh at Nandyal in rainfed areas.

Rapeseed-mustard: Growing sesbania as a green-manure crop preceding mustard recorded significantly higher mustard seed yield in north-eastern Rajasthan and Haryana.

Castor: Sulphur at 20 kg/ha through gypsum to castor in irrigated areas in Rajasthan, wherever the available soil S status is low to medium, gave higher seed yield and economic returns.

Safflower: In Vidarbha region (Akola) of Maharashtra, sulphur at 30 kg/ha through single superphosphate recorded increased seed yield and returns in rainfed areas.

In scarcity zone (Solapur) of Maharashtra, it is possible to substitute 50% N and P needs of chickpea-safflower rotation by seed treatment with phosphate-solubilizing bacteria (PSB) to chickpea and to safflower by *Azotobacter/Azospirillum* and PSB without any adverse effects on the productivity.

Soybean: Arbuscular mycorrhizal fungi found in soybean rhizosphere are *Glomus intraradices*, *Glomus* sp. 1 and *Glomus* sp.2. These dominant isolates can be mass produced and used for improving soybean productivity.

Pseudomonas isolates SP4, SP8, DP5, UP1, UP4 and UP8, identified from soybean rhizosphere, showed *in-vitro* potential for solubilizing zinc phosphate, zinc oxide and zinc carbonate.

Integration of 100% recommended dose of fertilizers + oil cake (250 kg/ha) + *Azospirillum* (5 kg/ha) + phosphate-solubilizing bacteria (5 kg/ha) + *Trichoderma viride* (2.5 kg/ha) + *Pseudomonas fluorescens* (2.5 kg/ha) in soybean resulted in higher yields, net monetary returns and benefit:cost ratio.

Pulses: Raised-bed planting of chickpea gave higher yield as compared to flat-bed planting, besides increasing water-use efficiency.

Intercropping pigeonpea + sorghum in 2:1 row ratio on raised-bed planting gave higher yield than flat-bed planting.

Raised-bed resulted in higher grain yield in lentil and fieldpea over flat-bed sowing. In lentil, grain yield also increased with increase in phosphorus from 25 kg/ha to 50 kg/ha and sulphur from 20 to 40 kg/ha.

In rice-chickpea sequential cropping, incorporation of chopped rice straw +20 kg N + irrigation resulted in significantly higher yields. Chickpea residue incorporation also proved beneficial over removal of straw. Foliar spray of 2% urea in chickpea at 75 days after sowing increased grain yield significantly over 200 kg per hectare.

Residue incorporation of the component crop significantly increased total productivity of rice-lentil system.

Short-duration pigeonpea variety Pusa 992 was found compatible for intercropping with urdbean and mungbean in the North Western Plains Zone, and medium duration GT 101, JKM 189, JKM 7 and BSMR 853 was compatible with groundnut, maize and soybean in the Central Zone.

In mungbean-ragi sequence, phosphate-solubilizing bacteria + 40 kg P_2O_5/ha to mungbean saved 30 kg P_2O_5/ha in the succeeding ragi. Mixed spray of 2% potassium chloride + 0.1 ppm boron and 2% of urea spray maximized yield of urdbean under drought.

Sugarcane: IISR-microbial formulation inoculated into farmyard manure/press-mud cake at 20 kg/hectare was recommended for application in furrows above seed-cane setts at the time of planting. This practice managed sugarcane diseases and improved sugarcane productivity.

In areas with limited irrigation, cane-setts required for one hectare should be soaked in saturated lime water (80 kg lime/1,000 litres of water) for two hours a day before planting to improve germination and cane yield.

In sugarcane-based sequential cropping systems,

Sugarcane ratoon management device

Ratoon management device performs off-baring, deep tilling and fertilizer placement in the ratoon crop simultaneously in one pass of the tractor. This device saved 8-10 tractor-hours, 200-250 man-hours in a hectare, thus economizing Rs 5,000-6,000 per hectare.

pre-planting weed control with Glyphosate, followed by in crop weed control with 'pre-emergence Atrazine' and 'post emergence Ethoxysulfuron' or 'directed post emergence Paraquat' or 'directed post emergence Glyphosate' managed weeds, including cynodon and nutgrass, which are persistent in nature in plant and ratoon sugarcanes.

Drip irrigation saved about 40% of water as compared to the conventional furrow irrigation. Cane yield data revealed that paired-row planting of sugarcane with fertigation helped save 25% of chemical fertilizers.

Cotton: *Bt hybrids*. At Nagpur and Coimbatore, irrigation through drip at 0.8 Etc or through furrows at 0.6 IW/CPE improved seed-cotton yield and water-use efficiency. In rainfed areas, cotton+greengram provided the highest cotton equivalent yield and water-use efficiency. Highest seed-cotton equivalent yield and net returns were obtained with multitier cropping of cotton with radish, beet-root and coriander.

Tobacco: Seedling growth under micro-sprinklers was vigorous; transplantable seedlings were more and ready for transplanting in 45 days as compared to 60 days from traditional method of watering seedbeds. Application of water to tobacco seedbeds through micro-sprinklers reduced labour cost by Rs 145,000/ha.

Mango: An optimum irrigation of 40% of evaporation losses under drip irrigation with an application of 65% of recommended dose of fertilizers through fertigation was optimum for getting higher yield. Pre-harvest application of radioactive tritiated water to developing fruits of Alphonso mango showed higher mobilization of water into seed in the affected fruits compared to seeds in healthy fruits.

Maximum fruit yield was recorded in the trees pruned on alternate limbs after harvesting with the application of Paclobutrazol @ 10g a.i./tree. For rejuvenation of overcrowded orchards, maximum fruit yield was recorded in heading back of crowded branches and centre opening with application of Paclobutrazol @ 10g a.i./tree during rest period. Modified central leader system of training gave maximum yield at Pantnagar and Pusa.

Banana: In banana, planting three suckers/pit at 1.8 m × 3.6 m spacing recorded higher leaf-area index and facilitated the plants to have lower light transmission ratio (39.5) for Poovan at Coimbatore. At Kannara, plant spacing of 2 m × 3 m with three plants/pit (5,001 plants/ha) with 100% RDF for Nendran recorded highest yield (39.05 tonnes/ha). Inclusion of VAM, PSB, *Azospirillum* at 250, 50, 50 g/plant, respectively, with 100% recommended dose of fertilizer was superior. Application of 25% CAN + 25% urea + 50% ammonium sulphate constituting 200g N, in addition to 50g P_2O_5 and 200g K_2O favoured higher bunch weight (13.5kg) for Ney Poovan banana at Coimbatore. Application of 250:90:250g $N:P_2O_5:K_2O$ plant/crop with bunch spray of 2,4-D (10 ppm) recorded higher yield and benefit:cost ratio for Grand Naine (AAA) at Gandevi and Barjahaji (AAA) at Jorhat. The application of 80% N and 20% K_2O of the RDF in the first five months after planting resulted in higher B:C ratio at Kannara.

Banana Ney Poovan and Karpuravalli showed better nitrogen assimilation capacity under salt affected field (EC 1:2.5 = 3.34) than Nendran and Rasthali. Saba, Karpuravalli and Ney Poovan showed normal finger development and fruit filling under salt-affected field (EC 1:2.5 = 3.34) and Nendran and Robusta recorded small and ill-filled fingers. Imbogo(AA) was found tolerant to soil moisture-deficit stress and Saba, Karpuravalli and Poovan showed drought-tolerant traits, viz. higher relative water content (43- 55%) and epicuticular wax.

Litchi: In litchi, maximum fruit yield was obtained with the use of biofertilizer, *Trichoderma* and *Pseudomonas*, along with half the recommended dose of N P K and 50kg FYM in Shahi. Irrigation and sprinkling of water had significant impact on reducing fruit cracking in Shahi at RAU, Pusa.

Papaya: In papaya, inclusion of VAM, PSB, *Azospirillum* at 50, 25, 25 g/plant, respectively in papaya with 100% recommended dose of fertilizer was observed superior for yield. At Coimbatore, in papaya, application of 30:30:30 g of $N:P_2O_5:K_2O$ (60% RDF) applied @ 100:25:25% during transplanting to flower emergence @ 0:50:50% from flowering to first harvesting and @ 0:25:25% from first harvesting to end of first cropping period recorded better fruit characters in papaya.

Citrus: Best site-specific treatment N800 – P400 – K600 – M1 (250 g/tree each of $FeSO_4$, $MnSO_4$ and $ZnSO_4$/tree) showed its clear cut superiority (yield 52.8 kg/tree) over recommended doses of fertilizers (yield 42.0 kg/tree) and farmers practices (yield 38.3 kg/tree) with reference to yield and quality in addition to higher tree efficiency.

Inclusion of VAM, PSB, *Azospirillum* and

Trichoderma harzianum (500, 100, 100 and 100 g/plant respectively) to 100% of recommended dose of fertilizer recorded higher growth in mandarin and better growth and yield characters for acid lime at Akola. Application of RDF through fertigation resulted in saving of RDF to 25% in Kinnow mandarin at Ludhiana. At Rahuri, intercropping of greengram (*kharif*) followed by gram (*rabi*) in sweet orange was superior in Maharashtra.

Grape: Highest raisin recovery was found in Thompson Seedless grafted on 110 r and dogridge. Tas-a-Ganesh grafted on dogridge recorded more shoots positioned vertically to cordon more fruitful than the horizontal. The bunch weight was more in single cordon placed horizontally than double and four cordon system. Cumulative total uptake of sodium in cane, lamina and petiole was significantly more in Tas-a-Ganesh grafted on dogridge 110r. Dogridge rootstock could not exclude sodium under saline irrigation. The total accumulation of chloride among different tissues was found highest in lamina followed by cane and petiole both in grafted and ungrafted vines. However, potassium concentration was low in all three vine parts in case of own rooted vines compared to grafted vines.

Walnut: In walnut, maximum grafting success was recorded in wedge grafting performed during 10-31 March. It gave maximum success of 68.31% under ordinary polyhouse conditions.

Almond: Medium high and high-density orcharding in almond has been standardized with early, mid and mid to late season varieties, Makhdoom, Shalimar and Waris respectively for Karewa conditions of Kashmir valley. The orchard has been established at three different spacing of 3.5 m × 3.5 m, 3.0 m × 3.0 m and 2.5 m × 2.5 m, accommodating 816,1111 and 1,600 trees/ha, respectively, against 278 trees/ha under conventional planting. Maximum yield (2.01 tonnes/ha) was recorded in almond Shalimar under high-density planting of 2.5 m × 2.5 m spacing, providing irrigation through drip at critical stages of kernel filling and development, maintaining optimum canopy under central modified leader system with more fruiting wood through regular pruning.

High-density plantation in almond

Apple: Five apple varieties on clonal rootstock, MM 106 were found very promising under high-density plantation of 2.5 m × 2.5 m spacing. In seventh year, with about 50% canopy cover Oregon Spur recorded maximum yield of 17.79 tonnes/ha, followed by Red Chief (16.64 tonnes/ha), Vance Delicious (16.16 tonnes/ha), Red Fuji (13.47 tonnes/ha) and Silver Spur (12.98 tonnes/ha). These cultivars were significantly superior to traditional cultivar Red Delicious (11.20 tonnes/ha). However, under Mukteshwar (Uttarakhand) conditions Red Chief, Well Spur, Starkrimson, Spur type Red Delicious and Skyline Supreme performed better.

High-density plantation in apple

Underutilized fruits: Soft wood grafting has been recommended for khirni *(Manilkara hexandra)* during March-June and July-August and for *Chiraunji (Buchanania lanzan)* plants in June and August.

Aonla-based multistorey cropping system ground storey crops did not exert any competition on the growth and development of aonla up to four years of intercropping. Moth bean-cumin and moth bean-gram was observed to be profitable crop combinations in arid region.

Vegetables: Intercropping of gram, lentil, and vegetable peas with potato increased net returns at Jalandhar. Highest system productivity was obtained in maize–potato–onion (45.7 tonnes/ha), followed by paddy–potato–wheat (43.2 tonnes/ha). Traditional method of potato storage in heaps and pits was improved with single spray application of the CIPC. CIPC residues in peels of treated potatoes was only 0.11-3.22 ppm after 100 days of storage.

Peas: Technology for growing double crop of peas has been standardized with FC 1 and Arkel. First main season crop can be successfully grown during October-May and second off-season crop from July to October. Rotation involving pea-chilli crops also resulted in lower incidence of wilt and higher chilli yield.

Coconut: Higher coconut yield was recorded under coconut + vegetable intercropping system

(130 nuts/ palm/year) compared to monocropping of coconut (118 nuts/palm/year). Growing vanilla as mixed crop in coconut garden with cowdung slurry application recorded more number of infloresences (21), beans (208) and fresh bean yield (2.0 kg) per vine, followed by vermiwash application and vermicompost + biofertilizer application treatments. Integrated nutrient management with NPK and organic manure application resulted in improvement in health of root (wilt) disease affected palms and higher yield. The coconut-based farming system involving coconut with integration of grass, pepper if trailed on coconut, banana (on border of garden), dairy and poultry resulted in the net returns of Rs l29,070/ ha. Coconut, milk and broilers sale accounted for 91% of the revenue generated from the system.

Arecanut: In arecanut garden, mixed cropping with pepper, banana, citrus found to economically advantageous in North East Region. In *tarai* region, flower crops like aster, marigold and gladiolus gave higher yield in arecanut garden. Application of 50 % VC +50% NPK recorded significantly higher nut yield (68.8 nuts/palm/year) and was on a par with application of 25% VC + 75% NPK treatment (66.3 nuts/palm/year) and differed significantly compared to other treatments.

Cashew: In high-density plantation (416 and 500 trees/ha) in cashew, yields was significantly higher (1,093 and 1,078 kg/ha respectively) than in normal tree density plantation (511 kg/ha). In intercropping trial, total net returns from intercrops as well as main crop (cashew) at Bhubaneshwar was maximum in colocasia (Rs 44,908) followed by brinjal (Rs 37,666), okra (Rs 36,650) and cowpea (Rs 36,398). The highest net return (Rs 48,766) was recorded by tapioca followed by colocasia (Rs 43,290).

Turmeric: The highest curcumin content of 3.5% was recorded in accession CL 57. Oleoresin content varied from 8.5 to 12.5%. The highest oleoresin content (12.5%) was found in CL 219. The essential oil content varied from 2.0 to 4.5%. The highest essential oil content (4.5%) was found in CL 20. Integrated treatment recorded highest rhizome yield (24.8 tonnes/ha) followed by inorganic (22.9 tonnes/ha), whereas organic treatment recorded 21.2 tonnes/ha in the trial on organic farming in turmeric at Jagatial. Soil application of FYM @ 30 tonnes/ha + 20 q/ha vermicompost + 8 q/ha neem oil cake produced maximum plant height (126.67 m), tillers/plant (5.40), leaves/tiller (14.60) and yield/plot (15.20 kg/3m^2) or yield (50.67 tonnes/ha), followed by soil application of FYM at 30 tonnes/ha + 15 q/ ha vermincompost + 8 q/ha neem oil cake at Dholi.

Fennel: In fennal, application of inorganic nitrogen (100%) + FYM 5 tonnes/ha + *Azospirillum*, inorganic nitrogen (75%) + *Azospirillum* + FYM 5 tonnes/ha and inorganic nitrogen (50%)+ *Azospirillum* + FYM-5 tonnes/ ha and inorganic nitrogen (50%) + *Azospirillum* + FYM 5 tonnes/ha were found significantly superior to the control for umbels/plant, umbellet/ umbel, grains/umbellet and grain yield/ha.

Mushroom

At Solan, the 1:1 combination of cotton ginning mill waste+paddy straw gave more than 25% yield in paddy straw mushroom, which was highest till date in first flush. The addition of laccase activator tannic acid and p-anisidine stimulated 3-fold higher dyes decolourization with *P.sajor-caju*. The pellet form of mushroom mycelia and agitated growth conditions enhanced days decolourization by oyster mushroom. The mushroom grown on cotton waste compost were found to contain higher protein content, followed by those grown on cotton waste + paddy straw and paddy straw.

Fenugreek: In fenugreek, JF 270 recorded higher yield of 573 kg/ha which was at par with Rmt 303 (543.33 kg/ha) at Coimbatore. FGK-14 was identified promising at Dholi. HM 348 and HM 355 were identified as promising in IET at Hisar. The J.Fg. 244 and NS 2006-3 were identified as drought tolerant at Jobner. Spraying of Tricontanol 1.0ml /litre at 40 days after sowing resulted in highest grain yield of 595 kg/ha.

Tuber crops: In taro, use of whole mother corm as planting material was recommended. The application of vermicompost @200 kg/ha with RDF with 80: 50: 100 or FYM (10 tonnes/ha) + neem cake (1 tonne/ha) or FYM (10 tonnes/ha) + mustard cake (1 tonne/ha) was recommended for Jharkhand and Chhattisgarh. The application of 50% N through vermicompost and remaining NPK through chemical fertilizers was recommended for Uttar Pradesh. Application of 125: 60: 100 kg NPK/ha along with 50 kg N through vermicompost was recommended for bunda crop in Uttar Pradesh. In greater yam, application of paddy straw @ 1 kg/pit and 75% recommended dose of NPK (80:60:80 kg/ha) was recommended for Chhattisgarh. In elephant-foot yam, application of FYM @10 tonnes/ha and mustard cake @0.5 kg/pit was recommended for West Bengal. In elephant-foot yam, application of vermicompost @200 kg/ha and 50% recommended dose of NPK (80:60:80) applied at the time of planting was recommended for Bihar.

PROTECTION

Rice: INRC 4598 is the new source of resistance identified against gall midge. Identity of the new gene in MR 1523, a donor for gall-midge resistance, is established by RM 17, RM 235, RM 28706,

RM 28784, lying on chromosome 12, which showed co-segregation.

IET 19913 (CR 662-2211-1-1) showed resistance to leaf blast, neck blast and tungro, IET 20441 (JKRH 1206) to leaf blast, neck blast and brown spot, IET 20448 (DRRH 57) to neck blast, tungro and sheath blight and IET 20453 (CRHR 25) to neck blast, sheath blight, sheath rot and brown spot.

Trifloxystrobin 25% + Febuconazole 50% (Native 75 WG) were found effective in checking severity of blast, sheath blight and glume discolouration and Fenoxanil 5% + Isoprothiolane 30% checked blast severity and increased grain yield.

Wheat: Seed treatment with Imidacloprid at 0.6 g a.i./kg of seeds was found promising in checking aphid build-up 70-85 days after sowing and also gave yields at a par or better than Imidacloprid at 100 ml/ha (check). Likewise foliar spray of Oxydemeton Methyl reduced aphid population and increased yield significantly.

Phalaris minor, wheat weed: Phalaris minor, a serious weed on wheat, has evolved for multiple herbicides resistance to three modes of action (photosynthesis at photosystem II site A, ACCase and ALS inhibitor). Some resistant populations had GR_{50} (50% growth reduction) values for Clodinafop; >11.7 times than those of the most susceptible populations. The populations resistant to these three modes of actions were found sensitive to Trizine (Metribuzin and Terbutryn), Dinitroaniline (Pendimethalin) herbicides as well as to Glyphosate and Paraquat.

Barley: Seed treatment with Vitavax powder at 3 g/kg and Imidacloprid 70 WS (Gaucho) at 0.6 g a.i./kg + foliar spray of Propiconazole (Tilt 25 EC) at 0.1% and Imidacloprid (Confidor) at 20 g a.i./ha reduced incidences of stripe and stem rusts, covered rusts, covered smut and foliar blight as well as aphids.

Maize: Five pink stem-borer *Sesamia inferens* resistant lines WNZ PBTL2, WNZ PBTL3, WNZ PBTL6, WNZ PBTL8 and WNZ PBTL9 with desirable agronomic traits have been developed for their use in developing pink stem-borer resistant hybrids/varieties.

Pearl millet: Hybrids/varieties MH 1248, MH 1291, MH 1294, MH 1299, MH 1328, MH 1397, MH 1363, GHB 538, GHB 558, PB 106, Pusa 266, Raj 171, ICMV 221 and JBV 2 have exhibited resistance against downy mildew, smut and rust.

Forage crops: *Verticillium* wilt of lucerne, caused by *Verticillium albo-atram* Reinke & Berthold, was first reported in Jhansi in 2007.

Application of 2% asafeotida suspension significantly reduced root-knot nematodes (p=0.0001 at 95%) in cowpea. Three sprays of *Ipomoea carnea* leaf extract (8% water extract), at 15 days interval, resulted in 65-70% reduction in major insect pests damage over control.

Groundnut: Genotypes NRCG CS 144, 156, 158, 159, 160, 168, 196, 222 and PBS 25001 are found to possess multiple disease resistance. These will now be tested at the hot-spot locations.

Soil application of castor-cake enriched *Trichoderma* (isolate T-170) at 50kg/ha (*Trichoderma* multiplied on sorghum grains and mixed with 50 kg castor-cake) + intercropping with maize (3:1 ratio) + gypsum at 500kg/ha at flowering + foliar application of Chlorothalonil effectively controlled collar rot, stem rot, early leaf spot and late leaf spot.

Azadirachta indica and *Annona squamosa* fresh leaves dried in shade and applied at 500g/10 kg of pods reduced post-harvest *Aspergillus flavus* infection and aflatoxin contamination.

Trichoderma isolates NRCG T 07, 11, 14 and 29, identified to be thermo-tolerant, could grow well at 35-37 ºC. *Trichoderma* isolate NRCG T12 enriched with neem-cake or castor-cake effectively controlled collar and stem rots, *A. flavus* infection and aflatoxin contamination. Soil drenching with talc-based *Trichoderma viride* at 2.5kg/ha applied at 30 days after sowing effectively reduced stem-rot disease.

Seed treatment with 0.0035% Imidacloprid + 2 sprays of 0.008% Imidacloprid at 30 and 45 days after sowing were quite effective against jassids and thrips.

Groundnut promising resistant germplasm accessions

Centre	Hot spot for	Disease/insect pressure	Promising germplasm accessions
Kadiri	Peanut Stem Necrosis Disease (PSND)	0.12-23.14%	NCAc 515 (0.2%)
Raichur	Peanut Bud Necrosis Disease (PBND)	4.0-72.0%	NRCG 6696 (5.2%) NRCG 13129 (7.1%) NRCG 13078 (7.7%) NRCG 9238 (8.8%) NRCG 13177 (9.8%)
Junagadh	Collar rot	0.0-35.0%	NRCGs 4206, 9740, 1079, 11604, 13011, 13010, 4236, 11611, 13024, 13076, 13051

Groundnut + castor and groundnut + *Bt* cotton intercropping systems reduced jassid population. Groundnut + castor and groundnut + hybrid cotton reduced thrips population. Intercropping with pigeonpea gave highest cost:benefit ratio (1: 3.99), followed by castor (1: 3.46) compared to sole groundnut and other intercrops.

The life-table of *Caryodon serratus* (pod borer) on groundnut pods was studied at 25, 30 and 35°C. The net reproductive rate was highest at 25°C (R_0 = 170.04), and on an average, a female insect could produce 170 female offsprings during its life-span; indicating that insect can assume a status of serious pest at this temperature.

Safflower: For effective and efficient control of safflower aphid, two sprayings either of 0.005%, Thiamethoxam 25 WG or 0.004% Acetamiprid 20 SP or one spray of each alternatively first at ETL (40-45 DAS) and second spray at 55-60 DAS were recommended in the scarcity water zone of Maharashtra (Solapur).

For effective and efficient management of safflower aphid, 2 need-based sprays of either 0.005% Thiamethoxam 25 WG or 0.0045% Imidacloprid (17.8%) were recommended particularly in the northern parts of Karnataka (Annigeri).

Rapeseed-mustard: Imidacloprid 70 WS at 7 g/kg of seeds was found effective in controlling painted bug incidence in Indian mustard. Oxy-demeton Methyl 25 EC spray at 1 ml/litre of water, followed by neem-seed kernel aqueous extract (5%) and neem oil (2%) proved best for controlling mustard aphid

Castor: *Trichoderma* sp. N 13 formulation was found to reduce *Botrytis ricinii* grey-rot disease significantly under detached spike technique.

Soybean: Seed treatment 50 days prior to sowing with Carboxim (37.5%) + Thiram (37.5%) at 0.2% besides giving best management of seed and seedling diseases of soybean also resulted in higher monetary returns and energy output.

Seed treatment with either Carboxim at 3g/kg or *Trichoderma* at 10g/kg and soil application of zinc at 2.5kg/ha with B at 0.5kg/ha reduced chaffy pods as well as disease incidence of charcoal rot due to *Macrophomina phaseolina* to the tune of 75- 85% as compared to control.

Seed treatment with *Trichoderma* and irrigation at the time of moisture stress especially at the time of pod formation reduced charcoal rot incidence by 50%.

Pigeonpea: Resistant sources for *Fusarium* wilt (ICP 14722, 89046, 89048, 89049, Banda palera, PI 397430, BWR 377), pod fly (ICP 4542, JBP 120A), *Heterodera cajani* (Pusa 2007, JKM 213, JSA 28, PA 296) and *Meloidogyne javanica* (JSA 81) have been identified.

Mass multiplication of *Trichoderma*

Eight locally available agrowaste substrates viz. wheat straw, soybean refuge, spent maize cob, safflower, mustard waste, chickpea, lentil wastes and grass straw individually and in consortium were tried for mass multiplication of *Trichoderma* species. *Trichoderma* multiplied in all the substrates. One and two years old substrates were better as compared to the fresh substrates for mass multiplication of *Trichoderma.*

Chickpea: Resistant sources for *Fusarium* wilt (GJG 0505, H 04-31, WCG 2000-12,H 04-87, Phule G 9621-8, GNG 1778, GJG 0506, IPC 2005-64,IPC 2006-13, H 82-2, BCP 91,JSC 35, MPJG 2001-04, GJG 02-05, GJG 03-12, JG 2000-14 and JG 2003-14-16), dry root rot (GJG 0419, GJG 0505, H 04-31, GJG 0107, GJG 0315), collar rot (IPC 2005-66, IPC 2005-61 GNG 1763, NDG 7-701 and Phule G 9621-8), *Ascochyta* blight (H 03-45, CSJ 479, NDG 7-602, GNG 1778, GNG1488 and GG 1362) and *Botrytis* grey mould (IPC 2005-64 and IC 269380) have been identified.

Mungbean: Resistant sources for *Cercospora* leaf spot (Co4, Co5, COGG 7, UPM 98, TM 98-50, BM 4, BM 7 and ML 515), mungbean yellow mosaic virus (MYCV) (KM 2241, COGG 923 and ML 1299) and root-knot nematodes (RMG 976 and ML 1299) have been identified.

Urdbean: Resistant sources for powdery mildew (DU 1) and leaf crinkle disease (PLU 662, UH 82-2, JU 4, IPU 99-218, IPU 99-229, IPU 99-259, Aligarh 1, U 15 and JU 2) have been identified. KUG 216 showed multiple resistance to mungbean yellow mosaic virus, stem necrosis, *Cercospora* leaf spot and anthracnose.

SUCCESS STORY

Pulse growers of Uttar Pradesh selected chickpea varieties

In Fatehpur district of Uttar Pradesh, farmers mostly follow paddy/*bajra*-wheat cropping sequence under irrigated conditions. Survey revealed that chickpea vanished from the cropping sequence mainly due to the continuous decline in the yield due to *Fusarium* wilt and non-availability of quality seeds in Fatehpur. In view of this, farmers participatory varietal selection programme was taken up at 20 sites across six villages in two years (2006-08). Six improved varieties of chickpea, DCP 92-3, JG 16, KWR 108, PG 186, KGD 1168 and JGK 1 and two local large- and small-seeded varieties were assessed. Varieties JG 16 (2,850 kg/ha) and DCP 92-3 (2,550 kg/ha) proved most promising in the region. Farmers preferred JG 16 for mid-October planting and DCP 92-3 for planting during the first week of November. They produced 28 tonnes of seeds of DCP 92-3 and 15 tonnes of JG 16.

Lentil: Resistant sources for wilt (RG/L 2, RG/L 17, ILL 9981, ILL 9976, RGC/L 14, ILL 8114, IPL 86, IPL PP 12), rust (L 4688, L 4691, L 4147, L 4583, VL 133, RLG 73, IPL 315 and HUL 57) and root-knot nematodes (LL 1020, PL 406, VL 516, L 4695) have been identified.

Fieldpea: Pant P 108, Pant P 74, Pant P 25, Pant P 86, TRCP 8, RFP 29 and Pant P 107 showed resistance against rust and powdery mildew.

Phenolic acids–chlorogenic, caffeic, coumaric and ferulic acids–imparted resistance against wilt in chickpea. Chlorogenic acid was most predominant phenolic acid for wilt resistance.

Dust formulation (30×10^5 IJS/ha) of EPN species *Steinernema masoodi* and *S. seemae*, worked better for the management of lepidopteran-borer complex. A dose of 6×10^5 IJS/ha of *S. masoodi*/plot was sufficient to kill physiologically matured larvae.

Seed soaking in 0.1% Imidacloprid or 0.1% Carbosulfan reduced nematode population and assured plant health.

Sugarcane: *Trichoderma viride* and *T. harzianum* were effective for management of red rot, wilt and smut.

Dipping of smut-affected setts before planting in *T. viride* (Tv-6) spore suspension (10^6 spores/ml) reduced smut incidence and enhanced number of millable canes and yield in plant-crop. In ratoon, smut incidence was comparatively low that resulted in more millable canes and yield.

Two split doses of urea at 75 kg N/ha at planting and at the appearance of 1st moth of third brood of top-borer (15-25th June) with three weekly releases of *Trichogramma japonicum* at 50,000 adults/ha combined with neem-based insecticide formulation spray at 3 litres/ha at the time of egg-laying reduced infestation and increased cane yield.

Jute: In stale seed-bed method, Glyphosate at 2.46 kg + 2,4-D at 2kg a.i./ha and Glyphosate 2.46 kg + Pyrozosulfuron Ethyl (PSE) at 60g/ha, followed by one hand-weeding was found promising for broad-range weed control at the early stage in jute field. It reduced *Cyperus rotundus* population by more than 80% over control after two years' cycle and yielded significant jute fibres/ha.

Glyphosate at 2.46 kg SL + Paraquat 0.72 kg SL per hectare at 15 DAE using herbicide-brush controlled wide range of weeds in jute and mesta fields.

Tobacco: Crude sugar ester fractions from *Nicotiana glutinosa* at 2% concentration brought about 92% mortality of the aphids.

Application of *Paecilomyces lilacinus* at 10g/m^2 in FCV tobacco nursery caused 32.1% increase in number of root-knot-free-healthy transplants compared to the check. It also reduced root-knot index to 2.05 compared to 3.75 in check, and was on a par with *P. lilacinus* + neem cake (1.87) and *P. lilacinus* + vermicompost (1.82).

Mango: Pongamia and neem oils at 0.2 % were highly synergistic with Imidacloprid (0.3 ml/litre) against chilli thrips, *Scirtothrips dorsalis* (73 – 76 % mortality). Acephate @ 1 g/litre along with pongamia oil 0.1 % resulted in 67 % mortality of thrips.

Wooden block methyl eugenol trap was found highly efficient in trapping fruit flies (1,584 flies/trap), followed by agriland, sun agro and bottle trap. Hot water treatment of fruits at 48±1°C for 1 hour controlled all stages of fruit fly, *Bactrocera zonata* in Dashehari, Langra, Chausa, Amrapali and Mallika without affecting ripening of fruits. Thiamethoxam (0.005%) was found highly effective in controlling mango thrips.

Guava: Sixteen Fusarium isolates (F6, F9, F10, F26, F27, F30, F31, F36, F39, F41, F43, F45, F46, F47, F49, F50) exhibited typical guava wilt symptoms. In field evaluation of bioagents for the management of guava wilt, *Aspergillus niger*-AN 17 showed plant growth-promoting activity. Isolates AN 9, AN 10 and AN 11 were also effective. Soil application of *Trichoderma viride* along with FYM applied in the root zone was found most effective in reducing the incidence of guava wilt at BCKV, Mohanpur.

Citrus: At Tirupati, coat protein gene of acid lime isolate of CTV was cloned in P drive vector and sequenced. The clone can be used for recombinant technology based diagnosis of CTV. At Rahuri, two sprays of acephate (0.1125%) or Imidacloprid (0.005%) or Thiamethoxam (0.0025%) were effective to control citrus leaf folder. Spraying of Acephate (0.1125%) at Periyakulam, Imidacloprid 200 SL (0.005%) at Tirupati and Imidachloropid 200 SL, Acephate (0.1125%) and single application of Ithiodicarb 75 WP (75%) at Tinsukia were effective against citrus leaf miner. Among natural products, NSKE (5%) was also effective at Periyakulam and Tirupati. At Periyakulam, NSKE (5%) and fish oil resin soap (0.3%) were effective against citrus butterfly.

The *Bacillus thuringiensis* (BT) @ 0.1% was effective for lemon butterfly and leaf miner management at Tirupati. Spraying of streptomycine sulphate (100 ppm) with copper oxychloride (0.3%) was best at Periyakulam, while NSKE (2%) was effective at Pusa. Biopesticides abamectin @ 0.32 ml/litre followed by spinosad @ 0.34 ml/litre and novaluron @ 0.87 ml/litre were found effective for 15 days against citrus leaf-miner. Application of petroleum spray oil @ 3.72 ml/litre and *Bacillus thuringiensis* @ 1.9 g/litre water were found

effective for 11 days. However, treatments of neem oil, azadirachtin, neem soap, and pongamia soap were found effective for one week. A chrysopid predator, *Mallada boninensis* and a eulophid parasitoid *Tamarixia radiata* released @ 30 larvae/tree and 40 adults/tree, respectively, alone and in combination in six Nagpur mandarin orchards with marigold as border crop covering Nagpur district resulted in 31-35, 46-49 and 26-32% reduction of blackfly, psylla and leaf miner population respectively. PCR technique for rapid detection of citrus greening bacterium was developed. A rapid and sensitive diagnostic assay based on PCR was developed.

Banana: For the management of rhizome rot disease of banana, suckers from diseased plot followed by dipping in copper oxychloride (0.4%) and streptocycline (0.03%) for 45 minutes was effective at Arabhavi, Coimbatore and Gandevi. Planting disease-free suckers from disease-free fields followed by dipping in Carbendazim (0.2%) for 45 minutes followed by drenching with Carbendazim (0.2%) at 5th, 7th and 9th month was highly effective against Panama wilt at Jorhat and Kannara. For the management of Sigatoka leaf spot disease in Robusta, spraying of propiconazole (0.1%) + *Pseudomonas fluorescens* (0.5%) was found to be effective (PDI-11.2) compared to the control (PDI-23.2) at Coimbatore. At Coimbatore, *Pseudomonas fluorescens* as both sucker treatment and soil application [10g as sucker application - *Pseudomonas fluorescens* (2.5 kg + 50 kg FYM mixture) and 20 g/sucker as soil application] was effective in suppressing nematode population, root and corm index and gave an increased yield (56% over control).

About 100% mortality in burrowing nematode was observed in two isolates at 100% concentration when exposed to 48 hour, whereas eight out of 12 bacterial isolates exhibited 100% mortality at 100% concentration when exposed to 72 hour. Promising biocontrol agents, viz. *Paecilomyces lilacinus, Trichoderma viride* and *T. harzianum* were mass multiplied by using banana wastes such as banana leaves, pseudostem and petiole. The genotypes, Karthobiumtham and Calcutta 4 showed tolerant/ resistant reaction to *P. coffeae*.

Grape: The rootstocks differed significantly in leaf damage caused by leaf blackening. The symptoms were more severe in Salt Creek followed by Dogridge and own rooted vines. However, symptoms were not observed in vines grafted on 110R rootstock. The 110R rootstock showed tolerance against saline water. A procedure of sampling grapes from vineyards was standardized for pesticide residue analysis. As per this procedure sampling by collecting 5 kg grapes comprising small bunchlets will be laboratory sample from 1 ha for residue analysis with homogenous results.

Plant Protection measures in bitter gourd

In bitter gourd, repellent spray of neem formulation enhanced the field performance of Male Annihilation Technique (MAT) and Bait Application Technique (BAT). The bait (molasses 10% + carbaryl 0.1%), repellent spray (neem formulation 0.3%) and installation of cue-lure baited traps @25 /ha) initiated from the flowering was most effective in reducing the fruit damage caused by fruit fly. Application of neem as a repellent increased the catch in para-pheromone traps and enhanced the luring ability of para-pheromone by 52%.

Sapota: Application of 5 kg vermicompost with 200g N, 40 g P_2O_5 and 150g K_2O/plant/year in sapota at Arabhavi and Periyakulam continue to record significantly higher growth and yield.

In sapota, Carbendazim (0.1%) effectively reduced leaf spot disease (after I spray) at Arabhavi. At Gandevi, a trap named "NAUROH-STONEHOUSE FRUIT FLY TRAP was designed and produced commercially to make available to the orchardists.

Pomegranate: Pomegranate bacterial blight (*Xanthomonas axonopodis* pv.*punicae*) was managed effectively avoiding rainy season crop (*Mrig bahar*) and regulating winter season (*Hastha bahar*) crop during October- April, orchard sanitation, pruning of diseased branches and application of Bordeaux paste to cut ends of stems, dusting orchard soil with copper dust 4% @ 20 kg/ha or drenching with bleaching powder @ 2.0% and regular sprays of Streptocycline (500 ppm) along with Carbendazim (0.15%)/mancozeb (0.2%)/ copper oxychloride (0.25%) at 15 days interval.The adoption of integrated schedule resulted in 82.2% bacterial blight control and managed fungal leaf and fruit spots caused by *Cercospora punicae, Colletotrichum gloeosporioides, Alternaria* spp. and *Phytophthora* sp. The defoliator *(Achaea janata)* was manged by spraying of Chlorpyriphos (0.1%) and fruit-borer *(Deudorix isocrates)*, mealy bug *(Ferussia virgata)* and ahids *(Aphis punicae)* were controlled effectively by spraying of Monocrotophos (0.15%).

Chilli: Seed and seedling treatment against wilt with Carbendazim (0.05%) and transplanting in second week of April on raised beds followed by drenching with Carbendazim (0.05%) using black polythene mulch in between rows reduced wilt incidence and increased yield of green and dry red chilli.

Black pepper: The plots treated with potassium phosphonate @ 0.3% and *Trichoderma harzianum* @ 50 g/vine was found effective in managing foot rot in black pepper, followed by Bordeaux

mixture 1% spray and COC 0.2 % drenched plots. Among the biorationals evaluated, neem gold (0.5%) was found effective in suppression of mussel scale *(Lepidosaphes piperis)* population and the least scale population was recorded on vines treated with Dimethoate (0.05%).

Cardamom: In cardamom, application of inorganic P alone or with P-solubilizer was significantly superior to other treatments. Panicle and clump infections due to capsule and rhizome rot disease were minimum in plots treated with *T. harzianum* and consortium of bacteria @ 50 g/ plant. The efficacy of Phorate (2.34), Imidacloprid (1.77), Thiamethaxam (1.90) and neem cake (2.33) were found superior in recording lowest number of dead hearts per clump compared to other chemicals. Significant reduction of cardamom root grub was observed in plots treated with combined application of Imidacloprid (0.006%) and *H. indica* (100IJ/grub).

Integrated pest management

IPM validation in rice. In rice, IPM validation in Dehraduni Basmati (Type 3) was carried out at village Tilwari, Dehra Dun, in 25 hectares with main interventions like seed treatment, pheromone traps for yellow stem borer (YSB) monitoring, release of parasitoid *Trichogramma japonicum* for YSB and leaf folder and spray of Carbendazim for rice blast disease, which suppressed the incidence of all major pests. Net returns were Rs 42,840/ha in IPM as compared to Rs 34,465/ha in farmers' practice. IPM validation programme was also initiated in Pusa Sugandh 4 (1121). *Bakane* disease was observed as the main problem of this cultivar, which was effectively managed by seed treatment and *Pseudomonas.* IPM provided higher cost : benefit ratio (1:6.76) as compared to farmers' practice (1:5.76).

IPM in brinjal. IPM and INM technologies in brinjal were advanced to organic trial and validated, which yielded clean and better quality produce as it did not contain any chemicals though the yields were lower compared to farmers' practice. It also resulted in increased biodiversity (natural enemies and soil flora and fauna) and non-pollution of underground water.

Pink bollworm management in cotton

Pink bollworm (PBW) in later stages of crop growth in cotton was managed successfully by mating-disruption technique. PBW moth catches in pheromone traps in control block ranged from 3.0 to 9.4 with a mean of 7.25 moths/week/trap against 0.8-2.8 with a mean of 0.65 moth/week/trap in an experimental block where PB Rope L was used. Green boll damage due to PBW (%), due to PBW larvae, open-boll damage and locule damage/20 bolls ranged from 0.4-2.0 (mean 1.43), 0.25-1.4 (mean 0.75), 9.8-12.2 (mean 11.04) and 3.2-4.4 (mean 3.64) in experimental block against 1.0-7.6 (mean 5.21), 0.6-6.2 (mean 3.64), 20.4-27.4 (mean 23.44) and 7.0-9.8 (mean 8.36) in control block. Seed-cotton yield at harvest remained higher in experimental block as compared to control block.

A hand-held device developed for e-pest surveillance

This is a portable, hand-held device, a type of protected Personal Digital Assistant (PDA), for capturing number of pests and beneficial insects, and the collected data can be sent to NCIPM database through Internet. A software for entering population dynamics of insect-pests in cotton and weather data was developed. The data from 23 centres of the AICCIP were collected for 2006-07. And the data were entered in this programme, which generates reports either in tabular or in chart form. Interaction studies using three years (2003-04 to 2005-06) data on mealy bug colonies with weather suggested that significantly higher rainfall associated with cooler winter provided congenial environment for outbreak of grape mealy bugs.

Biological control

Exotic egg parasitoid for managing diamond-back moth. Imported egg parasitoid *Trichogramma brassicae* release at 1 lakh/ha in Jorhat, Jammu, Pune and Coimbatore revealed its better efficacy than *T. chilonis* in controlling diamondback moth *Plutella xylostella* in cabbage at Jorhat and Jammu. In Pune and Coimbatore, *T. brassicae* was as effective as *T. chilonis* on cauliflower.

SUCCESS STORY

Biological control of rice pests

Rice-sucking pests, leaf folder and stem borer as well as sheath blight were controlled using *Trichogramma japonicum,* pheromone, neem oil and *Pseudomonas fluorescens* over 1,250 hectares of *Kole* lands of Adat Panchayat in Thrissur district. The perceived effect of the people's movement in this village was enhanced biodiversity of the rice-farms, in terms of increase in birds, predatory insects and reduction in pests in terms of insects and diseases in rice-crop as well as enhanced human and livestock health, as reported by villagers. The average yield level of 6.5 tonnes/ha as against the state average of 2.5 tonnes fetched premium price since the farmers' cooperative bank marketed it as non-chemical rice with premium price. Collateral co-ordination of input supply and marketing of paddy by the village panchayat brought economic advantage to farmers.

Development of fungal formulations with enhanced shelf-life: Formulations of *Trichoderma harzianum* with 12 months shelf-life have been developed, and the bioefficacy study confirmed potency of the organism. A simple and economical solid-state fermentation technique has been developed and commercialized.

Antagonistic organisms for control of mango fruit rot: *Trichoderma harzianum* and *Pseudomonas fluorescens*, isolated from mango orchards, as mixed pre-harvest sprays, followed by post-harvest dip of fruits in a suspension of *P. fluorescens* was found effective in suppressing post-harvest fruit rot in Dasheri mango at Pantnagar.

Natural enemies control cotton mealybug: Cotton mealybug *Phenacoccus solenopsis* notable natural enemies are predators, *Spalgis epius* caterpillars *Mallada desjardensis*, *Cryptolaemus montrouzieri* and a parasitoid *Promuscidea unfascialiventris*. Hymenopteran parasitoid, *Aenasius* sp. has been reported from Punjab. These natural enemies could be conserved by avoiding chemical pesticides and relying on natural suppression of mealy bugs.

Catterpillars of *S. epius* feeding on mealy bugs (*inset: Spalgis epius* adult)

Rodent management

In Punjab, rodent damage to rice and wheat was very low (up to 2% only) but damage to pea, groundnut and sugarcane was in the range of 2.0-11.5, 9.1 and 13.8%. In western Rajasthan, 36-65 live burrows of *Mus hurrianae* and *Tatera indica* were observed in *bajra*-mungbean-*guar* fields. Among pulses, pigeonpea, cowpea and soybean suffered 3-3.33, 6.6-7.7 and 7.0-7.5% pre-harvest rodent damage. Groundnut in Bangalore and Bidar districts recorded 9.0 and 6.0% damage by rodents. Similarly damage to sesame was 5 to 6.8% in Ramanagar rural district of Karnataka. In tuberose (a flower crop) at Bidar, a maximum (47 live burrows count/ha) rodent population was observed during flowering with a mean of 11% damage. In Assam, rice (*sali* and *bao*) recorded 10-15.9% tiller damage. Pea, mustard and pumpkin and potato crops suffered 11.54,2.36, 9.4 and 13.7% damage by field rodents.

Botanicals: Feeding of wheat-sugar-oil (WSO) mix supplemented with 1, 3, 5, 7 and 10% *Calotropis procera* latex to *Rattus rattus* resulted in antifeeding index from 1.03 to 41.95%; with its maximum value (41.95%) at 3% latex concentration. With daily consumption (g/100gbw) of bait having *C. procera* root powder mixed in WSO at 2, 4 and 6% results were comparable to plain WSO food, but the intake of treated bait prolonged the cyclicity of the treated rats. Male house rats fed on WSO containing 0.1, 0.2 and 0.3% beiao (antifertility agent extracted from

Indigenous storage structures in NEH region and rodent-proofing

Rodent species composition in grain storage in Assam (indoor and outdoor granaries) comprised *Rattus rattus, Bandicota bengalensis, M. musculus castaneus, R. norvegicus* and *Dremomys lokriah macmillani*.

There are two kinds of indigenous storage structures, one for indoors for small to medium period of storage, and the other one for longer duration of bulk storage outdoors. Both types of storage systems mainly utilize bamboo and mud plaster. Different types of indoor storage structures include (i) *Duli,* (ii)*Mer,* (iii) *Tum,* (iv) *Bakharu,* (v) *Hak*. Similarly for bulk storage outdoors, two kinds of structures *Guchi bharal* and *Guti bharal* are quite common. They are erected on bamboo poles supported by timber/ brick-cement pillars or large wooden blocks. *Guchi bharal* is mainly used for bulk storage of paddy and *Guti Bharal* is used for storing threshed paddy. Indoor structures are vulnerable to rodent attack therefore rodent-proofing can be done by fixing rat-guards made of GI or aluminum sheets on pillars supporting platforms at 60 cm above ground and keeping grains stored in bags in *duli, mer, tum* at a 50 cm distance from the walls. *Bharals* can also be made rodent-proof by fixing similar types of rat-guards on the pillars.

One of the indigenous storage structures in NEH region (*Mer*)

Tripterygium wilfordii) revealed no significant difference in the consumption of beiao treated and plain WSO by rats excepting at 0.3% concentration, indicating its good acceptability.

Rodenticides: *Cholecalciferol (Vitamin D_3):* Cholecalciferol (vitamin D_3) feeding at different doses to house rats resulted in higher values of calcium and phosphorus levels in the serum of treated rats as compared to the control rats. Toxic levels of calcium and phosphorus led to death of treated rats due to mineralization of soft tissues like heart, liver, lungs, kidneys and stomach.

Brodifacoum: Efficacy of brodifacoum in wax-cake formulation containing a.i. of 0.005% was evaluated against commensal rodents at Jodhpur, Bangalore and Jorhat. In no-choice trials, cent per cent mortality was observed in *B. bengalensis* and *R. rattus* within 4-10 days in the laboratory. In choice tests, the mortality was reduced to 80% in 5-10 days (*B. bengalensis)* and 70% in 4-10 days (*R. rattus)*. The bioefficacy and palatability of brodifacoum baits were comparable with that of bromadiolone.

Aluminium phosphide: Fumigation of live burrows of *Tatera indica* with an experimental formulation of aluminium phosphide (6% a.i) yielded a control success of 68.43% (horticulture), 66.66 %(silvipasture) and 65.39% (grasslands), which was closely comparable with the check treatment of celphos pellets (54% a.i.). The experimental fumigant may have an edge over celphos due to reduced a.i. of poison in formulation under similar bioefficacy.

Whitegrubs and other soil arthropods

Whitegrubs: In groundnut, seed treatment with Thiomethoxam 25 WG and Thiomethoxam 70 WS both at 1 g a.i./kg of seeds and Imidacloprid 200 SL at 0.6 g a.i./kg of seeds, and to suppress whitegrubs in standing crop, Thiomethoxam 25 WG at 150 g a.i./ha, Imidacloprid 0.75 G at 90 g a.i./ha and Thiomethoxam 70 WS at 150 g a.i./ha, were effective for managing *Holotrichia consanguinea*.

In the pot experiments, 1,200 IJs/grub gave 50% mortality on day 4 and dose of 1,500 IJs/grub gave 90% mortality on day 7. Entomopathogenic nematode strain *Heterorhabditis indica* provided 46-51% protection to groundnut against whitegrub *Holotrichia consanguinea* at 2 to 3 million IJs/10 m^2 doses.

In potato, soil application of Imidacloprid 200 SL at 48 g a.i./ha and Imidacloprid 0.75 G at 90 g a.i./ha were promising against whitegrubs, *Holotrichia longipennis* and *Apogonia* sp., as well as in arecanut against *Leucopholis lepidophora*.

Cutworms: In capsicum, spray of Imidacloprid at 0.04% and Lambda Cyhalothrin at 0.04% one week after transplanting were promising for managing cutworms in Kullu valley.

Plant-parasitic nematodes

Nematode distribution atlas of economically important plant-parasitic nematodes of major crops has been compiled and digitized.

Rodents in NEH region

Sporadic to mass flowering of bamboo *Dendrocalamus hamiltonii* and *Melocanna bacifera* was observed during October-November, and fruiting was from January-April in Mizoram, Meghalaya and Tripura. The rodent activities started increasing from April to September with an average number of active burrows ranging from 36 to 60.49 and 38.89 to 58 in Meghalaya and in Mizoram, respectively. Rodent activities in fields were maximum in July-October and were least in January-February. Highest activities of rodents were observed in upland cultivated areas.

A total of eight rodent species from Meghalaya and twelve from Mizoram were collected and identified. In overall collection, *Bandicota bengalensis* was the predominant species, followed by *Rattus* sp. In bamboo-flowering areas, *Rattus* sp. was predominant. Trap index was calculated, which varied from 0.0135 to 0.239 for local traps in Mizoram in different sites.

Rice crop was most affected by rodents. In Mizoram, damage to almost all crops increased significantly after shedding of bamboo fruits. Upland rice, lowland rice, *jhum* paddy and maize suffered losses between 14.67 and 32.54%, 18.52 and 30.05%, 32.70 and 36.90% and 18.60 and 40.12%, respectively. The bait preference studies with *Rattus* spp. indicated higher preference for bamboo fruit, followed by rice > maize > soybean. Among the local traps, *Vaithang* proved most effective with 70-90% catches in different locations, followed by *Chepthang* (50-80 %), which was fairly high in comparison to Sherman's traps (10-20%) and Snap traps (10-30 %). Among rodenticidal trials, zinc phosphide was most effective, followed by racumin and bromadiolone.Bait stations made up of bamboo proved effective in comparison of other methods.

Chepthang – a local rodent trap in Mizoram

SUCCESS STORY

Cyst nematode management in pigeonpea in Tamil Nadu

The crop is widely attacked by the nematodes in the state. To minimize losses caused by pigeonpea cyst nematode (*Heterodera cajani*), combined treatment of *Pseudomonas flourescens* + *Trichoderma viride* at 5 + 5 g/kg of seeds led to 32.5% decrease in *Heterodera cajani* population in soil and 37.1% increase in grain yield. The cost : benefit ratio was 1:2.29. This recommendation is widely accepted by Tamil Nadu farmers.

Hot-spot areas in paddy against *Aphelenchoides besseyi* in West Bengal and Himachal Pradesh and *Meloidogyne graminicola* in Tamil Nadu, Karnataka and Himachal Pradesh were identified. Polyhouses having carnation, capsicum in the districts of Bilaspur, Hamirpur and Kangra in Himachal Pradesh were badly infested with root-knot nematodes.

Management of *Meloidogyne graminicola* infesting paddy was achieved through soil solarization of nursery + Carbofuran at 1kg a.i./ha 45 days after transplanting or application of neem-cake at 100 g/m^2 in the nursery + Carbofuran in the main field.

The combined application of neem-cake at 100 g/m^2 + *Trichoderma viride* at 2.5 kg/ha as soil application at the sowing time was effective for root-knot nematode management in mungbean.

Agricultural acarology

In Gujarat, Propargite (0.05%) was statistically better than Diocofol (0.05%), wettable sulphur (0.125%), Ethion (0.1%) in reducing rice sheath mite damage.

At Bangalore, chilli PBC 61, Udaipur 2, BVC 47 and BVC 53 were free from yellow mite infestation.

In Gujarat, *Tetranychus urticae* was observed to have resistance to Dicofol 1.5 fold at Navasari, 1.6 at Wada, 1.9 at Dungri and 2.7 fold at Sandhier.

To sustain predatory mite populations of *Neoseilus longispinosus*, Frenchbean plants provided optimum food for spidermites up to 50 days, and hence spidermites (prey) can be mass produced on Frenchbean plants up to 50 days.

At Ludhiana, Propargite (Indofil) 57 EC at 850 g a.i./ha reduced significantly yellow mite population on chillies. Propargite was found comparatively safe to predatory mites and was not phytotoxic on chilli plants.

Spiromesifen (96 g a.i./ha), Diafenthiuron (450 g a.i./ha), Milbemectin (4 g a.i./ha), Chlorfenapyr (75 g a.i./ha) and Fenazaquin (125 g a.i./ha) were significantly effective in reducing yellow mite population in chillies up to 14 days after each application at Bangalore. At Ludhiana, Diafenthiuron (Polo) 50 SC at 300 g a.i./ha proved effective in reducing *Polyphagotarsonemus latus* up to 10 days after spray, followed by Propargite 57 EC at 750 ml/ha, and Dicofol provided good control up to 7 days after spray during July-August. Propargite 57 EC at 750 and 1,000 ml/ha and Spiromesifen 240 SC at 400 ml/ha were effective in reducing *Tetranychus urticae* on brinjal up to 14 days after spray during May-June.

Pesticide residues

Spirotetramat on chilli was studied at four locations – Jaipur, Kalyani, Vellayani and Hyderabad – at 60 and 120 g a.i./ha, first at fruiting and second 10 days after first spray. Red chilli at harvest and soil samples at 20 days after second spray did not show any residue of Spirotetramat and Enol metabolite.

At Hyderabad and Kalyani, new generation insecticide Spiromesifen was used as foliar spray at 120 and 240 g a.i./ha twice at interval of 10 days. Residues in fruit samples were below the limit of observed quantity (LOQ) level of 0.01 ppm after 3 days at the recommended dose with post-harvest interval of 3.12 days. At Kalyani, Solan and Vellayani, two foliar applications of Spiromesifen were given on tea-crop in 7 days interval at 400 and 800 ml/ha. The residues reached below LOQ level of 0.05 mg/kg in green tea leaves after 7-10 days at 400 ml/ha. No pesticide was detected in processed tea and tea liquor after 14 days of application.

At Kalyani, Vellayani, Rahuri and Ludhiana, Bifenthrin 10 EC was sprayed in sugarcane in basal furrow at 100 and 200 g a.i./ha. Residues in juice and soil samples at harvest after 290 days were below the limit of determination of 0.025 ppm.

A recently introduced ß-Cyfluthrin 9% + Imidacloprid 21% were tested in supervised field trial on brinjal, tomato and okra. Three sprays were given at an interval of 7 days at (18+42) and (36+84) g a.i./ha. The proposed waiting period after the spray is 7 days.

Combi-formulation of (Trifloxytrobin 25% + Tebuconazole 50%) WG at Hyderabad, Kalyani and Rahuri on chilli was applied first at fruiting stage and the second 10 days after first spray at two doses (62.5+125) and (125+250) g a.i./ha. Half-life of Tebuconazole on chilli was found 2 days and of Trifloxystrobin was 0.38 days. The proposed waiting period for this formulation is 15 days.

Flubendiamide 24% + Thiaclorid 24% 480 SC on tomato at Bangalore and Rahuri was applied twice at 10 days interval at (48+48) and (96+96) a.i./ha. The half life of Flubendiamide was found

1.59 days. Thiacloprid residues deposit on tomato was 0.37 and 0.63 mg/kg, which dissipated with a half-life of 1.29 days. Flubendiamide and Thiacloprid were below the detectable level in soil at harvest following dosages.

Agricultural ornithology

Birds damage in different crops: In rice, the Indian peafowl *Pavo cristatus*, teals and common moorhen *Gallinula cloropus* damaged the crop to the tune of 10.0, 5.0 and 12.0%. And in wheat field in Gujarat, migratory short-toed lark *Calandrella cinerea* and calendar lark *Melanocorpha calandra* damaged sown seed to the extent of 90%. In maize, rose-ringed parakeet *Psittacula krameri* in Andhra Pradesh caused 40% damage, and in sorghum damage was between 5 and 25%, mostly by rose-ringed parakeet *Psittacula krameri*, common myna *Acridotheres tristis* and munias *Ploceus* species.

Eco-friendly birds management practice: In IBPM in cultivators' fields, different management modules during *kharif* consisting of net (1,471 kg/ha), reflective ribbon (1,361 kg/ha) and botanical spray (1,305 kg/ha) proved effective in controlling bird damage in sorghum over control (912 kg/ha).

For the first time, birds like small green barbet *Megalaima viridis*, white cheeked bulbul *Pycnotus jocosus* and tree pie *Dendrocitta vagabunda* played a vital role in propagation of *Momordica dioica*, a cucurbitaceous climber. And the seeds found in the excreta of these birds readily germinated (100%), unlike seeds harvested manually.

Role of beneficial birds: In Kerala, insectivorous birds (14) controlled rice insect pests and recorded higher yield in experimental plot (3,215 kg/ha) than control (1,895 kg/ha). T-shaped perches with nucleopolyhedrosis virus proved effective in controlling medium and large-sized larva *Helicoverpa armigera* in pigeonpea in Gujarat. In castor, 22 birds species controlled 48% of *Spodoptera litura*, and in Kerala, crow pheasant *Centropus sinenis* in cardamom devoured 5% of stem-borer larvae, and termites were voraciously fed on by common crow *Corvus splendens*. In tomato-crop, 11 species of insectivorous birds reduced 25% of *Helicoverpa armigera* larvae while in chickpea 8 birds species reduced 20-23% of *H. armigera*. Nest boxes designs were standardized for cavity-nesting birds. In Kerala, feeding behaviour of barn owl *Tyto alba*, Fish-eating owl *Bubo flavipes* and spotted owlet *Athene brama* was studied that showed dietary rodent remnants (82%) in barn owl diet, crab remnants (65%) in fish-owl and insecta remnants (60%) in spotted owlet throughout the season.

9

Livestock Management

Cattle

Fibre digestibility: *Streptococccus bovis*, a numerically predominant bacteria in the rumen of crossbred cattle under different feeding regimes was charaterized. And the cellulase gene obtained from the best fibre degrading fungi isolated from the faecal matter of goat was cloned to *Streptococccus bovis* for enhancing the fibre digestibility of poor quality crop residues.

Suppression of methane production: *In vitro* gas production test revealed that methane suppression among the tree leaves ranged from 4.6 to 82% — minimum recorded in jatropha leaves (4.6%) that contained lowest tannin and the maximum (82%) in *Ficus bengalensis* leaves. Commonly used top feeds like *Sesbania grandiflora*, *Glyricedia maculata*, *Ficus mysorensis* and *Ficus religiosa* leaves showed a methane suppression ranging between 35 and 50%. A mixture of three plant species having anti-methanogenic activity *in vitro*, exhibited 12% reduction in methane emission in crossbred calves, which confirmed that there is a potential in using tree leaves for reducing methane production from enteric fermentation.

Use of fungi for enhanced digestibility of straws: Lignin content of *ragi* straw decreased with all the white rot fungi, viz. *Phanerochate chrysosporium*, *Pleurotus sajorcaju*, *Pleuritous ostreatus* and *Vorialla voloraceae*. High protease activity was observed during the first two days of fermentation after which it declined, and lignolytic enzymes, viz. laccase, manganese peroxidase and lignin peroxidase concomitantly increased up to the fifth day of fermentation. *Phanerochaete chrysosporium* showed the best potential in improving the digestibility of *ragi* straw followed by *P. ostreatus*.

Antifungal property of medicinal/aromatic plants: Melissa and thyme leaves exhibited good anti-fungal activity (>50%) against *Aspergillus parasiticus*. *Pachouli* leaves, curry leaves, rosemary leaves, cinnamon leaves, *sarpagandha* leaves, thumbe leaves, sweet worm wood leaves, *aswagandha* leaves, chicory powder, yellow oleander leaves, *Selastras paniculatus*, *Tinospora cardifolia*, railway creeper and Indian acalypha leaves showed high anti-fungal activity (>50-90%) against *Fusarium moniliforme*.

Energy supplementation for higher milk yield

Strategic supplementation of *ragi* (*Eleucine coracana*) grain to dairy cows during their early to mid lactation period resulted in increased milk production (average 1.9 litre/cow/day) and fat and SNF percentage (average 0.2-0.3%) and also reduced the milk urea content with a net increase in income of about Rs 19/cow a day under field conditions.

Buffalo

Nutrition for the onset of puberty: GnRH challenge studies in the calf attaining maturity at 3 years of age due to nutritional perturbation showed immature status of hypothalamo-hypophyseal-ovarian axis even at the age of 2 years 4 months.

Nutritional modulation of IGF: In sub-fertile male buffaloes nutritional modulation of IGF-I (as a mediator of metabolic hormonal effects) proved beneficial for various sperm functional attributes *in vitro*. The cleavage rate in embryos produced through IVF using such sperms, was also better.

Area specific mineral mixture: Supplementation of area specific mineral mixture (Ca, P, Zn, Mn, Cu) to buffaloes based on the deficiency in the North east zone of Haryana, improved productive and reproductive efficiency

as 70% buffaloes showed normal cyclicity, and 10% increase in milk production. Supplementation of area specific mineral mixture pellets @ 40g daily in cattle and buffaloes during lactation stage increased milk yield by 10-15%, brought cows into estrus within 30-45 days, and reduced the problem of skin keratinization.

Detection of pesticide residues: A rapid multi-residue method for analysis of neonicotinoid pesticides, viz. imidacloprid, acetamiprid and thiacloprid, was developed. The percent recovery from 0.5 to 2.0 ppm concentration varied from 95.6 to 81.17% for imidacloprid, 92.76 to 84.99% for acetamiprid, and 96.96 to 88.50% for thiacloprid with a detection limit of 5ppb, 10ppb and 20ppb, respectively.

Fibre digestibility: Isolates of anaerobic fungi collected from 5 different states and 6 different host species, revealed that isolates from Rajasthan had highest fibrolytic potential and the best isolate improved digestion of wheat straw in buffaloes.

Improving reproductive efficiency

- Buffalo embryos were produced *in vitro* @ 64% cleavage with 20% blastocyst using an improved IVEP protocol.
- A three dimensional (3D) collagen gel culture system for the *in vitro* growth and survival of the buffalo preantral follicles with IGF-I was developed.
- Early diagnosis of pregnancy (by day 20-21 post-breeding) was facilitated by using real time B-mode ultrasonography in goats and buffaloes.
- Bull-biostimulation curtailed the incidence of silent ovulation and service period and increased conception rate in post-partum buffaloes.

Enhancing productivity: Strategic supplementation of protein (<20% CP) during mid-lactation increased productivity of buffaloes. Vitamin E supplementation @300 IU daily was optimum to improve weight gain, and increased its concentration in the muscles of buffaloes.

Early embryonic mortality: Dynamic status of antioxidant enzymes in relation to the stages of oestrous cycle and tissue remodeling was observed. Effective modulation of prostaglandin production by the uterus may rescue corpus luteum and prevent early embryonic mortality.

Improvement of reproductive efficiency: Insemination dose could be reduced from 25 to 15 million spermatozoa without adversely affecting the conception rate. The results are being authenticated with more trials in farmers' herd. Frozen semen samples were evaluated for sperm motility attributes. Bulls with higher field conception rates also had higher sperm total motility, progressive motility, rapid motion and viability.

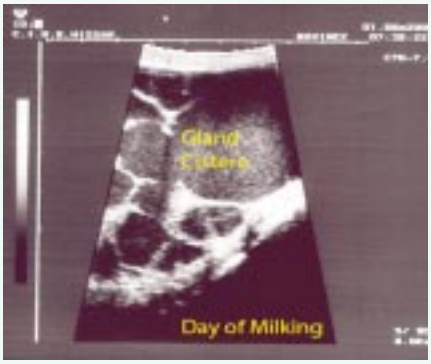
Sheep

Trace element status: Biochemical markers (Cu and Zn-dependent enzymes – ceruloplasmin and Cu/Zn- super oxide dismutase) were evaluated to assess the trace element (copper and zinc) status in sheep at different dietary levels of Cu and Zn. Prediction equations developed by correlating the absorbed Cu and Zn with Cu- and Zn-dependent enzymes; plasma Cu and Zn with Cu and Zn-dependent enzymes; liver tissue concentrations of Cu and Zn with absorbed Cu and Zn, revealed that Cu and Zn status of animals could be assessed by using these enzymes as biochemical markers.

Production performance: Bharat Merino and Gaddi Synthetic sheep under migration to highland pastures gained higher body weights and produced

Induction of lactation

Infertile Murrah buffaloes were treated with subcutaneous injections of estradiol-17 and progesterone for 7 consecutive days, and supplemented with largectil and dexamethasone at specific intervals for induction of lactation. One week of udder massage was given twice daily till the udder was turgid with milk, followed by milking, which started from day 21. Milk from induced-lactating buffaloes became normal within 10-15 days after start of milking. Four of the six treated buffaloes responded successfully and milk became normal between 4-20 days of the start of milking. The fat content stabilized at 7.72±0.3% after about 10 days of first milking. In successful cases, the peak milk yield between 20th and 75th day ranged between 2.5 and 7.0 kg/day. The effect of treatment for induction of lactation — which comprises sex steroids — was also assessed on the ovarian activity of treated



buffaloes. Ultrasonographic scanning revealed that pre-treatment ovarian follicular size of 7-13 mm, regressed to 2-3 mm within 8-10 days of start of the treatment and then no follicular activity was observed for 30 days during treatment. First ovulation took place between 55 and 60 days after treatment. In two buffaloes, follicular cysts of up to 35 mm diameter were detected.

Production and reproduction performance in sheep

The spent sheep after completing productive life constitute more than 30% of meat produced in the country. Pre-slaughter feeding of *ad lib.* concentrate mixture in spent ewes for 45 and 90 days improved body weight gain by 10-11kg. Supplementation of mineral mixture in sheep flocks maintained on degraded rangeland of semi arid Rajasthan brought anoestrus sheep into estrus after 15-20 days of supplementation.

Prototypes of vaginal speculum and plunger of different dimensions, suitable for transcervical insemination of Malpura sheep were fabricated from plastic and nylon material for successful transcervical insemination. Three different protocols for producing synchronized lamb crops were perfected, and the study indicated that ovagen alone and in conjunction with progesterone enhanced lambing in sheep.

more wool in comparison to stationary flocks.

Utilization of fibrous crop residues: Fortification with cellulase, xylanases, pectinase, phytase and protease enzymes enhanced dry matter digestibility by 7.00%, cell wall digestibility by 25.00%, and the end product fermentation by 15.00% of poor quality roughages. Supplementing probiotics of microbial origin like *Saccharomyces cerevisiae*, *Saccharomyces uvarum* and *Kluyveromyces marximanus* and a mixed yeast culture of above three in a ratio of 1:1:1 as microbial probiotics in lambs showed that *Saccharomyces cerevisiae* strain is superior in improving the growth of lambs.

Bioavailability of nutrients: Diets supplemented with condensed tannins improved nutrient utilization, immune response besides protection from GI parasites and fasciolosis in sheep.Supplementation of *Tinospora cordifolia* as a functional food imparted positive influence on the nitrogen metabolism and antioxidant levels in seminal plasma besides significantly improving the erythrocytic antioxidant status and cell-mediated immune response of adult Muzzafarnagari rams. Undecorticated jatropha (*Jatropha curcas*) meal after processing with 1% common salt and 0.5% lime, could replace protein of conventional oil cakes up to 25% in the concentrate mixture of adult sheep and goat for short-term feeding,

Goat

Standardization of* in vitro *fertility test

Hypo osmotic swelling test (HOST): Sperms were evaluated for strongly coiled, weakly coiled and non-coiled under oil immersion lens. The best swelling in terms of strong coiling and total coiling was in 75-mosmol hypo- osmotic solution. There was significant difference in swelling in different

Cylindrical sponges showed maximum retention

strengths of hypo osmotic solution. For frozen sperm 75-mosmol and for fresh diluted semen 100-mosmol hypo-osmotic solution was found to be the best.

Dual staining test: Dual staining technique was standardized for testing viability and acrosomal integrity in frozen and fresh semen. It saved time and chemicals in testing viability and acrosomal integrity thereby avoiding separate tests.

Semen quality: Twice a week semen collection, evaluation and freezing in Jamunapari bucks of 2-5 years of age group, indicated that the semen production was higher under intensively reared bucks compared to the semi-intensively managed bucks.

Rapid estrus detection methods: Sponges of different sizes and shapes were tested for their retention in vagina for 12 days in Sirohi goats for estrus detection. Circular sponges with a diameter of 30 mm and cylindrical shaped sponges with a diameter 25 mm had the highest percentages (>83%) of retention.

Mithun

Feed blocks with locally available feed resources: Feeding of *Lagerstroemia speciosa* tree leaves based complete feed blocks to mithuns showed that the tree leaves could be incorporated in the ration up to 30% for feeding mithuns under semi-intensive or intensive system.

Organic fertilizer: The excreta (faeces and urine) of both mithun and Tho Tho cattle were compared as a source of organic fertilizer. The quantum of faeces voided from mithun was more than that of Tho Tho cattle though faeces of Tho Tho cattle contained less water (more DM) compared to that of mithun. The chemical composition of faeces of mithun and local cattle did not differ significantly. Mithun produced more urine than Tho-Tho cattle. So per animal basis,

mithun supplied more excreta as organic fertilizer than Tho-Tho cattle in Nagaland.

Bakers yeast: Feeding bakers yeast (*Sacharomyces cerevisiae*), a probiotic on roughage based diet, significantly increased average daily gain of mithuns, intake of concentrate and roughage and also improved FCR.

Estrus synchronization protocols: Experiments conducted to synchronize estrus in cyclic and post-partum mithun cows showed more prominent behavioural signs of estrus than spontaneous heat. Application of CIDR on day 45-50 after parturition, induced first postpartum estrus immediately after uterine involution (day 53-58 post parturition). Unlike other bovines, mithun cows exhibit first postpartum estrus at around 97±19.6 days postpartum. Use of CIDR was advantageous in terms of prominent behavioural signs of estrus thereby ease in detection of estrus. The first calf was born from an anoestrus mithun cow synchronized with CIDR.

Hormone-induced maternal behaviour: Mother-neonate bonding was studied using oxytocin intranasal spray. Intranasal administration of oxytocin effectively induced maternal behaviour in primiparous bovine heifers where maternal behaviour was blocked chemically.

Embryo transfer technology: Estrus synchronization was performed by using CIDR protocol and four embryos (compact morula) were recovered successfully from two donors and subsequently transferred into three recipients.

Yak

Trace mineral supplementation: Soil, feeds and fodders of yak rearing zones are deficient in micronutrients, as reflected by the low productive and reproductive performances of yak. Supplementation of trace minerals like Zn, Cu, Co and Mn in the ratio of 40:20:2:1 along with the basal diet significantly increased milk production.

Production performance during winter: Body weight gain was significantly higher during October in calves but from November onwards no significant increase was observed. Bulls gained significantly higher body weight compared to calves up to December. The lactating yak cows lost about 5.84% of their body weight, and milk yield reduced mainly due to shortage of feed and fodder during long winter. Providing adequate nutrition during winter could help in ameliorating winter stress in yaks.

Modified temperature humidity index: Yaks were comfortable at THI of 52 and when THI exceeds 52 yaks experienced heat stress, as expressed through increased physiological responses.

Poultry

Stress related hormone: Under heat stress condition some of the lymphocyte proteins were repressed whereas some others were induced in broiler.

Bioavailability of micronutrients: Se supplementation in broiler chicken diets at 0.15 or 0.30 ppm complemented bioavailability of Zn. In contrast, Se antagonized retention of Mn, Cu and Fe in liver tissues. Se (0.15 ppm) and Zn (80 ppm) improved humoral and cell-mediated immune response in broiler chicks. Zn uptake by tissues was relatively more active during early age (2 week) than at later ages (4 and 6 week), whereas Se retention in tibia and liver was higher at 4 and 6 weeks than that at 2 weeks of age.

Se inclusion in broiler chick diets from 0.15 to 1.35 ppm linearly enhanced its retention in bone and liver tissues and complemented Zn uptake by tissues. Both Cu and Fe responded negatively to Se increases in diets at 5 weeks of age. Vitamin E at 40 IU enhanced Se uptake by bone, but did not influence retention of Zn, Mn, Cu or Fe. Moderate levels of Se (0.15 or 0.45 ppm) and vitamin E at 40 IU produced higher antibody titres, better cell-mediated immune and reduced stress in 5-week-old broilers.

Enhancing utilization of macronutrients: Protease enzyme produced from *Bacillus licheniformis* were supplemented to broiler diets @ 4,000 IU/kg to enhance the feeding value of commercial meat meals and soybean meal low in protein by 3-4% over the recommended level (22%). Meat meal diets responded better to protease supplementation and performance of broilers was equivalent to the control group that was maintained on 22% protein diet. Inclusion of enzyme had

Nutrient requirements of rural poultry

Ca and NPP levels in diet could be reduced to 0.6 and 0.3%, respectively, by maintaining the vitamin D_3 level at 1,200 IU/kg diet in Vanaraja female parent. The effect of interaction between Ca and NPP on performance and bone mineralization of Grampriya chicks during nursery (rearing period of 1 to 42 days) suggested that 0.6% Ca and 0.30% NPP were adequate.

Krishibro chicks responded positively to dietary energy levels (2,900 and 3,000 kcal ME/kg) in starter and finisher phases, respectively. The requirement of Ca, and NPP for dressing yields and bone mineralization in Krishibro chicks appeared to be equal/higher than 0.6 and 0.3%.

Carbohydrate in combination with fat produced better effect on body weight of broiler chickens than combination of fat and protein as chicks could utilize carbohydrate better than fat during initial post hatch period.

significant impact on different production parameters compared to non-supplemented diets, particularly when dietary protein levels were lower than the recommended levels.

Female reproductive system of *desi* fowls: Ovary and oviduct development was noticed clearly around 16 to 18 weeks of age in White Leghorn (WLH), around 20-22 weeks of age in Kadaknath (KN) and around 24 weeks in Aseel peela (AP). At the peak of sexual maturity, around 30 weeks of age, total length of the oviduct was greater in WLH (73 cm) as compared to *desi* fowl (66 cm). The transaminases activity of blood plasma, irrespective of breeds increased linearly with age. An increased pattern of ACP, GOT and GPT activity was found associated with maturation of female reproductive tract and reverse was true with ALP activity among all the breeds.

Enhancing egg production: Using simple feed formulation, egg production could be enhanced markedly over the age of 78 weeks in Aseel peela *desi* fowl. Large-scale replications at institute and field level are being taken up to validate the data.

Supplementation of melatonin: Dietary inclusion of aflatoxin @0.15 ppm level adversely affected body weight, feed intake and FCR and caused lipid peroxidation with simultaneous depletion of antioxidant enzymes (superoxide dismutase and catalase) in broilers. Melatonin supplementation @ 40mg/kg feed alleviated the adverse effect of aflatoxicosis at lower levels (<0.15ppm).

Moulting for enhanced production: Birds were force moulted by feed withdrawal method for 10 days. As the period of fasting progressed from 0 to 10 days a gradual but steady reduction was noticed in the levels of serum triglycerides, which was more pronounced and significant from the fourth day of commencement of feed withdrawal. A similar decline in serum total cholesterol concentration was noticed, which became very apparent from the sixth day after feed withdrawal and a reduction of 30% in total cholesterol concentration was achieved by the tenth day in the moulted hens. In contrast, serum HDL–cholesterol concentration progressively increased during the feed withdrawal period and peaked around the eighth day after withdrawing feed. Accumulation of high lipid in uterus in late laying age results in either shell less or poor shelled eggs. Feed withdrawal for longer period leads to mobilization of lipids from uterus.

Quail semen characterisation: Physical and biochemical characteristics of quail semen showed that birds having larger cloacal gland size ejaculated higher volume of semen and semen production was higher in CARI Uttam than CARI Sweta quails. Mass sperm motility in neat semen was only 50-60% immediately after collection that decreased continuously and reached to zero after 30 min. Sperm abnormalities were higher in CARI Sweta than CARI Uttam. Among the enzymes LDH was exceptionally high in all groups in both the lines, cations sodium and potassium were higher in birds having larger cloacal gland size whereas magnesium and calcium were more in the seminal plasma of birds with smaller cloacal gland. Methylene blue reduction time test revealed that quail spermatozoa are more active than chicken.

LIVESTOCK PROTECTION

A status of freedom from contagious bovine pleuropneumonia infection in cattle and buffalo was obtained from OIE.

Development and improvement of diagnostics and vaccines

Vaccines

- A low volume saponified haemorrhagic septicaemia vaccine was found safe and effective in farm cattle.
- Possibility of DNA vaccine construct against bovine brucellosis was ascertained.
- Chicken cytokine genes (MIP-□, lymphotactin and IFN□) were expressed in mammalian cells thereby opening up the possibility of their use as genetic adjuvant in DNA vaccine.
- LPS and genomic DNA containing CpG from *Salmonella* Gallinarum activated the innate immune system of chickens and gave higher protection after immunization with inactivated NDV in challenged birds.
- Conjugation of Fc with flagellin protein was a good model for efficient antigen delivery resulting in higher immune response than antigen alone.

Diagnostics

- A nested RT-PCR was developed using primers from RNA dependent RNA polymerase region for differentiation of ruminant pestiviruses.

Exotic and emerging diseases

BVDV-1 was identified in yaks of Himalayan region. Phylogenetic analysis established prevalence of BVDV-1b and 1c subtypes in Indian buffaloes and existence of close relationship between cattle and buffalo BVDV-1b viruses.

The phylogenetic analysis of avian influenza virus indicated that the virus might have been introduced into India through migratory birds.

The Indian isolate of PCV1 was found genetically closely related (0.6%) to isolates from China, USA, France and distantly related (1.4%) to the isolates from Taiwan.

- C18L gene based conventional PCR and TaqMan probe based real time PCR were developed for specific detection of buffalo pox virus.
- Duplex PCRs were developed for specific detection and differentiation of buffalo poxvirus from other orthopox viruses, and camel pox from other orthopox viruses.
- C18L gene-based real time PCR was standardized for quantification of camel poxvirus in clinical samples.
- A hybridizing probe based real-time PCR was developed for diagnosis of PMWS and the disease was diagnosed in four private farms in Uttar Pradesh.
- The expressed protein of N gene of PPR virus could be an alternative to whole virus antigen in sandwich ELISA for diagnosis of PPR.
- Developed indirect ELISA for serodiagnosis of Japanese encephalitis in pigs.
- Transformed fibroblast antigen was much superior antigen for detection of anti-avian leucosis virus antibodies in the serum samples of chicken, as compared to gsAg, as determined by an indirect ELISA.
- A highly sensitive PCR targeting new gene of *Mycobacterium a. paratuberculosis* and a quantitative real-time PCR (RT-PCR) were developed for the diagnosis of paratuberculosis in small ruminants.
- Serotype specific PCR was developed for detection of *Salmonella* Typhimurium and *S.* Enteritidis.
- Duplex PCR was developed for simultaneous detection of *Salmonella* genus and Typhimurium serotype.
- Germ tube formation test was developed for detection of chlamydospore in *Candida albicans.*
- Methodology for quick detection of *Echinococcus granulosus* genotypes by polymerase chain reaction coupled with restriction fragment length polymorphism was developed.
- A useful primer was developed and found effective in differentiating cryptic stage of *Echinococcus granulosus* and *Taenia.*

Molecular characterization of pathogens/receptors

- Mutants of *E. granulosus* isolate from Indian cattle and buffalo origin, were detected on the basis of sequence analysis of mitochondrial gene and non-coding spacer gene.
- Molecular characterization of toll-like receptors (TLR2, and TLR4) of *nilgai* revealed higher expression in skin and immune cells of *nilgai*, as compared to buffalo indicating stronger innate immunity.

Herbal medicines

- Immunomodulators prepared with extract of *Tinospora cordifolia* and a probiotic (*Mycobacterium phlei*) showed significant body weight gain in broiler birds and improved their health.
- Significant antidiarrhoeal activity was detected in the seed extract of *Caeslipinea bonducella.*

Surgical and clinical interventions

- The epoxy-pin external skeletal fixation technique was developed, and used to treat a variety of compound fractures of different long bones in small animals.
- A novel design of bilateral external fixator having opposite threadings in the side bars was developed for the management of long bone fractures in large animals.
- Transplantation of autologous bone marrow cells, along with hydroxyapatite induced faster healing of radius fracture in rabbits, as compared to transplantation of hydroxyapatite alone.

SUCCESS STORY

Cell culture vaccine for classical swine fever

Classical swine fever or hog cholera, the most important disease of pigs that causes death in 98 to 100% cases in susceptible populations, result in economic losses of around Rs 500 crore in India. Presently, vaccination is done with a lapinized vaccine that requires killing of rabbits for its manufacture. Since cell culture vaccine is not available in India for protection of pigs against classical swine fever, the Indian Veterinary Research Institute, Izatnagar, developed an effective PK-15 cell line-based live attenuated freeze-dried vaccine. Field validation of the cell culture vaccine on pigs revealed that immune response of the vaccine was highly satisfactory. Vaccinated pigs sero-convert from 21-30 days of vaccination. The vaccine has a shelf life of more than one year and provides immunity for at least a year following a single vaccination after weaning. It is safe, potent and can be applied even during pregnancy and there has been no report of any untoward post-vaccination reactions.

The newly developed vaccine is cell culture based and its production is easier and low cost as compared to the existing lapinized vaccine. Hence there would be a good demand for the product in market. Supply of country's demand of approximately 20 million doses of the vaccine seems possible by use of this cell culture vaccine. This would help in reducing the losses due to mortality and thus improve the economic condition of poor pig farmers in the country.

- Application of autologous bone marrow cells subcutaneously in the periphery of incisional and open cutaneous wounds induced faster healing, as compared to conventional antiseptic dressing of wounds.

Foot-and-mouth disease

Field samples (1,313) received from various states during the year were processed and subjected to sandwich ELISA for type identification. Only 705 samples were typed — 567 samples were typed as O, 58 samples as type Asia1, and 80 samples as A —, and no virus could be detected in rest of the samples. Samples were also processed in BHK 21 cells and virus could be recovered in 119 field samples comprising 24 type Asia 1, 75 type O and 21 type A.

To improve the diagnosis of FMD in suspected clinical samples, a multiplex PCR (m-PCR) was developed and evaluated. Using the test, 42% of the outbreaks that went undiagnosed using ELISA, were identified indicating that mPGR could be used as best supplentary to ELISA to increase the percentage of FMD outbreak diagnosis in the country.

Two-dimensional micro-neutralization test (2D-MNT), a modified form of SNT, was routinely used to test new field isolates to determine the appropriateness of the existing vaccine strains and to select new vaccine strains, if required. In serotype A the most worrying factor, which merits attention is the antigenic heterogeneity of the isolates. In the sense some strains show close antigenic match to the current vaccine strain (17/82) and others to the new strain (IND40/00) in *in-vitro* micro neutralization test. One isolate IND 53/08 from Chhattisgarh, was unique both antigenically and genetically forming a separate cluster with another isolate IND 109/06 from Chhattisgarh.

Among all serotypes prevalent in India, type A virus population is genetically and antigenically most heterogeneous in nature. VP1 coding (1D) region based molecular phylogeny has established circulation of four genotypes of type A so far in India. There is once again an upsurge in incidence of outbreaks due to lineage genotypes VII with amino cicer (aa) deletion at 59th position of VP3. This single aa deletion is at an antigenically critical position in structural protein VP3, which is considered to be a major evolutionary jump probably due to immune selection.

Field isolates (17) of serotype A recovered from outbreaks in Karnataka, Tamil Nadu, Chhattisgarh, West Bengal and Haryana were sequenced at 1D (VP1) region for molecular epidemiological analysis. The determined sequences were aligned with other Indian sequences and some of the retrieved exotic sequences. All the isolates clustered within genotype VII in the N-J tree. Genotype VII is restricted to only India as none of the exotic sequences clustered in this group. Thirteen out of the seventeen isolates sequenced, clustered in the deletion group. 1D region based phylogeny also revealed that this lineage is genetically diverging with time giving rise to three lineages (VII b, f and g) so far.

In serotype O, PanAsia II strains dominated the outbreaks, nevertheless Panasia I and II 2001 also co-circulated. Asia 1 field isolates (19) were subjected to 1D gene sequence analysis. The isolates were grouped with lineage CI that dominated Asia 1 outbreaks. The isolates of 2007 and 2008 showed 15.4 to 16.7% and 12.4 to 14.7% divergence at nucleotide and amino acid level, respectively, from in-use vaccine strain (IND63/72).

The Central laboratory, Mukteswar, contains 1,402 (893-O, 261-Asia 1, 233-A, 15-C) field isolates. Pre- and post-vaccinate serum samples collected up to sixth phase of FMD-CP showed increased levels of protective antibodies against serotypes O, A and Asia 1 over different phases of vaccination.

SUCCESS STORY

Rapid immunoassay kit for serological monitoring of infectious bursal disease of chickens

Infectious bursal disease also known as Gumboro disease, a highly contagious viral disease affecting young chickens, 3 to 6 week-old, has worldwide occurrence. Morbidity of the disease is high with mortality usually of 0-20%, but sometimes up to 60%, thus adversely affecting the economy of poultry industry.

Serological diagnosis of the disease is either labour intensive, slow or require sophisticated equipment. A need was felt to replace these laboratory tests with a simple pen side test. A recombinant protein produced from a heterologous expression system was used as a diagnostic antigen in a simple field assay format. The developed protocol allows the user to rapidly interpret the immune/disease status of the bird by a simple agglutination phenomenon of antigen-coated beads with naked eye within 5 min. This in turn, helps the farmers and poultry breeders in determining the time of vaccination of the chicks. Test results are comparable with agar gel precipitation test and enzyme linked immunosorbent assay under test conditions

The kit has been validated under laboratory conditions from different parts of the country and the technology was transferred to National Research Development Corporation, New Delhi, for further commercialization. The developed kit would help in minimizing the time required for diagnosis and develop judicious vaccination scheduling.

Animal disease monitoring and surveillance

A large databank on the livestock diseases of the country, based on reports submitted to the Government of India by various state governments was developed at the PDADMS. The institution was involved in the sero-monitoring of rinderpest. Large number of sera samples from various parts of the country is maintained in the National Livestock Serum Bank for retrospective studies.

- An offline version of the databank of livestock diseases of the country was developed. Based on the custom queries, various epidemiological analyses are possible e.g., frequency of disease occurrence, top diseases of the country, eco-patho zones. The spatial and temporal analysis of animal disease data is being carried out using this software.
- Molecular diagnosis of brucellosis was standardized that helped in differential diagnosis of *Brucella abortus* and *B. suis*. Based on the results of the serological, biochemical and molecular techniques a rare case of brucellosis in swine due to *B. abortus* was diagnosed. A standardized A-B ELISA kit for the detection of bovine *Brucella* antibodies was developed. An indirect ELISA kit was standardized to identify the magnitude of disease in ovines. Molecular epidemiological studies are being standardized to diagnose and differentiate the brucellosis of cattle, ovine, caprine and humans. Tests were developed to detect the etiological agent directly from the clinical samples such as aborted foetus, placenta and uterine discharges.
- A multiplex PCR was standardized to diagnose the pathogenic leptospira. A repository of the leptospira isolates is being maintained.
- Molecular studies on BHV-1 were carried out. A multiplex PCR for detection of BoHV-1 sequences was standardized. The PCR amplified products of gB (293 bp), gC (173 bp), gD (343 bp) and US 1 (464 bp) were subjected to partial nucleotide sequencing and aligned with different reference sequences of respective genomic regions.
- The PCR amplification of different 'tk'genomic region of BoHV-1 was standardized and the PCR amplicons thus obtained were confirmed using unique restriction enzyme. Multiple PCR using different combinations of primers specific for gB, gC and gD was standardized and was applied for screening of field samples. The partial nucleotide sequencing of gB, gD and US 1 were aligned with the reference sequences, and was analyzed with phylogenetic trees. These results would be of much help in profiling and characterizing BoHV-1 in livestock population.
- The serum samples obtained from Madhya Pradesh, Maharashtra, Andhra Pradesh, Manipur, Kerala, Orissa, West Bengal and Tamil Nadu, were screened for the presence of antibodies against IBR, using AB-ELISA kit and 41.90% of the samples were found positive for IBR antibodies.
- An mPCR for genome detection of leptospira, BoHV 1 and *Brucella* using known standards targeting the LipL32 gene of *Leptospira*, gB gene of BoHV 1 and bcsp31 gene of *Brucella*, was standardized.
- Occurrence of zoonotic bacterial pathogens from the livestock and livestock products was studied. The pathogens were isolated from various sources, and their molecular characterization was completed.
- A computer interface based BHV-1 whole antigen AB ELISA was developed as per the standards of IAEA, standardized and validated. The kit was critically evaluated both in-house and extensive field trials for detection of antibody to IBR virus in bovine serum. This test is highly sensitive, specific, economical and user friendly.
- A kit to detect the antibodies to *Brucella* in swine is being developed and is in the process of standardization.
- A PCR technique was developed to detect the carrier status in domesticated animals. A pair of primers specific to VSG gene of *Trypanosoma evansi* was developed. The PCR technique was standardized and 400 bp amplicon of VSG gene was obtained from the genomic DNA isolated from the blood of *T.evansi* infected experimental animal. Field validation of the technique is in progress.

Intensive expert system on animal diseases

A web based interactive expert system on animal diseases of the country was developed, and it can be accessed at www.nadres.res.in. It depicts national livestock statistics, animal diseases statistics, eco-patho zones of important livestock diseases, epi-reports and the animal disease forecasting. Based on the dynamic factor, frequency of occurrence of diseases, and the static factor, various precipitating factors, an interactive web service was designed. The user can know the probable occurrence of a particular disease in any district of the country by feeding the name of the state and district of his choice. This service is useful to researchers and particularly to the planners to implement the disease control measures well in advance.

- Serum Bank facility has more than 170,000 serum samples from all over the country, which is being used for long-term national surveys on various diseases of economic importance.
  - Development of relational database on Animal Health Information System
  - Development of *India.admasEpitrak* – a relational animal health information database software
  - Development and launching of National Animal Disease Referral Expert System
  - Identification of disease specific Eco-patho zones in the country
  - Providing eco-pathozones and spatial and temporal occurrence of diseases for effective vaccination and control of important diseases in different states e.g. PPR in Andhra Pradesh and Karnataka, Brucellosis in West Bengal and Andhra Pradesh, FMD, PPR, HS and BQ in Maharashtra, Andhra Pradesh and Karnataka.
  - Providing the logistic support to national network projects like bluetongue and HS projects for disease monitoring and surveillance.

Bluetongue

A repository of blue tongue virus isolates BTV-1 (2 isolates), BTV-2 (4 isolates), BTV-9 (3 isolates), BTV-15 (5 isolates), BTV-18 (4 isolates) and BTV-23 (7 isolates) from Izatnagar, Hyderabad, Parbhani, Kolkata, Parbhani, Hisar and Chennai, was made. No outbreak of bluetongue was recorded in the country except Andhra Pradesh, Karnataka and Tamil Nadu. Disease forecasting model was developed. The incidence was as high as 95.5% sheep from Uttarakhand; 88.6% cattle from Panjab; 63.8% goat and 55.6% sheep from Manipur; 50.0% sheep from Jammu and Kashmir; and 18.22% goat from Delhi. A VP7 gene incorporated recombinant antigen based indirect ELISA kit was developed for detection of group specific antibodies in the sera.

Inactivated pentavalent bluetongue vaccine was evaluated at different places particularly in the bluetongue affected states. Vaccine was satisfactory except a nodule formation at the site of inoculation.

Type specific primer designing, VP2, VP5 and VP7 gene cloning and expression, multiplex RT-PCR for BTV, RNA-PAGE and nucleotide sequence studies, were standardized. Confirmation of virus isolates was done by RT-PCR using VP7 gene specific primers.

Haemorrhagic septicaemia

Isolates (93) of *Pasteurella multocida* were characterized and a new serogroup E of *Pasteurella multocida* was identified first time in the country. Most of the *Pasteurella multocida* isolates were sensitive to enrofloxacin, ofloxcin chloramphenicol, doxycycline and resistant to vancomycin, bacitracin, and sulphadiazine. Molecular characterization of different isolates of *Pasteurella multocida* recovered from different species of animals and poultry were carried out by PM-PCR, HSB-PCR, multiplex-PCR, ERIC-PCR and REP-PCR. A low volume saponified HS vaccine was validated successfully in farm cattle, and it was found satisfactory. The OMP vaccine against *P.multocida* type A in ducks provided higher protection as compared to the bacterins. The biofilm vaccine against *P.multocida* type A of sheep origin was prepared and compared with the whole cell vaccine, and it produced higher immune responses on using montanoide oil adjuvant. Economic loss of more than Rs 225 million was estimated due to haemorrhagic septicaemia in cattle and buffalo.

Ethnovetrerinary medicine

Concomitant use of hydromethanolic (1:1) extract of fruit pulp and seeds of tamarind (*Tamarindus indica*) at different doses reduced F concentration in blood and bones and enhanced urinary excretion in rats indicating the ameliorative potential of tamarind fruits in fluoride toxicity. Testing of bio-fractions A, B and C, revealed that fraction B and C reduced the fluoride, whereas fraction A showed antibacterial activities. An indigenous herbal teat dip was developed for effective control of mastitis and the same is being cross validated to facilitate patent**.** *Azadirachta indica* stem extract effectively treated sub clinical mastitis, and for it standardized dose of *A. indica* stem extract was established. An alkaloid isolated from test herb ANAND-EVM-NW-4 revealed antibacterial efficacy against common isolates from field cases of mastitis. Ethanolic extract of AAU-EVM-NW-3 showed potential effects @ 500 and 750 mg/kg p.o. in clinical case of fasciolosis in ovines, and 7.5% ointment of AAU- EVM –NW-2 was effective in *Psoroptic* mange in rabbit (*Oryctologus cuniculus*). Toxicity testing of all the effective herbs established their safety.

Gastrointestinal parasitism

In Rajasthan software 'FROGIN' was evaluated for forecasting of gastrointestinal (GI) nematodosis in semi-arid and arid regions. It gives results as predicted faecal egg counts (FEC) on start of month, intensity of FEC for next 60 day and pasture larval burden for that month. The Garole sheep was not found completely refractory to infection of *Haemonchus contortus*. *Haemonchus, Bunostomum, Nematodirus* and *Oesophagostomum* spp. were found in all the zones in Sikkim. 170 kDa polypeptide of larval antigen of *H. contortus*

was recognized by 4 day sera (prepatent sera) of sheep in western blotting. Zymogram studies revealed that 120 and 170 kDa polypeptide belonged to metalloproteases based upon protease inhibitor studies. In the ES product, cysteine protease and GST (glutathione-S-tranferase) were identified, which are of immunodiagnostic and immunoprophylectic value. In *H.contortus* ES antigen 30-32 kDa polypeptide showed protease activity, which was inhibited by E–64 confirming it to be a cysteine protease. GST was confirmed in western blotting utilizing anti-GST antibody. ES antigen was better than gut antigen of *Ascaris suum.* Dipstic ELISA was comparatively found more efficient than plate ELISA. No correlation could be established between worm burden and antibody titre in naturally infected sera of pig with *A.suum.* Immunodominant polypeptide in *Bunostomum* and *Oesophagostomum* spp. was identified, and a diagnostic kit for serodiagnosis was developed and revalidated. Allele specific PCR was applied to field population of larvae for detection of benzimidazole resistance and was compared to FECRT and EHA. Frequency of BZ-rr (homozygous BZ-resistant) larvae in population ranged from 73.39 to 100% in Northern Rajasthan. Effect of *Fec* B gene on resistance to GIN was conducted in sheep naturally infected with GINs. Lower incidence was observed in Garole sheep. H-11 and H-gal-GP polypeptides of *H. contortus* are being utilized for immunoprophylaxis and studies on H-gal-GP were completed. In H-gal-GP of *H. contortus* MEP-2 fragment showed 94% homology to other international strains.

Equines

Nation-wide active equine disease surveillance, sero-survey was conducted at Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, and Jammu and Kashmir. Antibodies to EHV-1 were detected in 7.1% samples, *Babesia equi* in 24.3% sera tested, and Japanese encephalitis in 5.5% serum samples tested. None of the serum samples tested was positive for equine infectious anemia, African horse sickness, equine influenza and *Salmonella* Abortus-equi. Outbreaks of glanders reported from Uttarakhand, Andhra Pradesh, Himachal Pradesh and Haryana were investigated and diagnosed, and etiological agent *Burkholderia mallei* was islolated. Comparative sero-prevalence of JE in different animal species (equine, cattle, buffalo, pigs) was done in different regions of Haryana and highest incidence was in buffaloes followed by pigs, horses and cattle. EHV-4 virus was isolated from 11 out of 138 samples using equine embryonic lung cells. These results were confirmed by sequencing of PCR products. The centre succeeded in *in vitro* cultivation of bloodstream forms of *Trypanosoma evansi.* The characterization of *T. evansi* antigen by SDS-PAGE of sonicated antigen revealed five major polypeptides in the molecular weight range of 41-81 kDa and proteins of 35-41 kDa exhibited proteolytic activity. Serum neutralization test (SNT) and haemagglutination inhibition (HAI) were standardized for specific differentiation of two related arboviruses i.e., Japanese encephalitis (JE) and West Nile virus (WNV). On comparison sensitivity of HAI was 96.29% and specificity 100% in comparison to SNT. RT-PCR using E-gene (291 bp) was also developed for diagnosis of JE in equines.

An ELISA was developed for detection of *Babesia equi* specific antibodies. The sensitivity and specificity of the ELISA in comparison to commercial CI-ELISA was 94 and 96%, respectively. To study the polymorhphism of the MHC class II gene in Marwari horses, regions of MHC class-II (DRB-2a and 2b) gene fragments of 276 bp and 229 bp were amplified. Restriction analysis revealed that MHC-DRB2 (276 bp fragment) on digestion with *Hin*fI exhibits polymorphism in 48.39% genotypes.

Microsatellite based parentage testing was done using 194 DNA samples collected from blood leukocytes of different horse breeds. Genotyping was performed by analysis of nine microsatellite and selected microsatellites were highly polymorphic as mean number of alleles ranged from 3.78 to 10.78. Total exclusionary power of both parents in all breeds was more than 0.9 and all the foals (67) qualified the offspring-candidate parent compatibility.

Yak

A slide enzyme linked immunosorbent assay (SELISA) was standardized for the detection of *Babesia bigemina* antibodies in yak sera. Serological studies for detection of *B. bigemina* specific antibodies in yak from an organized farm and under field conditions revealed 44.16 and 56.10% seropositivity, respectively. It could be concluded that being more economical and technically simpler, SELISA could be used for seroprevalence studies on babesiosis in yak.

Keratoconjunctivitis was noticed in yaks, and *Moraxella bovis* and *Neisseria* were recovered from the ocular swabs. Serum samples from the affected animals were analyzed by viral neutralization test. AB-ELISA for the presence of bovine herpes virus -1

Bovine herpes virus-1 associated kerato-conjunctivitis in a yak

Equine welfare

The centre extended equine welfare activities in different parts of the country by organizing equine health camps and farmer meets (*Ashwa Palak Goshthis*) to educate the equine owners on various aspects of disease control and management.

(BHV-1) specific antibody. Nested PCR conducted using glycoprotein B and glycoprotein E specific primers (of BHV-1) revealed the presence of BHV-1 in the ocular swab of the affected yaks. The serological and molecular analyses indicated the possible role of BHV-1 in severe forms of keratoconjunctivitis in yaks.

Yak sera samples collected from different yak tracts of India were screened for the detection of BHV-1 specific antibody. The overall prevalence of BHV-1 specific antibody was alarmingly high (more than 40%) in yaks. Sex and location of different yak tracts did not have any influence over the IBR prevalence. However, the prevalence increased with the age of the animals, and was highest in yaks more than 3-year-old. Conjunctivitis and reproductive abnormalities were predominant symptoms among the seropositive yaks. The common ecological niche for feeding, watering and grazing with other domestic and wild animals is the possible avenue of infection in yaks.

Poultry

Marek's disease virus (MDV) circulating in PDP flocks was low virulent strain. MD incidence could be reduced more effectively with HVT (cell free) double dose or HVT+SB1 cell associated vaccines than single dose of HVT vaccine. Tumour samples could be safely stored in phenol-chloroform-isoamyl alcohol for PCR. Leg weakness associated with osteomyelitis caused by *Staphylococcus* spp. was recorded in young broilers, while aspergillosis was observed in female line of Gramapriya.

FISHERIES

Capture fisheries

Marine fish landings and catch structure: The marine fish landings of India during the year 2007 has been estimated as 2.88 million tonnes with an increase of about 1.7 lakh tonnes (6.5%) against the estimate of the previous year. The pelagic finfishes constituted 57%, demersal fishes 25%, crustaceans 14%, and molluscs 4% of the total landings. The sector-wise contributions were — mechanized landings 68%, motorized landings 28% and the atisanal landings 4%. Among the commercially important groups, the landings of oil sardine (26% increase over the previous year), penaeid prawns (13.4%), Indian mackerel (26%), croakers (41.9%) and other clupeids (55.6%) recorded substantial increase over their previous year's landings. The landings of non-penaeid prawns (18.6% decrease from the previous year), ribbon fishes (44%), Bombay duck (4.8%), thread fin breams (16.3%) and cuttle fish (27.2%) recorded marginal to substantial reduction from their previous year's landings. The estimates of region-wise production in the total production were—north-east region 13.2%, south-east region 22.6%, north-west region 29.3%, and south-west region 34.9%.

Ring seine fishery for oil sardine along the northern coast of Tamil Nadu: Oil sardine (*Sardinella longiceps*), is the most important pelagic resource on the west coast of India, and its occurrence along the east coast was considered sporadic and rare. In July 2008, large shoals of oil sardine appeared in the near shore coastal waters of Devanampattinam, Cuddalore and Puducherry. This supported high catches in the ring seine units newly introduced fishing practice, from the near shore waters for a month.

Inland fisheries

Exotic fish species invasion in West Bengal wetlands – a cause of concern: During fish stock assessment, breeding populations of exotic tropical South American Sailfin catfish, *Pterygoplichthys disjunctivus* and *Pterygoplichthys pardalis*, were recorded in Gomokpota *beel* under East Kolkata Wetlands. Huge biomass of these species, approximately 20 metric tonnes, was caught in a single month. These fishes do not fetch remunerative price as food fish but occasionally find place in aquaria. These species are prolonged breeders and voracious detritivores. A number of other exotic fish species, viz. *Barbonymus gonionotus* (*Puntius gonionotus*), *Pangasianodon hypophthalmus* (*Pangasius sutchi*), *Clarias gariepinnus*, *Oreochromis niloticus niloticus* and *Piaractus brachypomus* were also recorded in some other wetlands in the state. This has serious ecological and economic implications for the wetland fisheries in the state.

Culture fisheries

Reservoir fisheries enhancement: Fisheries enhancement in reservoirs Dahod in Madhya

Revival of *ghol* and *koth* fishery along the coast of Gujarat

Making the end of long period of decline and poor catch of *ghol* (*Protonibea diacanthus*) and *koth* (*Otolithoides biauritus*), bumper catches of large size fishes by multi-day trawlers occurred at Salaya landing center, Jamnagar, Gujarat. They were caught from Bay of Kutch at 25-30 m depth.

Cobia fishery at Kochi

Cobia (*Rachycentron canadum*), highly priced, but previously of a rare occurrence in the catch, landed in large numbers at Kochi fisheries harbour by multi-day gill-netters and hooks and line units operated in distant waters continuously from September this year. Fishery was supported mainly by large adult fishes weighing 10kg to over 30 kg. Fishery and biology of the species are being monitored.

Pradesh and Pahuj in Uttar Pradesh, was attempted through stocking of fish seed and improvement of institutional arrangements for fish catch and marketing. This resulted in improved fish production by over 60% in one year of experimental intervention. The catch/month, total fish catch and per month fishing days increased. The case studies will be helpful in formulating strategies for reservoir development in the Indo-Gangetic basin.

Freshwater aquaculture

***Labeo gonius* in polyculture system:** The compatibility of *Labeo gonius* with other major carps was studied through three combinations catla, silver carp, rohu and gonius; catla, silver carp, mrigal and gonius; and catla, silver carp, rohu and mrigal at combined density of 7,500 fingerlings/ha. Silver carp gave higher overall species survival, while catla showed the lowest level. Survival of rohu, mrigal and gonius, was intermediate and did not differ among them.

Coastal aquaculture

Low fish meal feed for shrimp: A low fish meal shrimp feed was developed by replacing fish meal and other marine protein sources with plant protein sources. Shrimp production after four months of feeding on the low fish meal feed was 1,308 kg shrimp/ha with a feed conversion ratio (FCR) of 1.31:1. This feed can be successfully used for culturing tiger shrimp at low cost of production.

WSSV risks to shrimp farming due to increased culture of crabs: Crabs are known carriers of white spot syndrome virus (WSSV), hence to address apprehensions of shrimp farmers

Fish stock enhancement in beel fisheries

Haribhanga *beel,* covering an effective area of 125 ha, is under the control of Assam Fisheries Development Corporation (AFDC). The pen culture technology intervention in a partnership mode with leaseholder resulted in doubling fish production/unit and recording a benefit cost ratio of 1.89 and 2.01 for consecutive two years.

The fish catch recorded was 131.1 tonnes of which Indian major carps contributed the major share followed by exotic carps, thus registering per unit increase in per unit productivity to 1,050 kg/ha in the *beel*. With an initial investment of Rs 10 lakh, the net income was Rs 53.5 lakh. The benefit-cost ratio of the lessee was 2.40.

to crab culture, studies were carried out to assess WSSV risks to shrimp farming due to enhanced culture of crabs. The prevalence of WSSV in crustaceans in different geographical regions was estimated based on samples from Andhra Pradesh, Tamil Nadu, Maharashtra and West Bengal. The prevalence levels in crabs used for crab fattening or those found in wild crabs indicate that they do not pose any additional WSSV risks.

Coconut wood for canoe construction

The strength properties of coconut wood compare well with those of other structural timbers like teak and jungle jack, and studies showed that wood with a density of more than 600 kg/m^3 can be used for boat building. A plank built type of canoe (length 6.4 m, breadth 0.83 m and depth 0.42 m) for gillnetting in backwaters was constructed out of coconut wood of more than 50 years old. The price of coconut wood is less than half of the conventional boat building timber, viz. *aini* (*Artocarpus hirsuta*).

Canoe structured of coconut wood

9

Livestock Management

Cattle

Fibre digestibility: *Streptococccus bovis*, a numerically predominant bacteria in the rumen of crossbred cattle under different feeding regimes was charaterized. And the cellulase gene obtained from the best fibre degrading fungi isolated from the faecal matter of goat was cloned to *Streptococccus bovis* for enhancing the fibre digestibility of poor quality crop residues.

Suppression of methane production: *In vitro* gas production test revealed that methane suppression among the tree leaves ranged from 4.6 to 82% — minimum recorded in jatropha leaves (4.6%) that contained lowest tannin and the maximum (82%) in *Ficus bengalensis* leaves. Commonly used top feeds like *Sesbania grandiflora*, *Glyricedia maculata*, *Ficus mysorensis* and *Ficus religiosa* leaves showed a methane suppression ranging between 35 and 50%. A mixture of three plant species having anti-methanogenic activity *in vitro*, exhibited 12% reduction in methane emission in crossbred calves, which confirmed that there is a potential in using tree leaves for reducing methane production from enteric fermentation.

Use of fungi for enhanced digestibility of straws: Lignin content of *ragi* straw decreased with all the white rot fungi, viz. *Phanerochate chrysosporium*, *Pleurotus sajorcaju*, *Pleuritous ostreatus* and *Vorialla voloraceae*. High protease activity was observed during the first two days of fermentation after which it declined, and lignolytic enzymes, viz. laccase, manganese peroxidase and lignin peroxidase concomitantly increased up to the fifth day of fermentation. *Phanerochaete chrysosporium* showed the best potential in improving the digestibility of *ragi* straw followed by *P. ostreatus*.

Antifungal property of medicinal/aromatic plants: Melissa and thyme leaves exhibited good anti-fungal activity (>50%) against *Aspergillus parasiticus*. *Pachouli* leaves, curry leaves, rosemary leaves, cinnamon leaves, *sarpagandha* leaves, thumbe leaves, sweet worm wood leaves, *aswagandha* leaves, chicory powder, yellow oleander leaves, *Selastras paniculatus*, *Tinospora cardifolia*, railway creeper and Indian acalypha leaves showed high anti-fungal activity (>50-90%) against *Fusarium moniliforme*.

Energy supplementation for higher milk yield

Strategic supplementation of *ragi* (*Eleucine coracana*) grain to dairy cows during their early to mid lactation period resulted in increased milk production (average 1.9 litre/cow/day) and fat and SNF percentage (average 0.2-0.3%) and also reduced the milk urea content with a net increase in income of about Rs 19/cow a day under field conditions.

Buffalo

Nutrition for the onset of puberty: GnRH challenge studies in the calf attaining maturity at 3 years of age due to nutritional perturbation showed immature status of hypothalamo-hypophyseal-ovarian axis even at the age of 2 years 4 months.

Nutritional modulation of IGF: In sub-fertile male buffaloes nutritional modulation of IGF-I (as a mediator of metabolic hormonal effects) proved beneficial for various sperm functional attributes *in vitro*. The cleavage rate in embryos produced through IVF using such sperms, was also better.

Area specific mineral mixture: Supplementation of area specific mineral mixture (Ca, P, Zn, Mn, Cu) to buffaloes based on the deficiency in the North east zone of Haryana, improved productive and reproductive efficiency

as 70% buffaloes showed normal cyclicity, and 10% increase in milk production. Supplementation of area specific mineral mixture pellets @ 40g daily in cattle and buffaloes during lactation stage increased milk yield by 10-15%, brought cows into estrus within 30-45 days, and reduced the problem of skin keratinization.

Detection of pesticide residues: A rapid multi-residue method for analysis of neonicotinoid pesticides, viz. imidacloprid, acetamiprid and thiacloprid, was developed. The percent recovery from 0.5 to 2.0 ppm concentration varied from 95.6 to 81.17% for imidacloprid, 92.76 to 84.99% for acetamiprid, and 96.96 to 88.50% for thiacloprid with a detection limit of 5ppb, 10ppb and 20ppb, respectively.

Fibre digestibility: Isolates of anaerobic fungi collected from 5 different states and 6 different host species, revealed that isolates from Rajasthan had highest fibrolytic potential and the best isolate improved digestion of wheat straw in buffaloes.

Improving reproductive efficiency

- Buffalo embryos were produced *in vitro* @ 64% cleavage with 20% blastocyst using an improved IVEP protocol.
- A three dimensional (3D) collagen gel culture system for the *in vitro* growth and survival of the buffalo preantral follicles with IGF-I was developed.
- Early diagnosis of pregnancy (by day 20-21 post-breeding) was facilitated by using real time B-mode ultrasonography in goats and buffaloes.
- Bull-biostimulation curtailed the incidence of silent ovulation and service period and increased conception rate in post-partum buffaloes.

Enhancing productivity: Strategic supplementation of protein (<20% CP) during mid-lactation increased productivity of buffaloes. Vitamin E supplementation @300 IU daily was optimum to improve weight gain, and increased its concentration in the muscles of buffaloes.

Early embryonic mortality: Dynamic status of antioxidant enzymes in relation to the stages of oestrous cycle and tissue remodeling was observed. Effective modulation of prostaglandin production by the uterus may rescue corpus luteum and prevent early embryonic mortality.

Improvement of reproductive efficiency: Insemination dose could be reduced from 25 to 15 million spermatozoa without adversely affecting the conception rate. The results are being authenticated with more trials in farmers' herd. Frozen semen samples were evaluated for sperm motility attributes. Bulls with higher field conception rates also had higher sperm total motility, progressive motility, rapid motion and viability.

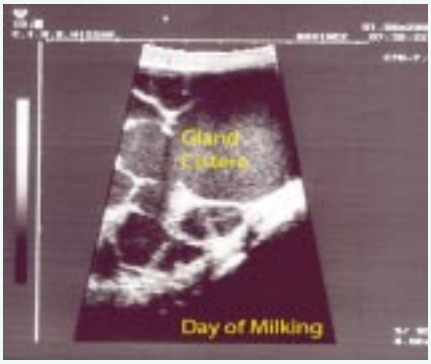
Sheep

Trace element status: Biochemical markers (Cu and Zn-dependent enzymes – ceruloplasmin and Cu/Zn- super oxide dismutase) were evaluated to assess the trace element (copper and zinc) status in sheep at different dietary levels of Cu and Zn. Prediction equations developed by correlating the absorbed Cu and Zn with Cu- and Zn-dependent enzymes; plasma Cu and Zn with Cu and Zn-dependent enzymes; liver tissue concentrations of Cu and Zn with absorbed Cu and Zn, revealed that Cu and Zn status of animals could be assessed by using these enzymes as biochemical markers.

Production performance: Bharat Merino and Gaddi Synthetic sheep under migration to highland pastures gained higher body weights and produced

Induction of lactation

Infertile Murrah buffaloes were treated with subcutaneous injections of estradiol-17 and progesterone for 7 consecutive days, and supplemented with largectil and dexamethasone at specific intervals for induction of lactation. One week of udder massage was given twice daily till the udder was turgid with milk, followed by milking, which started from day 21. Milk from induced-lactating buffaloes became normal within 10-15 days after start of milking. Four of the six treated buffaloes responded successfully and milk became normal between 4-20 days of the start of milking. The fat content stabilized at 7.72±0.3% after about 10 days of first milking. In successful cases, the peak milk yield between 20th and 75th day ranged between 2.5 and 7.0 kg/day. The effect of treatment for induction of lactation — which comprises sex steroids — was also assessed on the ovarian activity of treated



buffaloes. Ultrasonographic scanning revealed that pre-treatment ovarian follicular size of 7-13 mm, regressed to 2-3 mm within 8-10 days of start of the treatment and then no follicular activity was observed for 30 days during treatment. First ovulation took place between 55 and 60 days after treatment. In two buffaloes, follicular cysts of up to 35 mm diameter were detected.

Production and reproduction performance in sheep

The spent sheep after completing productive life constitute more than 30% of meat produced in the country. Pre-slaughter feeding of *ad lib.* concentrate mixture in spent ewes for 45 and 90 days improved body weight gain by 10-11kg. Supplementation of mineral mixture in sheep flocks maintained on degraded rangeland of semi arid Rajasthan brought anoestrus sheep into estrus after 15-20 days of supplementation.

Prototypes of vaginal speculum and plunger of different dimensions, suitable for transcervical insemination of Malpura sheep were fabricated from plastic and nylon material for successful transcervical insemination. Three different protocols for producing synchronized lamb crops were perfected, and the study indicated that ovagen alone and in conjunction with progesterone enhanced lambing in sheep.

more wool in comparison to stationary flocks.

Utilization of fibrous crop residues: Fortification with cellulase, xylanases, pectinase, phytase and protease enzymes enhanced dry matter digestibility by 7.00%, cell wall digestibility by 25.00%, and the end product fermentation by 15.00% of poor quality roughages. Supplementing probiotics of microbial origin like *Saccharomyces cerevisiae*, *Saccharomyces uvarum* and *Kluyveromyces marximanus* and a mixed yeast culture of above three in a ratio of 1:1:1 as microbial probiotics in lambs showed that *Saccharomyces cerevisiae* strain is superior in improving the growth of lambs.

Bioavailability of nutrients: Diets supplemented with condensed tannins improved nutrient utilization, immune response besides protection from GI parasites and fasciolosis in sheep.Supplementation of *Tinospora cordifolia* as a functional food imparted positive influence on the nitrogen metabolism and antioxidant levels in seminal plasma besides significantly improving the erythrocytic antioxidant status and cell-mediated immune response of adult Muzzafarnagari rams. Undecorticated jatropha (*Jatropha curcas*) meal after processing with 1% common salt and 0.5% lime, could replace protein of conventional oil cakes up to 25% in the concentrate mixture of adult sheep and goat for short-term feeding,

Goat

Standardization of* in vitro *fertility test

Hypo osmotic swelling test (HOST): Sperms were evaluated for strongly coiled, weakly coiled and non-coiled under oil immersion lens. The best swelling in terms of strong coiling and total coiling was in 75-mosmol hypo- osmotic solution. There was significant difference in swelling in different

Cylindrical sponges showed maximum retention

strengths of hypo osmotic solution. For frozen sperm 75-mosmol and for fresh diluted semen 100-mosmol hypo-osmotic solution was found to be the best.

Dual staining test: Dual staining technique was standardized for testing viability and acrosomal integrity in frozen and fresh semen. It saved time and chemicals in testing viability and acrosomal integrity thereby avoiding separate tests.

Semen quality: Twice a week semen collection, evaluation and freezing in Jamunapari bucks of 2-5 years of age group, indicated that the semen production was higher under intensively reared bucks compared to the semi-intensively managed bucks.

Rapid estrus detection methods: Sponges of different sizes and shapes were tested for their retention in vagina for 12 days in Sirohi goats for estrus detection. Circular sponges with a diameter of 30 mm and cylindrical shaped sponges with a diameter 25 mm had the highest percentages (>83%) of retention.

Mithun

Feed blocks with locally available feed resources: Feeding of *Lagerstroemia speciosa* tree leaves based complete feed blocks to mithuns showed that the tree leaves could be incorporated in the ration up to 30% for feeding mithuns under semi-intensive or intensive system.

Organic fertilizer: The excreta (faeces and urine) of both mithun and Tho Tho cattle were compared as a source of organic fertilizer. The quantum of faeces voided from mithun was more than that of Tho Tho cattle though faeces of Tho Tho cattle contained less water (more DM) compared to that of mithun. The chemical composition of faeces of mithun and local cattle did not differ significantly. Mithun produced more urine than Tho-Tho cattle. So per animal basis,

mithun supplied more excreta as organic fertilizer than Tho-Tho cattle in Nagaland.

Bakers yeast: Feeding bakers yeast (*Sacharomyces cerevisiae*), a probiotic on roughage based diet, significantly increased average daily gain of mithuns, intake of concentrate and roughage and also improved FCR.

Estrus synchronization protocols: Experiments conducted to synchronize estrus in cyclic and post-partum mithun cows showed more prominent behavioural signs of estrus than spontaneous heat. Application of CIDR on day 45-50 after parturition, induced first postpartum estrus immediately after uterine involution (day 53-58 post parturition). Unlike other bovines, mithun cows exhibit first postpartum estrus at around 97±19.6 days postpartum. Use of CIDR was advantageous in terms of prominent behavioural signs of estrus thereby ease in detection of estrus. The first calf was born from an anoestrus mithun cow synchronized with CIDR.

Hormone-induced maternal behaviour: Mother-neonate bonding was studied using oxytocin intranasal spray. Intranasal administration of oxytocin effectively induced maternal behaviour in primiparous bovine heifers where maternal behaviour was blocked chemically.

Embryo transfer technology: Estrus synchronization was performed by using CIDR protocol and four embryos (compact morula) were recovered successfully from two donors and subsequently transferred into three recipients.

Yak

Trace mineral supplementation: Soil, feeds and fodders of yak rearing zones are deficient in micronutrients, as reflected by the low productive and reproductive performances of yak. Supplementation of trace minerals like Zn, Cu, Co and Mn in the ratio of 40:20:2:1 along with the basal diet significantly increased milk production.

Production performance during winter: Body weight gain was significantly higher during October in calves but from November onwards no significant increase was observed. Bulls gained significantly higher body weight compared to calves up to December. The lactating yak cows lost about 5.84% of their body weight, and milk yield reduced mainly due to shortage of feed and fodder during long winter. Providing adequate nutrition during winter could help in ameliorating winter stress in yaks.

Modified temperature humidity index: Yaks were comfortable at THI of 52 and when THI exceeds 52 yaks experienced heat stress, as expressed through increased physiological responses.

Poultry

Stress related hormone: Under heat stress condition some of the lymphocyte proteins were repressed whereas some others were induced in broiler.

Bioavailability of micronutrients: Se supplementation in broiler chicken diets at 0.15 or 0.30 ppm complemented bioavailability of Zn. In contrast, Se antagonized retention of Mn, Cu and Fe in liver tissues. Se (0.15 ppm) and Zn (80 ppm) improved humoral and cell-mediated immune response in broiler chicks. Zn uptake by tissues was relatively more active during early age (2 week) than at later ages (4 and 6 week), whereas Se retention in tibia and liver was higher at 4 and 6 weeks than that at 2 weeks of age.

Se inclusion in broiler chick diets from 0.15 to 1.35 ppm linearly enhanced its retention in bone and liver tissues and complemented Zn uptake by tissues. Both Cu and Fe responded negatively to Se increases in diets at 5 weeks of age. Vitamin E at 40 IU enhanced Se uptake by bone, but did not influence retention of Zn, Mn, Cu or Fe. Moderate levels of Se (0.15 or 0.45 ppm) and vitamin E at 40 IU produced higher antibody titres, better cell-mediated immune and reduced stress in 5-week-old broilers.

Enhancing utilization of macronutrients: Protease enzyme produced from *Bacillus licheniformis* were supplemented to broiler diets @ 4,000 IU/kg to enhance the feeding value of commercial meat meals and soybean meal low in protein by 3-4% over the recommended level (22%). Meat meal diets responded better to protease supplementation and performance of broilers was equivalent to the control group that was maintained on 22% protein diet. Inclusion of enzyme had

Nutrient requirements of rural poultry

Ca and NPP levels in diet could be reduced to 0.6 and 0.3%, respectively, by maintaining the vitamin D_3 level at 1,200 IU/kg diet in Vanaraja female parent. The effect of interaction between Ca and NPP on performance and bone mineralization of Grampriya chicks during nursery (rearing period of 1 to 42 days) suggested that 0.6% Ca and 0.30% NPP were adequate.

Krishibro chicks responded positively to dietary energy levels (2,900 and 3,000 kcal ME/kg) in starter and finisher phases, respectively. The requirement of Ca, and NPP for dressing yields and bone mineralization in Krishibro chicks appeared to be equal/higher than 0.6 and 0.3%.

Carbohydrate in combination with fat produced better effect on body weight of broiler chickens than combination of fat and protein as chicks could utilize carbohydrate better than fat during initial post hatch period.

significant impact on different production parameters compared to non-supplemented diets, particularly when dietary protein levels were lower than the recommended levels.

Female reproductive system of *desi* fowls: Ovary and oviduct development was noticed clearly around 16 to 18 weeks of age in White Leghorn (WLH), around 20-22 weeks of age in Kadaknath (KN) and around 24 weeks in Aseel peela (AP). At the peak of sexual maturity, around 30 weeks of age, total length of the oviduct was greater in WLH (73 cm) as compared to *desi* fowl (66 cm). The transaminases activity of blood plasma, irrespective of breeds increased linearly with age. An increased pattern of ACP, GOT and GPT activity was found associated with maturation of female reproductive tract and reverse was true with ALP activity among all the breeds.

Enhancing egg production: Using simple feed formulation, egg production could be enhanced markedly over the age of 78 weeks in Aseel peela *desi* fowl. Large-scale replications at institute and field level are being taken up to validate the data.

Supplementation of melatonin: Dietary inclusion of aflatoxin @0.15 ppm level adversely affected body weight, feed intake and FCR and caused lipid peroxidation with simultaneous depletion of antioxidant enzymes (superoxide dismutase and catalase) in broilers. Melatonin supplementation @ 40mg/kg feed alleviated the adverse effect of aflatoxicosis at lower levels (<0.15ppm).

Moulting for enhanced production: Birds were force moulted by feed withdrawal method for 10 days. As the period of fasting progressed from 0 to 10 days a gradual but steady reduction was noticed in the levels of serum triglycerides, which was more pronounced and significant from the fourth day of commencement of feed withdrawal. A similar decline in serum total cholesterol concentration was noticed, which became very apparent from the sixth day after feed withdrawal and a reduction of 30% in total cholesterol concentration was achieved by the tenth day in the moulted hens. In contrast, serum HDL–cholesterol concentration progressively increased during the feed withdrawal period and peaked around the eighth day after withdrawing feed. Accumulation of high lipid in uterus in late laying age results in either shell less or poor shelled eggs. Feed withdrawal for longer period leads to mobilization of lipids from uterus.

Quail semen characterisation: Physical and biochemical characteristics of quail semen showed that birds having larger cloacal gland size ejaculated higher volume of semen and semen production was higher in CARI Uttam than CARI Sweta quails. Mass sperm motility in neat semen was only 50-60% immediately after collection that decreased continuously and reached to zero after 30 min. Sperm abnormalities were higher in CARI Sweta than CARI Uttam. Among the enzymes LDH was exceptionally high in all groups in both the lines, cations sodium and potassium were higher in birds having larger cloacal gland size whereas magnesium and calcium were more in the seminal plasma of birds with smaller cloacal gland. Methylene blue reduction time test revealed that quail spermatozoa are more active than chicken.

LIVESTOCK PROTECTION

A status of freedom from contagious bovine pleuropneumonia infection in cattle and buffalo was obtained from OIE.

Development and improvement of diagnostics and vaccines

Vaccines

- A low volume saponified haemorrhagic septicaemia vaccine was found safe and effective in farm cattle.
- Possibility of DNA vaccine construct against bovine brucellosis was ascertained.
- Chicken cytokine genes (MIP-□, lymphotactin and IFN□) were expressed in mammalian cells thereby opening up the possibility of their use as genetic adjuvant in DNA vaccine.
- LPS and genomic DNA containing CpG from *Salmonella* Gallinarum activated the innate immune system of chickens and gave higher protection after immunization with inactivated NDV in challenged birds.
- Conjugation of Fc with flagellin protein was a good model for efficient antigen delivery resulting in higher immune response than antigen alone.

Diagnostics

- A nested RT-PCR was developed using primers from RNA dependent RNA polymerase region for differentiation of ruminant pestiviruses.

Exotic and emerging diseases

BVDV-1 was identified in yaks of Himalayan region. Phylogenetic analysis established prevalence of BVDV-1b and 1c subtypes in Indian buffaloes and existence of close relationship between cattle and buffalo BVDV-1b viruses.

The phylogenetic analysis of avian influenza virus indicated that the virus might have been introduced into India through migratory birds.

The Indian isolate of PCV1 was found genetically closely related (0.6%) to isolates from China, USA, France and distantly related (1.4%) to the isolates from Taiwan.

- C18L gene based conventional PCR and TaqMan probe based real time PCR were developed for specific detection of buffalo pox virus.
- Duplex PCRs were developed for specific detection and differentiation of buffalo poxvirus from other orthopox viruses, and camel pox from other orthopox viruses.
- C18L gene-based real time PCR was standardized for quantification of camel poxvirus in clinical samples.
- A hybridizing probe based real-time PCR was developed for diagnosis of PMWS and the disease was diagnosed in four private farms in Uttar Pradesh.
- The expressed protein of N gene of PPR virus could be an alternative to whole virus antigen in sandwich ELISA for diagnosis of PPR.
- Developed indirect ELISA for serodiagnosis of Japanese encephalitis in pigs.
- Transformed fibroblast antigen was much superior antigen for detection of anti-avian leucosis virus antibodies in the serum samples of chicken, as compared to gsAg, as determined by an indirect ELISA.
- A highly sensitive PCR targeting new gene of *Mycobacterium a. paratuberculosis* and a quantitative real-time PCR (RT-PCR) were developed for the diagnosis of paratuberculosis in small ruminants.
- Serotype specific PCR was developed for detection of *Salmonella* Typhimurium and *S.* Enteritidis.
- Duplex PCR was developed for simultaneous detection of *Salmonella* genus and Typhimurium serotype.
- Germ tube formation test was developed for detection of chlamydospore in *Candida albicans.*
- Methodology for quick detection of *Echinococcus granulosus* genotypes by polymerase chain reaction coupled with restriction fragment length polymorphism was developed.
- A useful primer was developed and found effective in differentiating cryptic stage of *Echinococcus granulosus* and *Taenia.*

Molecular characterization of pathogens/receptors

- Mutants of *E. granulosus* isolate from Indian cattle and buffalo origin, were detected on the basis of sequence analysis of mitochondrial gene and non-coding spacer gene.
- Molecular characterization of toll-like receptors (TLR2, and TLR4) of *nilgai* revealed higher expression in skin and immune cells of *nilgai*, as compared to buffalo indicating stronger innate immunity.

Herbal medicines

- Immunomodulators prepared with extract of *Tinospora cordifolia* and a probiotic (*Mycobacterium phlei*) showed significant body weight gain in broiler birds and improved their health.
- Significant antidiarrhoeal activity was detected in the seed extract of *Caeslipinea bonducella.*

Surgical and clinical interventions

- The epoxy-pin external skeletal fixation technique was developed, and used to treat a variety of compound fractures of different long bones in small animals.
- A novel design of bilateral external fixator having opposite threadings in the side bars was developed for the management of long bone fractures in large animals.
- Transplantation of autologous bone marrow cells, along with hydroxyapatite induced faster healing of radius fracture in rabbits, as compared to transplantation of hydroxyapatite alone.

SUCCESS STORY

Cell culture vaccine for classical swine fever

Classical swine fever or hog cholera, the most important disease of pigs that causes death in 98 to 100% cases in susceptible populations, result in economic losses of around Rs 500 crore in India. Presently, vaccination is done with a lapinized vaccine that requires killing of rabbits for its manufacture. Since cell culture vaccine is not available in India for protection of pigs against classical swine fever, the Indian Veterinary Research Institute, Izatnagar, developed an effective PK-15 cell line-based live attenuated freeze-dried vaccine. Field validation of the cell culture vaccine on pigs revealed that immune response of the vaccine was highly satisfactory. Vaccinated pigs sero-convert from 21-30 days of vaccination. The vaccine has a shelf life of more than one year and provides immunity for at least a year following a single vaccination after weaning. It is safe, potent and can be applied even during pregnancy and there has been no report of any untoward post-vaccination reactions.

The newly developed vaccine is cell culture based and its production is easier and low cost as compared to the existing lapinized vaccine. Hence there would be a good demand for the product in market. Supply of country's demand of approximately 20 million doses of the vaccine seems possible by use of this cell culture vaccine. This would help in reducing the losses due to mortality and thus improve the economic condition of poor pig farmers in the country.

- Application of autologous bone marrow cells subcutaneously in the periphery of incisional and open cutaneous wounds induced faster healing, as compared to conventional antiseptic dressing of wounds.

Foot-and-mouth disease

Field samples (1,313) received from various states during the year were processed and subjected to sandwich ELISA for type identification. Only 705 samples were typed — 567 samples were typed as O, 58 samples as type Asia1, and 80 samples as A —, and no virus could be detected in rest of the samples. Samples were also processed in BHK 21 cells and virus could be recovered in 119 field samples comprising 24 type Asia 1, 75 type O and 21 type A.

To improve the diagnosis of FMD in suspected clinical samples, a multiplex PCR (m-PCR) was developed and evaluated. Using the test, 42% of the outbreaks that went undiagnosed using ELISA, were identified indicating that mPGR could be used as best supplentary to ELISA to increase the percentage of FMD outbreak diagnosis in the country.

Two-dimensional micro-neutralization test (2D-MNT), a modified form of SNT, was routinely used to test new field isolates to determine the appropriateness of the existing vaccine strains and to select new vaccine strains, if required. In serotype A the most worrying factor, which merits attention is the antigenic heterogeneity of the isolates. In the sense some strains show close antigenic match to the current vaccine strain (17/82) and others to the new strain (IND40/00) in *in-vitro* micro neutralization test. One isolate IND 53/08 from Chhattisgarh, was unique both antigenically and genetically forming a separate cluster with another isolate IND 109/06 from Chhattisgarh.

Among all serotypes prevalent in India, type A virus population is genetically and antigenically most heterogeneous in nature. VP1 coding (1D) region based molecular phylogeny has established circulation of four genotypes of type A so far in India. There is once again an upsurge in incidence of outbreaks due to lineage genotypes VII with amino cicer (aa) deletion at 59th position of VP3. This single aa deletion is at an antigenically critical position in structural protein VP3, which is considered to be a major evolutionary jump probably due to immune selection.

Field isolates (17) of serotype A recovered from outbreaks in Karnataka, Tamil Nadu, Chhattisgarh, West Bengal and Haryana were sequenced at 1D (VP1) region for molecular epidemiological analysis. The determined sequences were aligned with other Indian sequences and some of the retrieved exotic sequences. All the isolates clustered within genotype VII in the N-J tree. Genotype VII is restricted to only India as none of the exotic sequences clustered in this group. Thirteen out of the seventeen isolates sequenced, clustered in the deletion group. 1D region based phylogeny also revealed that this lineage is genetically diverging with time giving rise to three lineages (VII b, f and g) so far.

In serotype O, PanAsia II strains dominated the outbreaks, nevertheless Panasia I and II 2001 also co-circulated. Asia 1 field isolates (19) were subjected to 1D gene sequence analysis. The isolates were grouped with lineage CI that dominated Asia 1 outbreaks. The isolates of 2007 and 2008 showed 15.4 to 16.7% and 12.4 to 14.7% divergence at nucleotide and amino acid level, respectively, from in-use vaccine strain (IND63/72).

The Central laboratory, Mukteswar, contains 1,402 (893-O, 261-Asia 1, 233-A, 15-C) field isolates. Pre- and post-vaccinate serum samples collected up to sixth phase of FMD-CP showed increased levels of protective antibodies against serotypes O, A and Asia 1 over different phases of vaccination.

SUCCESS STORY

Rapid immunoassay kit for serological monitoring of infectious bursal disease of chickens

Infectious bursal disease also known as Gumboro disease, a highly contagious viral disease affecting young chickens, 3 to 6 week-old, has worldwide occurrence. Morbidity of the disease is high with mortality usually of 0-20%, but sometimes up to 60%, thus adversely affecting the economy of poultry industry.

Serological diagnosis of the disease is either labour intensive, slow or require sophisticated equipment. A need was felt to replace these laboratory tests with a simple pen side test. A recombinant protein produced from a heterologous expression system was used as a diagnostic antigen in a simple field assay format. The developed protocol allows the user to rapidly interpret the immune/disease status of the bird by a simple agglutination phenomenon of antigen-coated beads with naked eye within 5 min. This in turn, helps the farmers and poultry breeders in determining the time of vaccination of the chicks. Test results are comparable with agar gel precipitation test and enzyme linked immunosorbent assay under test conditions

The kit has been validated under laboratory conditions from different parts of the country and the technology was transferred to National Research Development Corporation, New Delhi, for further commercialization. The developed kit would help in minimizing the time required for diagnosis and develop judicious vaccination scheduling.

Animal disease monitoring and surveillance

A large databank on the livestock diseases of the country, based on reports submitted to the Government of India by various state governments was developed at the PDADMS. The institution was involved in the sero-monitoring of rinderpest. Large number of sera samples from various parts of the country is maintained in the National Livestock Serum Bank for retrospective studies.

- An offline version of the databank of livestock diseases of the country was developed. Based on the custom queries, various epidemiological analyses are possible e.g., frequency of disease occurrence, top diseases of the country, eco-patho zones. The spatial and temporal analysis of animal disease data is being carried out using this software.
- Molecular diagnosis of brucellosis was standardized that helped in differential diagnosis of *Brucella abortus* and *B. suis*. Based on the results of the serological, biochemical and molecular techniques a rare case of brucellosis in swine due to *B. abortus* was diagnosed. A standardized A-B ELISA kit for the detection of bovine *Brucella* antibodies was developed. An indirect ELISA kit was standardized to identify the magnitude of disease in ovines. Molecular epidemiological studies are being standardized to diagnose and differentiate the brucellosis of cattle, ovine, caprine and humans. Tests were developed to detect the etiological agent directly from the clinical samples such as aborted foetus, placenta and uterine discharges.
- A multiplex PCR was standardized to diagnose the pathogenic leptospira. A repository of the leptospira isolates is being maintained.
- Molecular studies on BHV-1 were carried out. A multiplex PCR for detection of BoHV-1 sequences was standardized. The PCR amplified products of gB (293 bp), gC (173 bp), gD (343 bp) and US 1 (464 bp) were subjected to partial nucleotide sequencing and aligned with different reference sequences of respective genomic regions.
- The PCR amplification of different 'tk'genomic region of BoHV-1 was standardized and the PCR amplicons thus obtained were confirmed using unique restriction enzyme. Multiple PCR using different combinations of primers specific for gB, gC and gD was standardized and was applied for screening of field samples. The partial nucleotide sequencing of gB, gD and US 1 were aligned with the reference sequences, and was analyzed with phylogenetic trees. These results would be of much help in profiling and characterizing BoHV-1 in livestock population.
- The serum samples obtained from Madhya Pradesh, Maharashtra, Andhra Pradesh, Manipur, Kerala, Orissa, West Bengal and Tamil Nadu, were screened for the presence of antibodies against IBR, using AB-ELISA kit and 41.90% of the samples were found positive for IBR antibodies.
- An mPCR for genome detection of leptospira, BoHV 1 and *Brucella* using known standards targeting the LipL32 gene of *Leptospira*, gB gene of BoHV 1 and bcsp31 gene of *Brucella*, was standardized.
- Occurrence of zoonotic bacterial pathogens from the livestock and livestock products was studied. The pathogens were isolated from various sources, and their molecular characterization was completed.
- A computer interface based BHV-1 whole antigen AB ELISA was developed as per the standards of IAEA, standardized and validated. The kit was critically evaluated both in-house and extensive field trials for detection of antibody to IBR virus in bovine serum. This test is highly sensitive, specific, economical and user friendly.
- A kit to detect the antibodies to *Brucella* in swine is being developed and is in the process of standardization.
- A PCR technique was developed to detect the carrier status in domesticated animals. A pair of primers specific to VSG gene of *Trypanosoma evansi* was developed. The PCR technique was standardized and 400 bp amplicon of VSG gene was obtained from the genomic DNA isolated from the blood of *T.evansi* infected experimental animal. Field validation of the technique is in progress.

Intensive expert system on animal diseases

A web based interactive expert system on animal diseases of the country was developed, and it can be accessed at www.nadres.res.in. It depicts national livestock statistics, animal diseases statistics, eco-patho zones of important livestock diseases, epi-reports and the animal disease forecasting. Based on the dynamic factor, frequency of occurrence of diseases, and the static factor, various precipitating factors, an interactive web service was designed. The user can know the probable occurrence of a particular disease in any district of the country by feeding the name of the state and district of his choice. This service is useful to researchers and particularly to the planners to implement the disease control measures well in advance.

- Serum Bank facility has more than 170,000 serum samples from all over the country, which is being used for long-term national surveys on various diseases of economic importance.
  - Development of relational database on Animal Health Information System
  - Development of *India.admasEpitrak* – a relational animal health information database software
  - Development and launching of National Animal Disease Referral Expert System
  - Identification of disease specific Eco-patho zones in the country
  - Providing eco-pathozones and spatial and temporal occurrence of diseases for effective vaccination and control of important diseases in different states e.g. PPR in Andhra Pradesh and Karnataka, Brucellosis in West Bengal and Andhra Pradesh, FMD, PPR, HS and BQ in Maharashtra, Andhra Pradesh and Karnataka.
  - Providing the logistic support to national network projects like bluetongue and HS projects for disease monitoring and surveillance.

Bluetongue

A repository of blue tongue virus isolates BTV-1 (2 isolates), BTV-2 (4 isolates), BTV-9 (3 isolates), BTV-15 (5 isolates), BTV-18 (4 isolates) and BTV-23 (7 isolates) from Izatnagar, Hyderabad, Parbhani, Kolkata, Parbhani, Hisar and Chennai, was made. No outbreak of bluetongue was recorded in the country except Andhra Pradesh, Karnataka and Tamil Nadu. Disease forecasting model was developed. The incidence was as high as 95.5% sheep from Uttarakhand; 88.6% cattle from Panjab; 63.8% goat and 55.6% sheep from Manipur; 50.0% sheep from Jammu and Kashmir; and 18.22% goat from Delhi. A VP7 gene incorporated recombinant antigen based indirect ELISA kit was developed for detection of group specific antibodies in the sera.

Inactivated pentavalent bluetongue vaccine was evaluated at different places particularly in the bluetongue affected states. Vaccine was satisfactory except a nodule formation at the site of inoculation.

Type specific primer designing, VP2, VP5 and VP7 gene cloning and expression, multiplex RT-PCR for BTV, RNA-PAGE and nucleotide sequence studies, were standardized. Confirmation of virus isolates was done by RT-PCR using VP7 gene specific primers.

Haemorrhagic septicaemia

Isolates (93) of *Pasteurella multocida* were characterized and a new serogroup E of *Pasteurella multocida* was identified first time in the country. Most of the *Pasteurella multocida* isolates were sensitive to enrofloxacin, ofloxcin chloramphenicol, doxycycline and resistant to vancomycin, bacitracin, and sulphadiazine. Molecular characterization of different isolates of *Pasteurella multocida* recovered from different species of animals and poultry were carried out by PM-PCR, HSB-PCR, multiplex-PCR, ERIC-PCR and REP-PCR. A low volume saponified HS vaccine was validated successfully in farm cattle, and it was found satisfactory. The OMP vaccine against *P.multocida* type A in ducks provided higher protection as compared to the bacterins. The biofilm vaccine against *P.multocida* type A of sheep origin was prepared and compared with the whole cell vaccine, and it produced higher immune responses on using montanoide oil adjuvant. Economic loss of more than Rs 225 million was estimated due to haemorrhagic septicaemia in cattle and buffalo.

Ethnovetrerinary medicine

Concomitant use of hydromethanolic (1:1) extract of fruit pulp and seeds of tamarind (*Tamarindus indica*) at different doses reduced F concentration in blood and bones and enhanced urinary excretion in rats indicating the ameliorative potential of tamarind fruits in fluoride toxicity. Testing of bio-fractions A, B and C, revealed that fraction B and C reduced the fluoride, whereas fraction A showed antibacterial activities. An indigenous herbal teat dip was developed for effective control of mastitis and the same is being cross validated to facilitate patent**.** *Azadirachta indica* stem extract effectively treated sub clinical mastitis, and for it standardized dose of *A. indica* stem extract was established. An alkaloid isolated from test herb ANAND-EVM-NW-4 revealed antibacterial efficacy against common isolates from field cases of mastitis. Ethanolic extract of AAU-EVM-NW-3 showed potential effects @ 500 and 750 mg/kg p.o. in clinical case of fasciolosis in ovines, and 7.5% ointment of AAU- EVM –NW-2 was effective in *Psoroptic* mange in rabbit (*Oryctologus cuniculus*). Toxicity testing of all the effective herbs established their safety.

Gastrointestinal parasitism

In Rajasthan software 'FROGIN' was evaluated for forecasting of gastrointestinal (GI) nematodosis in semi-arid and arid regions. It gives results as predicted faecal egg counts (FEC) on start of month, intensity of FEC for next 60 day and pasture larval burden for that month. The Garole sheep was not found completely refractory to infection of *Haemonchus contortus*. *Haemonchus, Bunostomum, Nematodirus* and *Oesophagostomum* spp. were found in all the zones in Sikkim. 170 kDa polypeptide of larval antigen of *H. contortus*

was recognized by 4 day sera (prepatent sera) of sheep in western blotting. Zymogram studies revealed that 120 and 170 kDa polypeptide belonged to metalloproteases based upon protease inhibitor studies. In the ES product, cysteine protease and GST (glutathione-S-tranferase) were identified, which are of immunodiagnostic and immunoprophylectic value. In *H.contortus* ES antigen 30-32 kDa polypeptide showed protease activity, which was inhibited by E–64 confirming it to be a cysteine protease. GST was confirmed in western blotting utilizing anti-GST antibody. ES antigen was better than gut antigen of *Ascaris suum.* Dipstic ELISA was comparatively found more efficient than plate ELISA. No correlation could be established between worm burden and antibody titre in naturally infected sera of pig with *A.suum.* Immunodominant polypeptide in *Bunostomum* and *Oesophagostomum* spp. was identified, and a diagnostic kit for serodiagnosis was developed and revalidated. Allele specific PCR was applied to field population of larvae for detection of benzimidazole resistance and was compared to FECRT and EHA. Frequency of BZ-rr (homozygous BZ-resistant) larvae in population ranged from 73.39 to 100% in Northern Rajasthan. Effect of *Fec* B gene on resistance to GIN was conducted in sheep naturally infected with GINs. Lower incidence was observed in Garole sheep. H-11 and H-gal-GP polypeptides of *H. contortus* are being utilized for immunoprophylaxis and studies on H-gal-GP were completed. In H-gal-GP of *H. contortus* MEP-2 fragment showed 94% homology to other international strains.

Equines

Nation-wide active equine disease surveillance, sero-survey was conducted at Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, and Jammu and Kashmir. Antibodies to EHV-1 were detected in 7.1% samples, *Babesia equi* in 24.3% sera tested, and Japanese encephalitis in 5.5% serum samples tested. None of the serum samples tested was positive for equine infectious anemia, African horse sickness, equine influenza and *Salmonella* Abortus-equi. Outbreaks of glanders reported from Uttarakhand, Andhra Pradesh, Himachal Pradesh and Haryana were investigated and diagnosed, and etiological agent *Burkholderia mallei* was islolated. Comparative sero-prevalence of JE in different animal species (equine, cattle, buffalo, pigs) was done in different regions of Haryana and highest incidence was in buffaloes followed by pigs, horses and cattle. EHV-4 virus was isolated from 11 out of 138 samples using equine embryonic lung cells. These results were confirmed by sequencing of PCR products. The centre succeeded in *in vitro* cultivation of bloodstream forms of *Trypanosoma evansi.* The characterization of *T. evansi* antigen by SDS-PAGE of sonicated antigen revealed five major polypeptides in the molecular weight range of 41-81 kDa and proteins of 35-41 kDa exhibited proteolytic activity. Serum neutralization test (SNT) and haemagglutination inhibition (HAI) were standardized for specific differentiation of two related arboviruses i.e., Japanese encephalitis (JE) and West Nile virus (WNV). On comparison sensitivity of HAI was 96.29% and specificity 100% in comparison to SNT. RT-PCR using E-gene (291 bp) was also developed for diagnosis of JE in equines.

An ELISA was developed for detection of *Babesia equi* specific antibodies. The sensitivity and specificity of the ELISA in comparison to commercial CI-ELISA was 94 and 96%, respectively. To study the polymorhphism of the MHC class II gene in Marwari horses, regions of MHC class-II (DRB-2a and 2b) gene fragments of 276 bp and 229 bp were amplified. Restriction analysis revealed that MHC-DRB2 (276 bp fragment) on digestion with *Hin*fI exhibits polymorphism in 48.39% genotypes.

Microsatellite based parentage testing was done using 194 DNA samples collected from blood leukocytes of different horse breeds. Genotyping was performed by analysis of nine microsatellite and selected microsatellites were highly polymorphic as mean number of alleles ranged from 3.78 to 10.78. Total exclusionary power of both parents in all breeds was more than 0.9 and all the foals (67) qualified the offspring-candidate parent compatibility.

Yak

A slide enzyme linked immunosorbent assay (SELISA) was standardized for the detection of *Babesia bigemina* antibodies in yak sera. Serological studies for detection of *B. bigemina* specific antibodies in yak from an organized farm and under field conditions revealed 44.16 and 56.10% seropositivity, respectively. It could be concluded that being more economical and technically simpler, SELISA could be used for seroprevalence studies on babesiosis in yak.

Keratoconjunctivitis was noticed in yaks, and *Moraxella bovis* and *Neisseria* were recovered from the ocular swabs. Serum samples from the affected animals were analyzed by viral neutralization test. AB-ELISA for the presence of bovine herpes virus -1

Bovine herpes virus-1 associated kerato-conjunctivitis in a yak

Equine welfare

The centre extended equine welfare activities in different parts of the country by organizing equine health camps and farmer meets (*Ashwa Palak Goshthis*) to educate the equine owners on various aspects of disease control and management.

(BHV-1) specific antibody. Nested PCR conducted using glycoprotein B and glycoprotein E specific primers (of BHV-1) revealed the presence of BHV-1 in the ocular swab of the affected yaks. The serological and molecular analyses indicated the possible role of BHV-1 in severe forms of keratoconjunctivitis in yaks.

Yak sera samples collected from different yak tracts of India were screened for the detection of BHV-1 specific antibody. The overall prevalence of BHV-1 specific antibody was alarmingly high (more than 40%) in yaks. Sex and location of different yak tracts did not have any influence over the IBR prevalence. However, the prevalence increased with the age of the animals, and was highest in yaks more than 3-year-old. Conjunctivitis and reproductive abnormalities were predominant symptoms among the seropositive yaks. The common ecological niche for feeding, watering and grazing with other domestic and wild animals is the possible avenue of infection in yaks.

Poultry

Marek's disease virus (MDV) circulating in PDP flocks was low virulent strain. MD incidence could be reduced more effectively with HVT (cell free) double dose or HVT+SB1 cell associated vaccines than single dose of HVT vaccine. Tumour samples could be safely stored in phenol-chloroform-isoamyl alcohol for PCR. Leg weakness associated with osteomyelitis caused by *Staphylococcus* spp. was recorded in young broilers, while aspergillosis was observed in female line of Gramapriya.

FISHERIES

Capture fisheries

Marine fish landings and catch structure: The marine fish landings of India during the year 2007 has been estimated as 2.88 million tonnes with an increase of about 1.7 lakh tonnes (6.5%) against the estimate of the previous year. The pelagic finfishes constituted 57%, demersal fishes 25%, crustaceans 14%, and molluscs 4% of the total landings. The sector-wise contributions were — mechanized landings 68%, motorized landings 28% and the atisanal landings 4%. Among the commercially important groups, the landings of oil sardine (26% increase over the previous year), penaeid prawns (13.4%), Indian mackerel (26%), croakers (41.9%) and other clupeids (55.6%) recorded substantial increase over their previous year's landings. The landings of non-penaeid prawns (18.6% decrease from the previous year), ribbon fishes (44%), Bombay duck (4.8%), thread fin breams (16.3%) and cuttle fish (27.2%) recorded marginal to substantial reduction from their previous year's landings. The estimates of region-wise production in the total production were—north-east region 13.2%, south-east region 22.6%, north-west region 29.3%, and south-west region 34.9%.

Ring seine fishery for oil sardine along the northern coast of Tamil Nadu: Oil sardine (*Sardinella longiceps*), is the most important pelagic resource on the west coast of India, and its occurrence along the east coast was considered sporadic and rare. In July 2008, large shoals of oil sardine appeared in the near shore coastal waters of Devanampattinam, Cuddalore and Puducherry. This supported high catches in the ring seine units newly introduced fishing practice, from the near shore waters for a month.

Inland fisheries

Exotic fish species invasion in West Bengal wetlands – a cause of concern: During fish stock assessment, breeding populations of exotic tropical South American Sailfin catfish, *Pterygoplichthys disjunctivus* and *Pterygoplichthys pardalis*, were recorded in Gomokpota *beel* under East Kolkata Wetlands. Huge biomass of these species, approximately 20 metric tonnes, was caught in a single month. These fishes do not fetch remunerative price as food fish but occasionally find place in aquaria. These species are prolonged breeders and voracious detritivores. A number of other exotic fish species, viz. *Barbonymus gonionotus* (*Puntius gonionotus*), *Pangasianodon hypophthalmus* (*Pangasius sutchi*), *Clarias gariepinnus*, *Oreochromis niloticus niloticus* and *Piaractus brachypomus* were also recorded in some other wetlands in the state. This has serious ecological and economic implications for the wetland fisheries in the state.

Culture fisheries

Reservoir fisheries enhancement: Fisheries enhancement in reservoirs Dahod in Madhya

Revival of *ghol* and *koth* fishery along the coast of Gujarat

Making the end of long period of decline and poor catch of *ghol* (*Protonibea diacanthus*) and *koth* (*Otolithoides biauritus*), bumper catches of large size fishes by multi-day trawlers occurred at Salaya landing center, Jamnagar, Gujarat. They were caught from Bay of Kutch at 25-30 m depth.

Cobia fishery at Kochi

Cobia (*Rachycentron canadum*), highly priced, but previously of a rare occurrence in the catch, landed in large numbers at Kochi fisheries harbour by multi-day gill-netters and hooks and line units operated in distant waters continuously from September this year. Fishery was supported mainly by large adult fishes weighing 10kg to over 30 kg. Fishery and biology of the species are being monitored.

Pradesh and Pahuj in Uttar Pradesh, was attempted through stocking of fish seed and improvement of institutional arrangements for fish catch and marketing. This resulted in improved fish production by over 60% in one year of experimental intervention. The catch/month, total fish catch and per month fishing days increased. The case studies will be helpful in formulating strategies for reservoir development in the Indo-Gangetic basin.

Freshwater aquaculture

***Labeo gonius* in polyculture system:** The compatibility of *Labeo gonius* with other major carps was studied through three combinations catla, silver carp, rohu and gonius; catla, silver carp, mrigal and gonius; and catla, silver carp, rohu and mrigal at combined density of 7,500 fingerlings/ha. Silver carp gave higher overall species survival, while catla showed the lowest level. Survival of rohu, mrigal and gonius, was intermediate and did not differ among them.

Coastal aquaculture

Low fish meal feed for shrimp: A low fish meal shrimp feed was developed by replacing fish meal and other marine protein sources with plant protein sources. Shrimp production after four months of feeding on the low fish meal feed was 1,308 kg shrimp/ha with a feed conversion ratio (FCR) of 1.31:1. This feed can be successfully used for culturing tiger shrimp at low cost of production.

WSSV risks to shrimp farming due to increased culture of crabs: Crabs are known carriers of white spot syndrome virus (WSSV), hence to address apprehensions of shrimp farmers

Fish stock enhancement in beel fisheries

Haribhanga *beel,* covering an effective area of 125 ha, is under the control of Assam Fisheries Development Corporation (AFDC). The pen culture technology intervention in a partnership mode with leaseholder resulted in doubling fish production/unit and recording a benefit cost ratio of 1.89 and 2.01 for consecutive two years.

The fish catch recorded was 131.1 tonnes of which Indian major carps contributed the major share followed by exotic carps, thus registering per unit increase in per unit productivity to 1,050 kg/ha in the *beel*. With an initial investment of Rs 10 lakh, the net income was Rs 53.5 lakh. The benefit-cost ratio of the lessee was 2.40.

to crab culture, studies were carried out to assess WSSV risks to shrimp farming due to enhanced culture of crabs. The prevalence of WSSV in crustaceans in different geographical regions was estimated based on samples from Andhra Pradesh, Tamil Nadu, Maharashtra and West Bengal. The prevalence levels in crabs used for crab fattening or those found in wild crabs indicate that they do not pose any additional WSSV risks.

Coconut wood for canoe construction

The strength properties of coconut wood compare well with those of other structural timbers like teak and jungle jack, and studies showed that wood with a density of more than 600 kg/m^3 can be used for boat building. A plank built type of canoe (length 6.4 m, breadth 0.83 m and depth 0.42 m) for gillnetting in backwaters was constructed out of coconut wood of more than 50 years old. The price of coconut wood is less than half of the conventional boat building timber, viz. *aini* (*Artocarpus hirsuta*).

Canoe structured of coconut wood

10

Post-harvest Management and Value-addition

Thermal disinfestation set-up for pulses: Optimum combinations of temperature-time, vacuum-time and microwave energy-time were determined for chemical-free disinfestation of pulses. Insect mortality of 100% for the pulse beetle could be achieved at the temperature - time combinations of 55°C and 60 s or 60°C and 50s for all the 3 pulses, i.e. greengram, pigeonpea and chickpea. Optimum combinations of vacuum pressure and treatment duration in vacuum treatment of pigeonpea, chickpea, and greengram were 100 mm-Hg and 168 hr, 120 mm-Hg and 360 hr, and 120 mm-Hg and 96 hr, respectively. Optimum microwave exposure time at 700 W microwave exposure was found to be 70, 90 and 100 s for greengram, pigeonpea and chickpea, respectively. Thermal disinfestation equipment developed has a batch capacity of 100 kg. The cost of disinfestation is Rs. 1.10/kg of grain.

Thermal disinfestation set-up for pulses has a batch capacity of 100 kg

Production of full fat soy flour from sprouted soybean: Two varieties of soybean, viz. JS 9305 and MAUS 47 were found superior in nutritional quality. The best time, temperature and humidity combination for germination of these varieties was 3 days at 25°C and 90% RH. Germination improved the nutritional profile by improving solubility of protein, decreasing levels of fat, reducing the trypsin inhibitor levels to 60% and phytic acid levels to 50%. The sprouted soybean was dried to bring down the trypsin inhibitor content to safe levels and the moisture to 6–8% for milling. Sprouting, followed by sun drying is recommended for production of full fat soy flour (FFSF) to be used for incorporation into bakery products due to its superior functional quality. The steamed sprouted soybean, followed by sun drying is ideal for use at the domestic level and microwaving at 630 W for 9 min on a commercial scale for the production of FFSF. Sprouting of soybean, followed by drying leads to production of nutritionally enriched (high protein, low fat, high fibre), anti-nutrient free (safe levels of trypsin inhibitor, low levels of phytic acid), functionally

Aonla dietary fibre-enriched biscuits

Dietary fibre, vitamin C and antioxidant-enriched biscuits were developed by incorporation of *aonla* pomace (a byproduct generated in *aonla* juice processing). The dietary fibre content of the finished product was about 5 times higher than

the control, while vitamin C and antioxidant concentration were 15.6 mg/100g and 0.25 g %, respectively. Biscuits had a shelf-life of more than 3 months when wrapped in 100-gauge polypropylene pouches under ambient conditions.

Ready-to-eat bittergourd chips

Bittergourd chips were prepared and popularized among rural and urban areas as snack foods. The process for manufacturing of bittergourd chips involves cutting of bittergourd to 0.25–0.30 cm thick slices, followed by cooking in 0.1% sodium bicarbonate solution at 100°C for 30–40 min. The cooked bittergourd slices were subjected to osmotic diffusion treatment of 1–2% brine solution at 50–60°C for 2 hr. The osmotically diffused bittergourd slices were dried at 55–60°C for 5–7 hr and fried in refined oil at 160–180°C for 5–7 sec. The fried chips were packed in laminated pouch.

superior (good colour, nitrogen solubility, water absorption capacity) FFSF. Sprouted roasted soybean as a ready-to-eat snack was prepared by roasting sprouts at 180°C for 45 min, followed by addition of spices. The products contained 39% protein, 22% fat and negligible amount of trypsin inhibitor.

HACCP protocols for the production of soy biscuits: Hazard Analysis and Critical Control Points (HACCP) protocols were drafted for the production of soy paneer and soy biscuits. The guidelines included good manufacturing practices, good hygiene practices, and standard operating procedures which are the prerequisites for implementing the HACCP. The expected quality of these products under study were put forth which were experimentally verified with and without HACCP. The data indicate that HACCP yielded better quality soy paneer and soy biscuits. The soy biscuits may be used for theraputic purposes.

SUCCESS STORY

Using palm oil mill effluent

Palm oil mill effluent (POME), a waste released while processing fresh fruit bunches (FFB) in palm oil mills was evaluated for its use in animal and fish feed formulations as organic fertilizer and biogas production. Dehydrated POME could be incorporated in the diets of buffalo calves and buffaloes up to 40 % level, lambs up to 60 % level, kids (goats) up to 50 % level and piglets up to 20 % level. Dried palm oil sludge (POS) can be incorporated in the feed of freshwater fish Rohu as well as ornamental fish Koi- Carp up to 60% and for freswater fish *Catla catla* up to 40%. Inclusion of Palm kernel cake (PKC) in diets of Rohu showed good growth rate with 10% inclusion of PKC. The POME slurry is comparable and even better than cowdung for biogas production. Composite formulation of essential micro-organisms comprising Saccharomyces, Lactobacilli and Rhodopseudomonas improved the quality of POME by reducing BOD and COD to the eco-friendly level.

Similarly, the soy paneer processed through HACCP is of better quality.

Mango: An integrated protocol consisting of pre-harvest fungicidal spray, followed by standardized post-harvest practices and ma packing in semi-permeable d-955 film extended the storage-life of mango Alphonso and Banganapalli to 5 weeks at 8°C.

Papaya: A process was standardized to make osmotically dehydrated papaya slices from Taiwan Red Lady. Slices osmotically dehydrated using 60° Brix syrup containing 0.2% citric acid with additives produced best quality products with one year shelf-life at room temperature. Pre-treatment dip of slices in calcium chloride solution (0.5%) improved textural and sensory quality.

Grape: Minimum loss of weight was recorded in bunches of Tas-A-Ganesh with knot as compared to bunches without knot. The grape juice diluted with soda water up to TSS level of 14° Brix did not affect the acceptance in terms of colour, sweetness and flavour.

Banana: The storage of Ney Poovan banana was standardized at 13.5 °C. A recipe was standardized for preparation of banana flower-based ready-to-make soup powder. Storage method using steeping solution was developed for storage of banana stem for further product preparation or culinary use. The bulk production technique of banana wine was standardized where fermentation at 10 °C took 13 days for total sugars to reach below 1% and alcohol to 15%.

Litchi: The litchi fruits treated with KMS (1%), followed by citric acid dip (2%) and dried alternatively in sun and oven gave good quality litchi nuts.

Mahua: A process was standardized for developing good quality mahua wine by fermenting fresh flower juice with *Saccharomyces cerevisiae*. The wine prepared from fresh flowers had shining light yellow appearance than that made from stored flowers, which turned brown. The burnt rice flavour of mahua was suppressed by using lemon peel. The wine was siphoned, aged and bottled. The final alcohol content in mature wine ranged from 9 to 10%.

Mushroom: The washing treatment of 100 ppm EDTA + 0.02% KMS, followed by packaging in 100-gauge thick polypropylene bags gave superior shelf-life to stored button mushrooms. Blanching of oyster mushroom and milky mushroom for 2 min in 0.2% salt + 0.1% citric acid solution, followed by sun-drying improved the post-harvest shelf-life of both the mushrooms.

Onion: Irradiation of onion bulbs with gamma rays at 60gy reduced sprouting losses as well as total losses. The irradiation helps in reducing total losses by 20% and sprouting losses by 100%.

SUCCESS STORY

Gum technology from *Acacia senegal* in the Thar desert

Acacia senegal (Kumat) is an important source of gum-arabic that finds widespread use in medicines and pharmaceuticals, and is also an important component for paper, textile, adhesive, minerals, fertilizers, explosives, cosmetics, soap, ceramics, food, beverages and confectionary industries. In India, production of gum from *A. senegal* is meagre despite the occurrence of extensive stands of the tree in the dry parts of Rajasthan, Gujarat, Madhya Pradesh and Haryana. Consequently, the country imports annually 5,000 tonnes of the gum, especially from Sudan, costing Rs 7.3 million. The average international price of the Sudanese gum arabic is ~US $ 1,500/tonne.

Considering the market potential of gum arabic, a simple technology that involves administering a gum-inducing solution (ethephon) into the main stem of a tree through a small hole, plugging the hole with cleaned clay paste, and without causing any further injury or cut to the plant. The gum exudation starts within 5-10 days of giving the treatment and may continue for 1 or 2 months. Depending on environmental conditions, the appropriate time for treating the trees in western Rajasthan starts from the last week of February and extends up to May. The physico-chemical characteristics of the exuded gum conform to Pharmacopoeia of India specifications for Indian gum. The cost of the treatment is Rs 10/tree, while the gum production/tree is 500 g (average). The current sale price of the gum is Rs 100-300/kg.

This low-cost, environment-friendly technology is now being propagated through CAZRI's extension wing and the KVKs. The state government agriculture extension department has also started propagating the technology. Due to its immense benefit at no management cost, simple technique, low capital investment, low gestation period, high benefit:cost ratio, employment generation and utilization of existing natural resource, the farmers of western Rajasthan have tremendously responded to its adoption, especially in the districts of Barmer, Jodhpur, Nagaur, Bikaner, Jaipur and Bhilwara. The farmers are not only adopting the technology, but are also demanding to plant more *A. senegal* trees in their field boundaries, and in their community lands.

Widespread application of the gum-inducing technology would not only help the country to meet the domestic demand of gum-arabic and saving precious foreign exchange, but will also open the avenue for international marketing. It is estimated that there is scope for producing 20,000 tonnes of gum arabic for the international market.

Well-cured bulbs of *rabi* season treated can be stored up to 6 months. Genotypical differential response to gamma irradiation was also observed. Light red varieties mostly recommended for *rabi* season responded very well to irradiation than dark red varieties recommended for *kharif* and late *kharif* seasons.

Coconut: A prototype of small-scale fermentation plant was developed to produce virgin coconut oil by fermentation technique. Technology to produce sweet coconut chips, osmotically dehydrated using jaggery syrup and flavoured with natural cardamom, ginger and cumin was developed.

Ginger: Fresh ginger oil was rich in citral, whereas dry ginger contained higher levels of zingiberene, farnesene and sesquiphellandrene.The chief components of *C. sulphuratum* bark oil were identified as linalool and tetradecanal.

Cassava: Graft copolymers of cassava starch with acrylamide were synthesized, which had decreased crystallinity, hard texture and excellent water absorption capacity, film-forming property etc. These properties facilitate an enhanced use of the product in cosmetic and oil-drilling industries.

Functional pasta products (protein, fibre and carotene enriched) were made from cassava flour, incorporating whey protein concentrate (WPC), oat meal and carrot powder, respectively. Besides, functional extruded snack foods having minimum oil content, good puffing and high protein were made by fortifying cassava flour with defatted soy flour, finger millet, coconut residue (after virgin oil extraction etc.).

Skin care products from *Aloe vera*: *Aloe vera*, locally known as *guar patha*, is a traditional medicinal plant and is used as an ingredient in manufacture of several products (both edible and non-edible), including cosmetic ones. The plant is hardy and well adapted to arid region of Rajasthan. Locally the plant is also used as vegetable, but the potential of the plant has not been fully exploited.

Two products for skin care namely, aloe crack cream and aloe moisturizer, which are very useful for different types of skin were developed from *Aloe vera*. Each product has a shelf-life of more than 10 months. Aloe crack cream was found very effective against cracked heels and dry and dehydrated skin. It even stops bleeding from the cracked heels and makes the hard skin smooth within a week, if used properly. Aloe moisturizer is suitable for oily skin and prevents the skin from drying in winter.

Candy and preserve from tumba fruit: Tumba (*Citrullus colocynthis*) is a natural perennial creeper of the desert. The pulp of fruit is used as feed for animals and seed for extraction of non-edible oil used in soap industry. The fresh fruits have 72% pulp containing 0.22% cucurbitacin, besides 26%

oil and 13.5% protein in seeds. It profusely produces fruits (25–30 tonnes/ha). At Jaisalmer, Rajasthan efforts were made to provide value-additions to bitter pulp. Candy and preserve were made successfully which can be used as dessert purpose in confectionary, empty stomach intake lowers acidity and constipation. The preserve costs Rs 15/kg and the candy costs Rs 20/kg. At these prices the benefit : cost ratio for the preserve and candy would be 2 and 1.5, respectively.

Date products: At Jaisalmer, products like *chutney* and toffee have been prepared from unripe and low-quality fruits of date palm or *khajoor*. The date toffee has granular texture with good elasticity, which is liked by children. The date *chutney* has a pleasant aroma.

Solar PV mobile unit: A solar PV mobile unit was designed and developed to provide a complete self-sustained mobile power unit for domestic, small agricultural and other rural applications in isolated cluster of houses (*dhanis*) of arid region. It comprises an especially designed mobile structure to keep 2 PV modules (70 Wp each) facing due south at 26° from horizontal to receive maximum solar radiation and also to provide shade to sub-components. The PV modules are fixed on a folding system with auto locking arrangement, so that these panels can be folded inwards for easy movement of the unit and again opened to place the panels at an optimum angle. The frame of the mobile unit is made of iron angle with 4 wheels at the lower end of the frame (2 on the rear side and 2 on a guiding trapezoidal frame) with an appropriate handle to pull it with ease. Side support is provided to firmly hold a storage battery and electronic sub-systems on a wooden base to ensure intactness of the components during movement of the unit.

The PV array (140 Wp) output is fed to the battery (12 V 120 Ah) through a regulator and a maximum power tracker to charge the battery in an optimum way and then to derive power through an in-built inverter for the working devices that could be operated for illumination, running radio, a small TV in the domestic front. The unit can be used also for operating a churner for butter extraction and for winnowing operation. The utility of this power unit can be extended for other cottage-scale applications.

Production of beetroot powder and its utilization: The total time taken in drying of beetroot after blanching at different temperatures was in the range of 8–13 hr. The recovery of the completely-dried beetroot at different temperatures was in the range of 13.9 – 14.6%. The hammer mill was used for grinding the beetroot for powder. About 60% of the beetroot powder of 65 mesh size can be obtained from properly-dried beetroot. The mean particle size of the beetroot powder was 0.215 mm. The solubility of beetroot powder with different particle size was in the range of 77.3 – 79.9%. Average protein, fat, ash, fibre and total carbohydrates content in beetroot powder was 11.99%, 2.17%, 4.57%, 7.40% and 79.87%, respectively. Acid insoluble ash content in beetroot powder was 0.067%.

Ready-to-serve drink was prepared from beetroot powder with different level of sugar, citric acid and water and evaluated by a panel for different sensory attributes. The overall sensory acceptability of drink was maximum for the sample with 2.6 g citric acid and 225 g sugar/litre of the ready drink. The minimum overall sensory acceptability of the drink was observed for the drink with lowest citric acid and sugar content. Reconstituted drink to get the benefits of beetroot was developed using beetroot powder at 2.5, 3.5 and 4.5% with water and evaluated for different sensory attributes with reference to the fresh beetroot juice. The mean sensory scores for overall acceptability of reconstituted beetroot powder in the form drink at 4.5% level was maximum as compared to fresh juice.

Carrot powder: Carrot was dried after blanching. The total time taken in drying of carrot at different temperatures was in the range of 8–13 hr. The recovery of the completely-dried carrot at different temperatures was in the range of 8.4 – 9.4%. Carrot samples, 2 particle size, viz. 65 mesh size and 100 mesh size were evaluated for solubility at different water temperature (30–90°C) using the water bath. Solubility of the carrot powder of 65 mesh size was in the range of 60.19 – 69.65%. The solubility of carrot powder of 100 mesh size at lower temperature (i.e. 30°C) was slightly higher than the carrot powder of 65 mesh size. Solubility of the carrot powder of 100 mesh size was in the range of 64.25% – 69.8%. Average protein, fat, ash, and fibre content in carrot powder was 6.87%, 2.77%, 8.81%, and 8.38% (d.b.), respectively. Acid insoluble ash content in carrot powder was 0.36%. The carotene content in the carrot powder samples obtained from carrot dried at different temperatures was in the range of 60.47 – 70.82 mg/100g (d.b.).

***Aonla* pricking machine:** An *aonla*-pricking machine was designed and developed which reduces labour cost, maintains uniform pricking depth and improves efficiency and accuracy. It is operated with 1 hp motor and its capacity is 100 kg/hr.

Novel value-added extruded products using apple powder: The extruded product of apple powder was prepared along with rice brokens, wheat grits (*dalia*) and *dhal*. The products obtained were very tasty, crispy, had good appearance and

look like *kukure*. It does not have any sour and hot taste or any particular flavour, because the ingredients in the extruded product are only apple powder, *dalia*, rice, and *dhal* in 15:40:35:10 proportions. Colouring agents and artificial flavours were not added. Product scored 7.7 value during sensory evaluation on 9-point hedonic scale.

Drying of henna leaves using solar energy: Solar dryer took about 12–14 hr to dry henna leaves. The thickness of henna leave was about 0.399 mm and having moisture content of 221.54% d.b. It was found that solar-dried henna leaves retained good quality of green colour. Two-term model with highest R^2 value of 0.99 was found to represent the thin layer drying behaviour of henna leaves in solar dryer. Effective moisture diffusivity of henna leaves ranged from 8.27×10^{-10} to 1.278×10^{-8} m^2/s. The moisture diffusivity increased as drying air temperature was increased. The maximum temperature inside the solar dryer was 52°C and minimum RH was 9%.

Modified atmosphere packaging for okra and betel leaf: Okra, being very delicate should be handled gently after harvest, pre-cooled (hydro-cooled as well as air-cooled) and then stored under modified atmosphere packaging in perforated polypropylene film packages to extend its shelf-life reasonably, to maintain the qualitative parameters and its market quality. Under these conditions, the green colour retention would be substantial as well as no blackening of ridges would be observed for 7 days of storage.

Okra should be stored under ideal temperature range of 10–15°C. Beneficial modified atmospheres containing low O_2 (6–8%) and high CO_2 (11–13%) concentrations can be generated automatically in polypropylene (PP) film packages. To create these modified atmospheres, okra should be packaged (500 g) in the perforated (2 holes; hole diameter: 0.3 mm, normal pinhole) normal polypropylene film packages (bag dimensions: 210 mm × 275 mm; thickness: 35 micron) and then kept for storage at 15°C. Under these conditions, the equilibrium gas concentration is suitable for retention/maintenance of its bright green colour, retention of qualitative parameters and a shelf-life of 7 days without blackening of ridges or excessive weight loss. Also, under these storage conditions, the water vapour production is checked which helps in maintaining the qualitative parameters.

Modified atmosphere (MA) technology was applied at CIPHET, Ludhiana for packaging of betel leaf for retail handling and storage. The pigments and phenolic content of betel leaf can be sufficiently maintained in polypropylene film packages which show the potential of use of MAP for packaging of betel leaf. Betel leaves can be stored for 10 days at 20°C under MAP.

Continuous feed seed removal unit for *aonla:* A continuous feed type *aonla* segmentation unit was developed for removal of seeds from fruit for use by the *aonla* processing industries. The *aonla* fruit to be processed is placed on the rotating indexing assembly having 6 holes. A hole provided at the bottom allows discharge of the seed into the bottom-collecting tray. The process time is regulated by using the control panel assembly and controls the speed of the motor, synchronization of the cutting knife assembly and indexing table.

Continuous feed seed removal unit for use by the *aonla* processing industries

Production of fruit and vegetable-based bars/ confectioneries: Production processes for 5 types of fruit-vegetable bars, papaya-pumpkin, papaya-bottleguard, papaya-brinjal, papaya-cabbage and papaya-cauliflower and candy from *aonla* for pilot-plant scale production of 50 kg/day were developed. The quality of the bars/candies was found good on account of texture, colour, microbial load and consumer acceptance. Establishment of plant for production of 12,500 bars/candies annually may need an investment of Rs10 lakhs. The cost of production will be Rs130/kg.

Production processes for 5 types of fruit and vegetable bars

Large cardamom dryer for NEH region: The dryer installed at Sikkim centre, Gangtok was tested on site. The modified drying equipment

has capacity of 600 kg/batch of fresh (wet) cardamom. The drying temperature of 55–60°C was maintained uniformly in plenum chamber. It took about 12 hr to bring down the moisture content (wb) from 85 to 15%. There was no loss in quality, especially in natural colour of the husk of cardamom, which remained same after drying. The dried product was of A-Grade quality.

Wool: Work on technical felt revealed that non-woven felts from different blends of Bharat Merino wool with rabbit hair, viscose and cigarette fibres in the proportion of 50:50 having different thickness of 2, 4 and 6 mm could be prepared. The felts of less than 4 mm thickness were converted into value-added products like jackets and women ruffles. These products enhanced quality and consumer acceptance due to better lustre, durability and thermal insulation values. These products have great demand and can create employment opportunity in the rural/unorganized sector.

Microspinning of cotton sample: A new machine for lap preparation was developed at CIRCOT that is suitable for opening cotton samples weighing approx. 60–100 g and then converting them into mini laps in about 15 min. The machine has 3 motors, one each for feed, delivery and suction. The Inverter drive for speed control enables quick adjustments of speeds of the working elements. This new device was found to perform satisfactorily with quality output.

Extraction of banana psuedostem fibre and its utilization for preperation of value-added products: Experiments conducted on spinning of banana on jute system revealed that it is possible to produce yarns to tex values matching those for jute. Doubling of banana yarn improved its breaking load, breaking extension and tenacity by more than 50%. Addition of 20% jute in banana fibres also improved the breaking extension and tenacity of the blended yarn. These yarns were converted into plain woven fabric of about 250–400 GSM. This fabric may be useful as upholstery.

Paper produced from banana cut fibres obtained from scutcher waste was noted to have high quality; with the quality improving further with the use of NaOH in pulp preparation. It was observed that paper made from long length textile grade fibres of banana was of much better quality than that obtained by using cut fibres, matching with the quality of currency paper.

Characterization of natural dyes: HPTLC patterns of the extracts from flowers of marigold (3 types), chrysanthemum (2 types) and aster were developed in a solvent system which also facilitated recording of uv-vis spectra of the separated constituents. It could be inferred from the position of spots on the chromatogram and their uv-vis spectra that basic HPTLC pattern of all marigold flowers was similar and it was different from the basic HPTLC pattern of chrysanthemum and aster flowers. Basic HPTLC patterns of both types of chrysanthemum flowers were similar and had a resemblance with a part of HPTLC pattern of aster. Thus, it is inferred that the basic HPTLC pattern can serve as a marker for identification of these flowers.

Dyeing of jute fabric with sulphur dyes: Several sulphur dyes free from banned amines and safe from ecological considerations were used for dyeing of jute fabric and the dyeing process was standardized. The dyes are Ecofast Rubber Brown 31, Ecofast Dark Olive 44, Ecosol Navy Blue IRR, Ecosol Yellow IGCD, Solsul Mandarin Orange ZYY and Solsul Swedish Blue ILW. Evaluation of sulphur-dyed samples reveal that all the above dyes produce good colour yield and fastness properties. Sulphur-dyed jute fabric retains its tensile strength and the handle properties are also improved. Accelerated tendering test of sulphur-dyed jute fabric shows no negative effect.

Ornamental jute fabric: A handloom was designed, developed and fabricated exclusively to be used for jute and other fibres in blends. Shuttle box and sley race were incorporated to run big shuttle. There is no interruption in weaving, as in conventional looms, due to a positive take up arrangement. Cloth roller and cloth beam are inside the loom to hold longer length of fabric. The double beam arrangement facilitates feeding warp yarn of different linear density so that variable warp yarn tension is avoided during weaving and varieties of designs can be made through jacquard shedding.

Bioscouring of jute: To overcome the discrepancies of scouring by alkaline treatment the process of bioscouring was developed. It is a treatment with cellulose/xylanase enzyme and non-ionic surface active agents. The process has been standardized for jute fabric and the bioscoured samples have been found to be far superior to the alkali-scoured samples in respect of optical properties, absorbency, handle property and tensile characters.

Mannual ribboner and improved ribbon retting technology for jute: Technology of accelerated and eco-friendly retting of jute, developed by NIRJAFT, has been accepted by the Ministry of Textiles, Government of India as well as Department of Agriculture, Government of West Bengal for implementation under the Jute Technology Mission programme.

Frontline demonstrations have established consistently that the fibre quality is improved by 2 grades, retting period is shortened by 7–8 days and the requirement of water is reduced from 1:20 to 1:3 (plant:water).

Visual test for detection of adulteration of soymilk in milk: A colour-based test for detection of presence of soymilk in milk was developed, which is based on inhibition of activity of exogenously added enzyme by components of soymilk. Pure milk gives pink colour, whereas adulterated milk shows drastic reduction in the intensity of pink colour, which can be visually distinguished. The test results can be obtained in 50 min. The sensitivity of test is 2.5 to 10%, depending on the methods of preparation of soymilk. Other adulterants such as urea, starch, glucose, sucrose, hydrogen peroxide and formalin do not interfere with the test. The test does not require any expensive equipment and can be applied at quality control laboratories.

Reduction in colour intensity indicates presence of soymilk in milk

Immunological test for detection of adulteration of soymilk in milk: An immuno-diffusion test for detection of adulteration of soymilk in milk was developed. The test has the sensitivity to detect presence of 3% soymilk in adulterated milk. The results are available overnight. The precipitation (antigen-antibody complex) lines are stained for enhancing visibility. An innovative step in test was added to allow flow of milk micellar proteins in agarose gel during diffusion. The test does not require any expensive equipment and can be applied at quality control laboratories.

Technology for the manufacture of *Kradi*: *Kradi* (semisoft cheese), hitherto undocumented traditional dairy product of Jammu and Kashmir, is consumed either as a fried spiced item or a culinary dish. A process was standardized for its manufacture. The product was better than market samples on sensory evaluation. The vacuum packed product had a shelf-life of 15 to 20 days at 25°C, 3.5 to 4 months at 5°C and more than 6 months at –20°C. The developed technology could be commercially utilized for large-scale manufacture of this product.

Quarg type cheese from buffalo milk: Quarg is essentially a milk protein paste, manufactured by acid coagulation of milk by proper bacterial cultures with a small rennet addition for better separation of the protein coagulum from the whey. A process was developed for its manufacture from buffalo milk. Quarg cheese is of high nutritional value due to high concentration of proteins. It is excellent carrier for probiotic micro-organisms.


Buffalo milk quarg cheese

***Khoa* from low fat milk:** An integrated three-stage thin film scraped surface heat exchanger (SSHE) was designed and fabricated. Its performance was evaluated to manufacture *khoa* using low fat milk having 2, 3 and 4% fat. Yield is 50kg/hr *khoa* with buffalo milk (6% fat) and was enhanced to 120 kg/hr, if milk is pre-concentrated to 30%. It can run with buffalo milk and cow milk with any fat level. This method is hygienic and sanitation-friendly.

Meat and meat products technology

- Technology for the production of functional mutton nuggets was evolved.
- Identified optimum handling practices, new tenderization techniques and product formulations for efficient utilization of sheep and goat meat.
- The assessment of quality and safety of meat spread revealed that the product could be safely stored up to 60 days at refrigerated and 6 months at frozen temperature.
- **Sensory evaluation of mutton nuggets:** Mutton nuggets with low salt, low fat and high dietary fibre had very good acceptability on scientific evaluation.
- **Sensory evaluation of chicken soup:** The overall acceptability of premium chicken soup, with low salt and traces of fat was evaluated as 'very good' on scientific evaluation.
- **Assessment of the impact of technologies generated by IVRI:** Impact assessment of Olinall skin ointment, IVRI crystoscope and area-specific mineral mixture was done by collecting data from dealers, field veterinarians and farmers from Uttar Pradesh and Uttarakhand. The respondents considered the technologies as very useful.

Benefits of larger weight broilers: Broilers of relatively lower live weight are being produced in the country. Yield of deboned meat from primal cuts (leg, breast, and wing drummets) could be increased by 74.49 g, 36.34 g and 27.98 g,

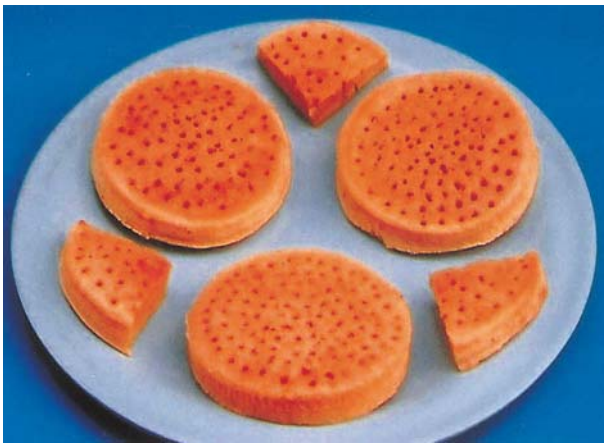
Whey-based oral rehydrating solution

The possible use of *Lactobacilli* with whey and its electrolyte for the therapy against diarrhoea was explored. Sodium, potassium, calcium and chloride contents are significantly present in higher concentration in paneer whey, the largest byproduct of dairy industry. The *Lactobacillus casei* 299 proved to be the most acid tolerant–surviving after 3 hr at pH 1.5. The highest bile tolerance was observed in NCDC 11 and NCDC 291 at 2% up to 12 hr. NCDC 17 and NCDC 299 showed maximum inhibitory zone against five diarrhoea-causing pathogens. Cell surface hydrophobicity was maximum in MTCC 1408 (77.10%), NCDC 299 (70.60%), followed by *L. paracasei* 17 (66.05%). All *Lactobacilli* strains were resistant to co-trimoxazole, metronidazole and vancomycin but sensitive to teteracycline and chloramphenicol. In simulated gastric and pancreatic juice, whey protects the cell from reaching the death by increasing the overall pH and inhibiting digestive protease activity. NCDC 17 and NCDC 299 grew faster in whey within 24 hr. The minimum residual lactose was observed for *L. paracasei* NCDC 17 (3.6mg/ml). Only NCDC 17 could suppress the growth of *Salmonella* in 24 hr of fermentation. Cell-free supernatant (whey) of NCDC 17 and NCDC 299 results in maximum reduction in viability of *Salmonella* within 8 hr of incubation.

Whey was fermented at 37°C for 24 hr with best selected probiotic culture (NCDC 17 and NCDC 299), and glucose supplement and base supplements were added along with orange flavour (food grade) after the fermentation was over. Fermented whey oral rehydrating solution (ORS) was sustainable at 4°C for 30 days. Small intestine showed the disruption of villi, oedema and increased PMNs during diarrhoeal infection. Fermented whey ORS treatment decreased intra-and-inter villi oedema and reduced villi disruption. Anti-*Salmonella* and anti-*Shigella* antibodies were secreted after drinking fermented whey ORS, which was effective in displacing pathogens. Findings indicated that whey is the best milk-based medium where fermentation with probiotic bacteria can enhance its therapeutic capability. A vacuum dried Bio-ORS was prepared by using whey as base and a standardized method for the formulation.

respectively, when broilers were grown from low to heavy, low to medium and medium to heavy weight, respectively. Cost of protein production was 26.86% less in heavy weight broilers compared to low weight. Heavy weight broilers also facilitate development of processed meat sector with higher yields of special cuts like chicken tenders. Thus, producing broilers of heavier weights has indicated benefits of producing primal cuts, deboned meat and valuable protein at lower cost to benefit the producers and consumers.

Shelf-stable meat products: ***Chicken dried meat:*** Technologies to prepare dried meat were developed. It is not only a value-added variety product but the technology is also useful when chicken prices are low due to poor demand.



Egg waffles

Chicken meat pickle: Technology was developed for preparing chicken meat pickle utilizing cooked meat from deboned frames, a byproduct of poultry processing industries. It is a value-added product and shelf stable for about 5 months.

Value-added egg product: Egg waffle, a nutritious and versatile snack food perfect for the breakfast meal, has good market potential, particularly at growing fast food outlets. Standardized processing methodology was developed. Egg waffles contain 13.72% protein, 12.53% fat and 34.1% moisture with low aerobic bacteria and yeast and mould counts (log 1.4–1.9 cfu/g, respectively) and complete absence of coliforms and staphylococci. Egg waffles, in vacuum, indicated an ambient (24±1°C) shelf-life of 4 days, and in aerobic packaging 3 days as against 10 and 6 days in respective packs at refrigeration temperature (4±1°C) with acceptable sensory and satisfactory microbiological quality. The cost of formulating one kg of processed ready-to-eat egg waffles was Rs 73.85 and of one cooked egg waffle weighing about 45g was estimated to be Rs 3.32.

Maricream: Maricream, essentially a ready-to-eat and highly nutritious product containing deodorized fish protein, is a mix of water, cooked cuttlefish, meat, sugar, butter, egg white, flavouring substances, stabilizers and emulsifiers. Cephalopods other than cuttlefish can also be used for maricream preparation. One important difference with other desserts is that the protein component is provided from a marine source. The product packed in plastic containers (food grade polypropylene), is frozen at –20°C and stored at –15°C. The product may be transported in insulated boxes under cold chain conditions.

Fish-enriched noodles: Fish-enriched noodles

were prepared to improve the nutritional value (protein, calcium and phosphorous) and taste of the market noodles. Shelf-life of dried fish noodles is 4 months at room temperature, and it could be a popular fast food item considering its nutritional and organoleptic qualities.

- Sandwich paste was prepared from Sciaenid fish and fortified with EPA and DHA in retortable pouch
- Fish curry prepared from freshwater fish tilapia (*Oreochromis mossambicus*) in retortable pouch

Improved lobster traps: Improved standard lobster traps were fabricated under the collaborative project Participatory Management and Conservation of Lobster Resources along the South West Coast of India (MPEDA, CMFRI and CIFT), and these traps were distributed to fishermen of Kadiyaptnam and Enyam fishing villages of Kanyakumari.

Solar dryer with LPG back-up: A fish drying system was developed using solar energy. Fish can be dried continuously by harnessing solar energy and using LPG back-up system to obtain a good quality product, with reduced drying time, without insect damage or contamination, and longer shelf-life. The dryer could also be used for fish, fruits, vegetables, spices and agroproducts.

Status of lac production, marketing and processing: Chhattisgarh and Jharkhand together produce two-thirds of the total lac production in the country. The total lac production during 2007–08 was estimated to be 20.6 m.kg. The other major lac producing states are Madhya Pradesh, West Bengal, Maharastra, Gujarat and Andhra Pradesh. A total of 29.8 m.kg. lac was processed during 2007–08. The import and export of lac was about 7.3 m.kg. each during the period.

Genetic diversity in Indian lac insects: Forty-eight lac insect lines, of the above collection were analyzed through RAPD markers. The RAPD profiles could clearly discriminate the lines and was used to develop a dendrogram based on Jaccard's similarity co-efficient and UPGMA method. The similarity co-efficient calculated was 0.34-0.92, suggesting the existence of a wide genetic diversity between the lines. The clustering analysis from RAPD data revealed 6 distinct clusters. Twenty lac insect lines were analyzed through ISSR markers which showed a similarity co-efficient range of 0.25–0.81, demonstrating a wide genetic variation of the lac insect lines studied. The clustering analysis from the ISSR data could group the 20 lac insect lines into 4 major clusters. The RAPD and ISSR markers were also employed to differentiate between 8 wild type (crimson) and yellow colour mutant of lac insect populations, each in a pair-wise fashion. Besides characterization, the above study has helped in understanding the genetic diversity in the lac insect lines and their phylogenetic relationship.

Physico-chemical parameters of lac from different countries

Seedlac of various countries	Major physico-chemical parameters			
	Colour	Flow (mm)	Life (min)	Bleach index
Indian	9	54	61	80
Thai	18	20	46	140
Chinese	20	20	44	140
Indonesian	16	16	60	110

Technologies assigned for commercial transfer

- A latex agglutination test for detection of Newcastle disease (NRDC)
- Swine fever virus cell culture vaccine (NRDC)
- Fusion protein and nucleotide as *Brucella* vaccine (BCIL)

Pilot plant of aleuritic acid: A pilot plant of aleuritic acid (capacity: 2 kg/batch) was set-up at Processing and Demonstration Unit of IINRG, Ranchi for training, demonstration and process refinement. Aleuritic acid (9, 10, 16-Trihydroxy-hexadecanoic acid), a major constituent acid of lac resin is present to an extent of 35%. It is a white powder moderately soluble in hot water and completely soluble in the lower alcohols such as methyl, ethyl and isopropyl alcohols. Most of the present production of aleuritic acid is exported. The market price for bleached aleuritic acid is about 1,000–1,200/kg.

Pilot plant for preparation of pure lac dye: A pilot plant for preparation of pure grade lac dye was set-up for training, demonstration and process refinement at IINRG, Ranchi. Natural pure lac dye represents a more sustainable source of colourants compared to synthetic counterparts. Natural colourants are used widely in food and beverage industry. The yield of pure lac dye was about 0.25% on the weight of sticklac, with purity of more than 99%. The dye gave a deep orange-red colour in aqueous solution.

The dye content was 70–71% and ash content 0.71–1.10%, respectively. The melting point was 230–238°C and soluble in cold water.

Transfer of technology: Training of lac cultivation, processing and uses was provided. A total of 161 courses were conducted benefiting some 10,643 people.

Entrepreneurship training was provided on the preparation of aleuritic acid, bleached lac, isoamberlite and processing of lac.

11

Agricultural Mechanization and Energy Management

A brief description of machines developed for seeding and placement of fertilizer, planting, puddling, spraying, trash shredding, harvesting and weeding is presented here.

Animal-drawn zero till seed-cum-fertilizer drill: The zero till seed-cum-fertilizer drill (unit price of Rs 3,500) was used for direct seeding of wheat and placement of fertilizer without preparatory tillage under high soil moisture condition. By use of zero till drill the seeding was done timely for higher yield at reduced cost of cultivation. The direct savings in cost of operation for sowing wheat compared to the traditional practices of farmers (cost of operation, Rs/ha = 3,000 for 03 tillage and seeding behind country plough) was Rs 2,250/ha. Considering the command area of the drill of 03 ha, the total annual benefit was Rs 6,700/machine.

Animal-drawn improved puddler: Improved puddlers of different designs were developed for puddling of rice fields prior to transplanting. It was advantageous in terms of better puddling with reduced number of passes (2 nos.) compared to the traditional method of puddling by use of wooden comb harrow (4 passes) or mould board ploughing and planking. Due to rolling, the draft load on the animals was low (60 kg) compared to the traditional puddler and the work rate was higher due to increased size and requiring less number of passes to prepare the puddle bed. The unit price of the improved lug wheel puddler is Rs 5,000 and its field capacity is 0.08 ha/hr. Direct saving in cost of puddling operation compared to the traditional practice of farmers (Rs/ha = 2,600) is Rs 1,850/ha. Considering the command area of 03 ha, the total annual benefit to the farmers was Rs 5,550/machine.

Animal-drawn tool carrier with ridge maker for vegetable cultivation: Rider bottom as an attachment to the tool carrier was developed for making ridges for planting of vegetable seeds/ seedlings. Compared to the manual ridge making by spades (Rs 20/100 m length of ridge; size, mm; base width = 300, top width = 100 and height = 100) the animal-drawn rider with tool carrier could save Rs 15/100 m length of ridge, besides making the work faster for seasonal planting. The unit price of the ridge maker attachment is Rs 1,000. Its average field capacity is 1,000 m of ridge/hr. The unit may be more useful for ridge making in lighter soils for raised/broad bed cultivations.

Animal-drawn biasi rice cultivator

The 2-row improved biasi rice cultivator gave higher work rate and reduced plant mortality compared to the traditional practice. The unit price of the improved biasi cultivator is Rs 2,000 and its draft requirement is 50 kg. Compared to the traditional practice of farmers (cost of biasi operation, Rs/ha = 1,350) the improved 2-bottom biasi cultivator saved Rs 700/ha. Considering the command area of 04 ha the total annual benefits was estimated to be Rs 2,800/unit.

Rotary transmission system for electricity generation using draught animals: To increase the annual utilization of draught animals, rotary transmission system was developed for rotary mode application of draught animals, especially during off-seasons with gadgets for electricity generation and agro-processing. Gear transmission system is with speed step up of 01:125; further stepping the speed up by pulley-belt combination to the input shaft of the alternator. The generated electricity is stored in battery (17 plate, 12 volt) with back-up time of 04 hr at output load of 250 W. Processing gadgets: seed cleaner-cum-grader, maize sheller, chaff cutter and flour mill were evaluated for output of 300, 120, 40 and 8 kg/ha, respectively using one camel on the rotary system.

A camel power-based rotary complex for electricity generation and agro-processing was established at the NRCC, Bikaner for further testing and demonstration.

Package of matching equipment for donkeys: A package of improved equipment matching the power output of large white Kathiawad breed donkeys (body weight = 150 kg and pulling capacity = 30% of body weight) was developed for field operation and transport. The package includes harness, iron plough, blade harrow, 2-row seed drill, blade hoe, 2-wheel steel cart and agro-processing gadgets (chaff cutter, caster decorticator and winnower) for operation in rotary mode.

A set of donkey-drawn implements with modified harness (modified Balram plough blade harrow, blade hoe, 2-row seed drill, seckon type harness with yoke, breast-cum-shoulder harness and single donkey steel cart) was supplied to NRC on Equines, Hisar for further testing and demonstration for use by farmers in light soils.

Rotary nozzles for tractor-operated sprayer for mango orchard: Rotary nozzles for mango orchard was developed. These nozzles were tested in the lab as well as in fields. The nozzles provide effective spraying, reduce loss of pesticide, cover large area of plant canopy and found effective in proper and even placement of pesticides. Field testing of tractor-operated Tycoon sprayer equipped with rotary nozzles was conducted for spraying operation in mango orchards.

Chopper type tynes for power tiller rotavator for sugarcane trash shredding: Handling of sugarcane trash and its incorporation in the soil is a big problem. Hence, chopper type tynes were developed for power tiller rotavator for sugarcane trash shredding. When L-shaped tynes are used for sugarcane trash shredding, entanglement of trash around the rotavator shaft is observed. The normal angle for L-shaped tynes is 118° +/-2° which was changed to 160° – 180° to make it chopper type tynes. Field trials of power tiller rotavator equipped with chopper type tynes were conducted as per BIS/RNAM test code on an area of above 2 ha. Effective field capacity of power tiller rotavator equipped with chopper type tynes was observed to be 0.065 – 0.085 ha/hr with 66.60 – 82.27% field efficiency. Operating cost was observed to be in the range of Rs 977 – 1,314/ha. Significant reduction in sugarcane trash size was observed in both field trials.

Self-propelled lucerne harvester: A walking type self-propelled lucerne harvester was developed. It consists of a gearbox and cutter bar. Cutter bar is bi-directional reciprocating type made from high carbon steel. Length of stroke for cutter bar is 25 mm and effective width of cutter bar is 860 mm. A man can walk behind the machine with an average speed of 2 km/hr. The recommended speed ratio of the average cutter bar speed to the forward speed of machine is 1.3 : 1.4. Two wheels are used for transportation purpose. The ground wheels drive the reel of the harvester. Ground drive provides the desirable feature of maintaining a constant speed ratio between peripheral speed and forward speed. The effective field capacity was found to be 0.113 ha/hr and field efficiency was noted as 70–75%. The average cost of operation was found to be Rs 850/ha as against Rs 1,770/ha by conventional method, giving a net saving of 52% in cost and 90% in time.

Tractor-operated vegetable transplanter for brinjal, cauliflower and tomato: A 2-row tractor-operated vegetable transplanter with picker wheel type metering mechanism was developed for transplanting seedlings of brinjal, cauliflower and tomato etc. It was modified to 3 rows to increase the capacity of the machine. The plant-to-plant spacing and row spacing in the modified machine can be adjusted to suit for transplanting requirements of different types of vegetables/crops. The plant-to-plant spacing in both the machines can be varied as 30, 45 and 60 cm by changing sprockets or number of fingers. Trials in chilli, cabbage, cauliflower, gobi sarson and brinjal indicated that the plant missing was about 2 – 3.5% at a speed of about 0.8–1.0 km/hr depending upon the plant-to-plant spacing and skill of operator. The yield was at par with the traditional methods. The machine saves about 80–84% labour in comparison to manual planting depending on crop spacing. The approximate price of the machine is Rs 70,000.

Tractor-operated rotary weeder: A rotary weeder was developed, consisting of a main frame, gearbox, 3 rotary weeding blade assemblies, a square shaft for transmission of power from

Tractor-mounted onion harvester-cum-elevator

Onion harvester-cum-elevator was developed for digging onion and other root crops. It consists of a digger blade made from high carbon wear-resistant steel. The width and thickness of the blade is 1,144 mm and 16 mm. The field capacity of the machine is 0.28, 0.24, and 0.21ha/hr when operated at speed of 2.78, 2.41 and 2.10 km/hr, respectively, whereas the damage is 1.98, 1.92 and less than 1.0%, respectively. The saving in labour ranged from 62 to 71%. Saving in cost of operation and labour for harvesting onion, carrot and garlic was 52.28, 46.71, 52.28% and 69.05, 59.29 and 69.05%, respectively as compared to manual harvesting. The approximate price of the machine is Rs 40,000.

gearbox to rotary assemblies and sets of sprockets and chains. A standard 3-point hitch arrangement has been provided to mount the frame to the tractor. Power from tractor PTO is transmitted to main square shaft through gearbox mounted on mainframe and set of sprockets and chain. The speed reduction from PTO to gearbox is 5:9. The machine was operated in more than 8.0 ha area on farmers' fields. It saves 54% labour and 74% cost of operation as compared to traditional method. The cost of the machine is about Rs 60,000.

Farmyard manure spreader: A 2-tonne capacity tractor-operated farmyard manure spreader was developed. It consists of manure spreading unit, feeding auger and slanting platform to convey the farmyard manure to the spreading unit. The field capacity and field efficiency of the machine were 0.34, 0.35, 0.36 ha/hr and 75, 76 and 74% at forward speeds of 2.25, 2.32 and 2.4 km/hr, respectively. Average width of application was 2.0 m. Manure application rate and uniformity of manure spreading increased with increase in flow/delivery rate of manure from the opening.

Controlled traffic rotary no-till slit drill: A 7-row (30 cm row spacing) controlled traffic rotary no-till slit drill for sowing of soybean under crop residue of wheat crop was developed. A modular seed box with furrow opener was directly mounted on rear frame of seed drill. The modular unit consists of primary and secondary seed hoppers and vertical rotor type seed metering system. The 180 mm diameter rotor picks the seed from secondary seed box and drops it in the seed delivery pipe. The flow of seeds from primary to secondary hopper is controlled through an adjustable seed delivery chute. Press wheels are provided in front for sowing under crop residue of wheat and rice.

Manually-operated tool for de-suckering for hill banana: A manually-operated banana de-suckering tool was developed. The tool consists of a handle for pushing the scoop and a pipe to which a de-suckering scoop is attached at the end. A small footrest is provided on the pipe for applying additional force for penetration in the sucker zone. The tool is effective in removal of the unwanted suckers in hill banana.

Desuckering and clump removal equipment for hill banana: The prototype of banana clump removal equipment, developed earlier, was attached to the light weight power tiller and tested at farmers' field at Gobichettipalayam, Erode district, Tamil Nadu. The average time taken to remove the big clump in dry condition was 5 min. and only 30 sec. for small clump in wet conditions. Serrated blade is provided at the cutting edges of the screw for easy cutting of clump material.

Raised bed maker-cum-planter-cum-cultivator: A customized raised bed maker-cum-planter-cum-cultivator for field trials was developed. The machine consists of 3 toolbars; the ridgers are mounted on the front, cultivators on middle and planting units on the rear toolbar. The rear toolbar on which planting units are mounted can be detached for interculture operations. For planting operation, the spacing between ridgers can be adjusted according to tractor tread. The working width of the machine is 1,500

Desucking and clump removal equipment takes 5 min to remove big clump in dry condition and only 30 sec for small clump in wet condition

Mole plough for Vertisols

A mole plough was designed and evaluated for its performance at CIAE farm. The dimension of the mole plough includes a leg with 1,000 × 250 × 25 mm and a foot of 100 mm with 110 mm bullet diameter. The total weight of the plough was 85 kg. Since the mole drain formation depends on the soil physical properties, soil samples were collected in 3-day interval to form mole drains during optimum moisture content (22–26%), using liquid limit apparatus. The liquid limit of soils in the experimental plot was worked out as 47.81% and plastic limit was found to be 22.7%. Unit cost of mole plough is Rs 8,000.

An increase of above 50% soybean yield was observed in 2, 4 and 6 m mole drain spacings, over control. The drains are functional for the last 3 monsoon seasons. Output capacity was 0.28 ha/hr at 4 m drain spacing.

One labour was required for monitoring the pump used for draining out the collected water. Cost of operation of the mole plough at 2, 4 and 6 m drain spacings was Rs 3,182, 1,811 and 1,169/ha, respectively. The drains performed well continuously for the 3 seasons. The returns on the investment can be obtained in the first year of installation due to enhanced soybean yield. Increase in yield of soybean due to mole drainage is @ 3 q/ha. The increase in income was worked out Rs 3,000/ha/year.

ORP trials of the technology were successfully carried out at farmers' fields in the villages of Raisen and Bhopal districts.

mm. During planting operation, the ridgers make a raised bed on which seeds are placed by the modular planting units. The spacing between the rows can be adjusted and minimum spacing of 225 mm can be achieved. The machine can also be used for intercrop sowing. Each of the functional components is modular and can be adjusted as per the requirements. Two units of the machine have been supplied to ICRISAT for sowing of soybean in Raisen and Sagar districts.

Energy saving control strategy for polyhouse environment under warm-humid climates: To save energy, a strategy with combination of different systems, i.e. natural ventilation system, fan and pad evaporative cooling, fogging and shading was worked out. The study was conducted with a pipe framed polyhouse (16□× 40□) equipped with various cooling and controlling devices and operating systems like mechanized natural ventilation, exhaust fan, excelsior cooling pad, wind pump water delivery and micro tube irrigation system, microprocessor-based greenhouse controlling system, foggers cooling and different pumping units.

In January, ventilators may be kept closed during night time to take advantage of CO_2 enrichment. In February, ventilators may be kept open during 9AM–5PM and closed during off sunshine hours, however, suitable shading may also be used during peak sunshine hours, i.e. between 12 noon and 3 PM. In first fortnight of March, use of evaporative cooling and shading may help to reduce 1 – 2 hr evaporative cooling period. During second fortnight, use of shading with forced evaporative cooling methods bring down inside air temperature below optimum range (25±5°C). Natural ventilation is enough during night hours. In April, suitable night cooling is also needed in addition to shading with forced cooling during day hours. During May–June, forced cooling with shading is needed in the greenhouse to bring down the temperature within the good production range.

Drainage technologies for crops sensitive to waterlogging in Vertisols: Surface and sub-surface drainage (SSD) systems for maize and pigeonpea crops were designed using meteorological data of 20 years. The different kinds of SSD systems (SSD with filter, SSD - chimney with filter, combination of surface and SSD with filter and SSD without filter) were installed at 20 m drain spacing and 1.0 m depth with drainage sump-wells fitted with automatic water pumping and measuring devices on 3.0 ha land. Field experiments were carried out during *kharif* seasons of 2005–07. The surface drainage at 20-drain spacing increased the yield of maize and pigeonpea by 20 – 40% over the control. The SSD lowered the temporary water-table by 0.40 m within a day. The maize and pigeonpea yields increased by 34 – 59.5% and 39 – 64.2% over the control, respectively under different SSD systems. The yield of subsequent *rabi* season chickpea and wheat crops (cultivated in SSD fields) increased by 14% and 12% over control, respectively due to sub-surface drainage. The benefit-cost (B/C) ratios for maize and pigeonpea cultivation in temporary waterlogged Vertisols were found to be 1.35 – 1.53 for surface drainage and 1.36 – 1.79 for SSD systems. The pay-back period for SSD systems for crops sensitive to waterlogging is 6–7 years. Under high water-table condition, when natural outlet is available near the field, the combination of surface and SSD is recommended for draining Vertisols effectively. For cultivation of the water-sensitive crops under temporarily waterlogged Vertisols surface drainage and SSD technologies are techno-economical feasible.

RENEWABLE ENERGY

Optimization of parameters for utilization of paddy straw, kinnow pulp and pea pods for production of cellulases, ethanol and feed supplements: Primary hydrolysis using sulphuric acid treatment resulted in about 25% hydrolysis of rice straw and the secondary hydrolysis resulted in further hydrolysis of about 13%, thus about 38%

Industrial application of solar tunnel dryer

A walk-in type solar tunnel dryer of 3.75 m × 17 m size floor area was installed in the premises of M/s Cotton Products India, Ayed, Udaipur for drying 600 kg treated cotton per batch from initial moisture content of 40% to a final moisture content of around 5% on a sunny day. The system is working satisfactorily for more than a year. Fully convinced with the technology, another firm M/s Raj Surgical, village Lakkadvas, Udaipur has installed 3 units of the walk-in type solar tunnel dryer at its factory each having a loading capacity of 600 kg of wet surgical cotton. Around 1,800 kg of treated cotton at mc of around 40% is spread on continuous trays of 2.75 m width in thin layers of approximately 5 cm thickness. The average temperature inside the dryer was found 15–18°C higher than the ambient temperature. The mc of the cotton reduced to around 5% in 1 sunny day. Cost of materials including labour for the 3 dryers was estimated to be Rs 4.1 lakh. Average cost of drying one batch of approximately 600 kg of wet cotton was estimated to be around Rs 560 as compared to Rs 1,240 in the existing diesel-fired dryers, primarily because of very high costs of electricity and petro-fuel consumption. The pay-back period has been estimated to be around 10 months. The system is under regular operation in the factory.

sugars were produced from the 2-stage hydrolysis of paddy straw.The furfural, furan and phenolic compound concentration was relatively much less even at 4% oxalic acid (w/v) concentration as compared to the production of furfural, furan and phenolic compound even at lower concentrations of strong acids such as HCl and H_2SO_4. Supplementing kinnow pulp with wheat bran in 3:2 in simple distilled water resulted in FPase and ß- glucosidase activity of 13.2 and 12.8 IU/gds and a ratio of nearly 1:1 which is considered to be most appropriate for achieving ideal saccharification efficiency of pretreated lignocellulosic material. Employing co-cultures of *Trichoderma reesei* RC 30 and *Aspergillus niger* BC 1 in the ratio 1:1 on paddy straw and wheat bran combination of 3:2 resulted in FPase, CMCase and ß- glucosidase activity of 28 IU/gds, 46 IU/gds and 25 IU/gds, respectively.Acid hydrolysate of kinnow waste using mild HCl without any detoxification treatment resulted in an ethanol concentration of 12g/l from total sugar concentration of 44g/l obtained by acid hydrolysis process with a fermentation efficiency of about 58%.

Solar dryer for silk cocoon drying: The solar dryer was evaluated for drying 50 kg of raw silk cocoons during March–May 2008. The cocoons were uniformly loaded in 30 trays (4.0 kg/m^2). The moisture content of raw silk cocoons reduced from 60.7% to 11.8% (wb) during 18 sun-shine hours in March. The solar intensity during drying was 600–900 W/m^2 and air flow rate was about 480 m^3/hr. The recommended moisture content for the dried cocoon is below 12%. Similarly, the moisture content of raw silk cocoons reduced from 60.2% to 11.5% (wb) during 16 sun-shine hours in May 2008. The solar intensity during drying process was 650–1,000 W/m^2 and airflow rate was 480 m^3/hr. The average rendita of the dried silk cocoons in the solar drier was 7.75 as compared to 7.78 in the electrical-dried cocoons. The reelability of the solar-dried cocoons were found to be at par with the electrical-dried cocoons. The average tenacity (load to break the thread) of the silk thread of 22 denier obtained from solar-dried and electrical-dried cocoons were 0.77 N and 0.75 N, respectively. The strength of the solar-dried cocoon thread and electrical-dried cocoon thread were 323.3 N/mm^2 and 314.6 N/mm^2, respectively. There was no significant difference in strength of thread between the solar and electrically-dried cocoon threads.

Moving platform type wood cutter: A moving platform type wood cutter using 30 cm diameter carbide tipped circular saw blade and powered with a 3-hp electric motor was developed for preparing the feed for a gasifier. The cutter was extensively tested on dry and freshly harvested *Prosopis juliflora* and mixed wood logs of 25 – 50 mm diameter. Three different types of blades having 40, 60 and 80 teeth were tried for their performance and the blade with 80 teeth gave the best performance. The output of the machine with 40 mm length size cuts was in the range of 225 – 250 kg/hr as against the presently used machine which gives output between 60 and 90 kg/hr. The moisture content of the freshly harvested wood logs was 39%. The energy required in cutting was 4 – 6 kWh/tonne and cost of sizing wood (when the length of cut was 4 cm) was between Rs 120 and 125/tonne of wood.

Technology for ethyl easter of jatropha oil: A simple process for ethyl estrification of jatropha oil was standardized to achieve maximum recovery of ester having low kinematic viscosity. Raw jatropha oil at 6:1 molar ratio may be reacted with 170° proof ethanol (moisture content 15%) at 70 – 75°C reaction temperature for 90 min. in presence of 3% KOH and then allowed to settle for 24 hr to get maximum ester recovery of around 83% with lowest kinematic viscosity of 5.39 cS. The relative fatty ester content of jatropha oil ethyl ester had 47.2% oleic acid ester, followed by 30.9% linoleic acid ester, 13.6% palmitic acid ester and 6.2% stearic acid ester.

Paddy straw-based biomethanation system: Based on the results of laboratory and pilot plant study a field scale 50 kg/day mesophilic plant to

Industrial application of packed bed solar air heater

M/s Vishwa Karma Solar Energy Corporation, Phillaur under the technical guidance of PAU centre of AICRP on RES, installed a solar drying system equipped with 30 packed bed type SAH panels, each of 1.5 m × 0.9 m size in the premises of CIPHET, Ludhiana during 2004 – 05. Recently, the firm has installed a SAH system to supplement the heat requirement for drying of bleached wool at factory site of M/s Raghav Woolen Mills at Ludhiana. The factory is drying bleached wool using diesel-fired air heating system. Seventy two packed bed type SAH panels, each of 1.25 m^2 area were installed at the roof of the factory to produce hot air for use in the factory. Temperature of the hot air varies in the range of 50–55°C and average thermal efficiency of the system is around 35%. The annual diesel consumption before installation of the solar air heating system was around 21.8 k litres. The diesel consumption after installation of solar air heating system has reduced to 15.6 k litres, resulting in a saving of diesel by around 28%. The total investment of Rs 5.5 lakh for the system will be paid back over a period of 2.7 years. The expected life of the system is 15–20 years. The system has recently been sanctioned a subsidy of Rs 1.58 lakh by MNRE, GOI. The pay-back period with subsidy has been computed as 1.95 years.

produce biogas from rice straw was commissioned. The plant after evaluation of its performance was proposed to be shifted to an identified farmer's/ user's place for carrying out long duration testing and evaluation of the system and its management. The system consists of 6 M S reactors, each having capacity to take load of 250 kg rice straw, an MS platform, ladder and piping. Since the reactors are insulated and the process is exothermic, it is being operated without giving external heat for maintaining reactor temperature. The feeding of first batch reactor was initiated in September 2007 using 680 kg prepared rice straw at 25% TS supplemented with 30 kg castor cake and 32 g of $FeCl_3$ and 826 kg of inoculum. All the 6 reactors were gradually filled at an interval of 5 days. Quantity of biogas produced in each reactor is being recorded daily. The biogas production of 191 l/kg TS was recorded after 25 days of incubation period and methane content in biogas was 56±2%.

12

Agricultural Human Resource Development

The Education Division undertakes planning, development, co-ordination, human resource development (HRD) and quality assurance in higher agricultural education in the country. The national agricultural education system presently has 52 units comprising State Agricultural Universities (SAUs), Deemed-to-be Universities (DUs), Central Agricultural University (CAU) and Central Universities (CUs) with agriculture faculty. The endeavours undertaken are mainly through a major Scheme entitled "*Strengthening and Development of Higher Agricultural Education in India*", divided into (i) Development and Strengthening of Agricultural Universities, Niche Area of Excellence, Experiential Learning and Library strengthening, (ii) Educational Quality and Reforms, (iii) HRD, and (iv) a new initiative, on Modernization of Agricultural University Farms. The National Academy of Agricultural Research Management (NAARM) constituent component of the Division facilitates capacity-building of the National Agricultural Research System (NARS). Further, time-bound special initiative, Indo-US Agricultural Knowledge Initiative (AKI) has also been steered for targeted capacity-building by the division.

Development and Strengthening Of Agricultural Universities

Major emphasis of the financial and professional support extended to SAUs, DUs and CU's was for making available new state-of-art equipments to support post-graduate (PG) research in basic and frontier areas, providing e-learning requisites, strengthening ICT facilities, establishment of central instrumentation laboratory, promoting novel and contemporary teaching methodologies, library strengthening, preparation of textbooks and practical manuals, developing multimedia learning resources, facilitating students' study tours and providing National Talent Scholarships. A development grant of Rs 361 crore including special grants of Rs 95 crores was extended during the year. The Special Grants comprised (i) Rs 45 crore instalment of the total grant of Rs 100 crore to PAU, Ludhiana, (ii) Rs 25 crores' instalment of Rs 50 crores total grant to the TNAU, Coimbatore, and (iii) Rs 25 crore instalment of Rs 50 crore total grant to the GBPUAT, Pantnagar.

CAPACITY BUILDING

Niche Area of Excellence: The new sub-programme started during the X Plan for building excellence in specific strategic areas in education and research continued. The programme elements include improving quality of human resource, providing adequate infrastructure, creating facilities for access to information, developing attitude and commitment of faculty/staff/students, facilitating interaction with peer groups in India and abroad and sharing vision and system of well-developed educational technology agencies. A total 28 niche areas of excellence continued to function during the year 2008-09.

Significant achievements include building excellence and establishing brand image of specific agricultural universities. Salient achievements specific to some universities are as follows:

At the Gobind Ballabh Pant University of Agriculture and Technology Pantnagar, under "Quality production of fin fishes for sustainable farming", early maturity of Indian major carps, improvement in gamete quality, improvements in fertilization rate (6-8%), percentage survival (10-12%) and growth of hatchings (11.4 %), and extending breeding season of Indian major carps and Chinese carps by providing balanced diet and intermittent doses of pituitary gland extract were achieved. Use of herbal solution of *Mirobolus indica* seed extract at 3-4 ppm controlled the

crushing of eggs during hatching due to various reasons. The technology for value-added products like fish cutlets and fish fingers was developed, and the products were marketed.

At Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar, under "Farming system to enhance farmers' income and conservation technologies", the production of improved quality seeds, soil test-based fertilizer adjustment equation for targeted crop yields, need-based training contributed to the upliftment of rural as well as urban populace in the region. During 2008-09, 15 training programmes for teachers/scientists/extension specialists and 12 training programmes for non-teaching staff were conducted.

At the University of Agricultural Sciences (UAS), Dharwad, novel genes and promoters for fungal diseases and insect resistance, drought resistance were cloned and gene-based SSR markers were identified under "Biotechnology of Microbes'.

At the Anand Agricultural University (AAU), Anand, a high-tech microbiological laboratory was established under the "Functional Fermented Dairy Product". It led to development of *dahi*-based symbiotic products which are highly acceptable with satisfactory probiotic lactobacillus count.

At the Dr Yashwant Singh Parmar University of Horticulture and Forestry (YSPUHF), Solan, excellence in teaching along with recommendations of technologies for high productivity of apple were the main achievements.

The Chaudhary Sarwan Kumar Krishi Vishwavidyalaya (CSKHPKV), Palampur, under the "Organic farming", developed organic farm on 15 hectares. A consortium of the organic practices and inputs like composts, manures, sprays and inoculums were successfully developed at the farm.

Experiential Learning: A total of 183 experiential learning units in 45 AUs established with Rs 145.40 crore were made operative. These units greatly helped in skill development and attitude building in undergraduate students and in linking agricultural education with professionalism. This sub-programme helped in transcending the mere knowledge-imparting education with limited practical training to experience-based behavioural change through comprehensive practice sessions involving all aspects of an agricultural enterprise, from production to consumption. Salient achievements specific to some universities are as follows:

At the Gobind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar, under the "Dietetics and Food Service Management", two laboratories of the department namely Catering Lab and Food Product Development Lab were renovated and modern facilities were created. These units were used for UG teaching particularly to run a six credit course of "Experiential Learning in Dietetics and Food Service Management (HFN 457)".

At the Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar, Fruit Juice Processing and Filling Unit and a Cereal Processing and other Food Production Unit, for hands-on training were set-up. A scheme on Production and Processing Meat and Dairy Products is also operating. A model plant on production of meat and dairy products is being developed with state-of-the-machinery for processing meat and dairy products, to provide hands-on training to students.

At the Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, the units on biotechnology, biocontrol, nursery management, microirrigation system, biofertilizer production, mushroom production, protected cultivation of gerbera, rose and capsicum, dairy byproduct technology were developed and utilized for skill development of UG students.

At the Uttar Banga Krishi Vishwavidyalaya (UBKV), *Cooch Behar*, facilities for hands-on training on Vermicompost Production, Production and Processing of Mushroom, Manufacturing of Farm Machinery and Equipment, Nursery Production and Management and Nursery Production through tissue culture for ornamental and horticultural crops, were created to equip the students with adequate knowledge, skill and experience. Micro-propagation of several important plants had been carried out. At UAS, Dharwad, the unit, "Biodiesel extraction and trans-esterification unit", was established.

At the Anand Agricultural University (AAU), Anand, learning programmes on High-Tech Floriculture, value-addition in *aonla*, mango, tomato and kagzi lime and training on cultivation, processing and marketing of Medicinal & Aromatic Plants were utilized for UG teaching and skill development.

At the Sri Venkateswara Veterinary University (SVVU), Tirupati, the diagnostic laboratory was modernized and facilities of small animal operation theatre, obstetrical ward, ophthalmology ward, were created for skill development in students.

At the Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Srinagar, two programmes—Model Meat and Poultry Products Processing Centre and Tissue Culture Laboratory, three months training programme was initiated for unemployed graduates in agriculture, veterinary and

fisheries sciences to enable them to develop entrepreneurship skills and establish their own units. Hands-on training in horticulture included grafting/budding and production of quality planting material of apple, pear, plum, quince, pomegranate, cherry, grape and apricot. In floriculture, scientific multiplication of lilium and gladiolus was initiated.

At the Dr Balasaheb Sawant Konkan Krishi Vidyapeeth (BSKKV), Depoli, the programmes have been started in Floriculture and Landscape Gardening, Post-Harvest Technology for Cashew Entrepreneurs, Mushroom Technology and Mechanization of Rice Farming.

At the Chaudhary Sarvan Kumar Krishi Vishwavidyalaya (CSKHPKV), Palampur, 136 students/unemployed youth were imparted training on all aspects of Bakery and Confectionery, 193 on various aspects of cultivation of White Button Mushroom, Oyster Mushroom, Milky Mushroom and Paddy Straw Mushroom, and 40 on different aspects of horticulture.

At Anand Agricultural University (AAU), Anand, e-learning programmes were sanctioned for High-Tech Floriculture, Value addition in *Aonla*, Mango, Tomato and Kagzi lime and trainings on cultivation, processing and marketing of Medicinal and Aromatic Plants were conducted.

Emeritus Scientist Scheme: Under this sub-programme significant contributions include development of heterotic hybrids and molecular mapping of fertility restorer genes in wheat, drought and high temperature stress tolerance in chickpea, genetic improvement of *Bacillus thuringiensis* S6 for its bioefficacy for the control of *Spodoptera litura*, impact assessment of climate change on major pests of maize and mustard, tillage-cum-organics mediated rhizospheric modulation of winter-initiated sugarcane, hybridization of oyster mushroom for yield and quality, characterization and evaluation of elite walnut genotypes for commercial exploitation, effect of heat stress on reproduction-related hormones and amelioration by dietary manipulation in buffaloes etc.

Improving Teaching-Learning: At the TNAU Coimbatore, educational tours, CD shows and guest lectures were conducted for the benefit of students. Strengthening of libraries was carried out. A new mode of teaching and learning through e-learning was introduced for the first time in the country. Possession of laptops by all the students has been made mandatory. Wi-Fi connectivity is provided to all the hostels. The university is also implementing, e-Assignments and e-Communication for the UG students. e-Learning programme has been strengthened by creation of interactive multimedia course content for B.Sc.(Ag.) programme and hosting this content on the National server for sharing by all the agricultural universities. Further, online examination is also one of the features of educational system in the university.

A video conferencing unit has been set up for strengthening the distance learning programme and inter-campus e-Learning programme. About 125 CD shows were also organized during the year.

The Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar has become global by developing inter-institutional linkages for education and research with the universities in USA and Europe.

At the Sri Venkateswara Veterinary University (SVVU), Tirupati, ICAR development grant was utilized in development of learning resources in endocrinology, internet-hubs for students, modernization of class-rooms and equipping them with ICTs, adoption of revised course curricula including practical content.

At the Kerala Agricultural University (KAU), Thrissur, modernization of the class rooms, laboratories, seminar halls, hostels in ten colleges of the University; development of good computer labs with 24-hour internet connectivity, library strengthening particularly on-line subscribing, and video-conferencing facilities to link agricultural college at Thiruvanthapuram, Thrissur and Padannakkad (Kasargod) were undertaken, and a science museum and herbarium at College of Forestry, Thrissur, were established.

At the Mahatma Phule Krishi Vidyapeeth (MPKV) Rahuri, modernization of laboratories with world class equipments/instruments and strengthening of libraries in respect of bar coding, digitization, CD Rom, internet and e-learning facilities were accomplished.

At the University of Agricultural Sciences Dharwad, classrooms with fixing latest audio-visual aids with LCD facility in Dharwad and Raichur campuses along with students' counseling, students' amenities, practical manuals and AV Aids were provided. Examination Cell was sufficiently strengthened to meet External Examinations in all the degree programmes.

At the Anand Agricultural University, Anand, Library was updated with e-facilities. At the Uttar Banga Krishi Vishwavidyalaya (UBKV), Cooch Behar, a number of class rooms have been equipped with audio-visual aids.

At Dr Yashwant Singh Parmar University of Horticulture and Forestry, Solan, the teaching facilities in the colleges were strengthened with electronic LCD display system and computers at KAU Thrissur, for high speed internet browsing for literature and data search and preparation of

At YSPUHF, computer with LAN and LCD projection facilities were provided

reports, computer facility with LAN, and the LCD projection facilities for handling hands-on training classes on computer based learning, were developed.

Rural Work Experience: At *GBPUAT, Pantnagar*, with the ICAR grant, hands- on-training units for training of undergraduate students in horticultural crops and value-addition and marketing of soybean products were established.

At Chaudhary Sarvan Kumar Krishi Vishwavidyalaya (CSKHPKV), Palampur, a total of 40 UG students (35 in College of Agriculture and 5 in College of Home Science) underwent RAWE/RHWE training programme.

Text Book writing: During the year, 14 proposals for textbook writing were approved. Bala Saheb Konkan Krishi Vishwavidyalaya, Dapoli published two text-books entitled "Cashew Processing and Export" and "Introduction to Agricultural Economics and Agribusiness Management" and YSPUHF, Solan, published a text book on "Agro-meteorology".

Promoting Gender Equity: Girls' hostels at Post Graduate Institute and constituent colleges of MPKV, Rahuri; One girls' hostel at UBKV, Cooch Behar; two girls' hostels at AAU, Anand; Girls' Hostel at Dapoli and Ratnagiri of BSKKV, Dapoli were completed; modernization and renovation of UG, PG and Girls' hostels at UAS, Dharwad and strengthening of facilities in the hostels of KAU, Thrissur was undertaken. Also, ladies' gymnasium was developed at Central Campus, Rahuri.

MANPOWER DEVELOPMENT

All-India Entrance Examination for Admissions to UG: For admissions up to 15% seats in 11 subjects of UG Programmes, 13th All-India Entrance Examinations including award of National Talent Scholarships (NTS) were conducted. In this, 21,463 candidates appeared and 1,687 were admitted in 45 Universities through counselling. In order to promote national integration, all those candidates, who took admission in an university outside their state of domicile, were awarded National Talent Scholarship (NTS) of Rs 1,000 per month.

All-India Entrance Examination for Admissions to PG: Admissions to 25% seats in PG programmes at 47 Universities and 100% seats in ICAR-DUs, were made through an All-India Entrance Examination. A total of 11,684 candidates appeared in the examination, out of which 1,875 were admitted.

Junior Research Fellowships (JRFs): There are about 475 Fellowships in 19 subject groups (90 subjects). The amount is Rs 8,640/month for non-veterinary and Rs 12,000/month for veterinary students. Besides, a contingency grant of Rs 6,000/ year is payable to all awardees.

Internship Assistance: To develop professional skills, internship assistance is provided to all the final year students of B.V.Sc. and A.H. programmes during their internship including defraying the travel expenses for to and fro journey to the place of internship.

Merit-cum-Means Scholarship (MCM): This scholarship is granted to students of economically weaker sections of the society to undertake UG studies in agriculture and allied science subjects. Maximum 7% students from one University are awarded the scholarship.

All-India Entrance Examination for award of Senior Research Fellowship for Ph.D.: ICAR SRF examination was held for awarding 202 fellowships in 13 major subject groups and 56 sub-subjects. The amount of fellowships has been enhanced which now stands at Rs 12,000/month for first and second years and Rs 14,000/month for third year for all disciplines other than Veterinary sciences; for the latter the amount is Rs 14,000/month for first and second years and Rs 15,000/month for the third year.

Admissions of Foreign Students: Candidates (229) came from Afghanistan, Bangladesh, Bhutan, Canada, Cambodia, Cote d'Ivoire, Egypt, Ethiopia, Fiji, Gambia, Iran, Iraq, Mozambique, Namibia, Nepal, Sanegalese, South Africa, Sudan, Sri Lanka, Syria, Tanzania, Vietnam and Yemen. Maximum candidates (49) came from Ethiopia.

PROMOTION OF EXCELLENCE AND HRD

ICAR National Professor Scheme: Major achievements of six national professors are as follows.

- Development of 'Pant-ICAR Subsoiler-cum-Differential Rate Fertilizer Applicator' for subsoil structure modification and band placement of inorganic fertilizers at different depths up to 50 cm is a technological breakthrough. The machine is being patented. The subsoil applicator could enhance yield, conserve moisture and increase use-efficiency of nutrients particularly in sodic land as well as in rainfed farming in general. Other machines developed include Pant Zero-Till Ferti-Seed Drill and 'Pant-ICAR Deep Soil Volume Loosener-cum-Fertilizer Applicator', the latter is used extensively as 'Sugarcane Ratoon Manager' after harvesting of plant crop.

  Real-time nitrogen management in rice was achieved by monitoring leaf colour that works very well in achieving high nitrogen-use-efficiency and yield. A criterion for assessing whether wheat crop needs additional application of fertilizer nitrogen at maximum tillering stage has been developed. A combination of prescriptive nitrogen management for rice followed by corrective N management using Green Seeker optical sensor was found to lead to high yields and improved nitrogen-use efficiency as compared to blanket fertilizer N recommendations.
- Studies on (i) Global Food Crisis: Causes, Severity and Outlook, (ii) Fertilizer Growth, Imbalances and Subsidies: Trends and Implications, (iii) WTO Agricultural Negotiations and Regional Cooperation, (iv) Prospects of Achieving Four per cent Growth in Agriculture, (v) Livestock Sector Composition and Factors Affecting its Growth and (vi) Progress and Potential of Horticulture in India have been completed.
- Developed column-wise coordinate exchange algorithms for generating balanced and nearly balanced two-level factors Super Saturated Designs (SSD) useful for economizing resources while screening large number of factors. A monograph on Hadamard Matrices has been published.

ICAR National Fellow Scheme: The areas of identified priority covered by National Fellows include, developing regional plans for managing poor quality irrigation waters, quantitative trait loci and marker assisted selection in indigenous breeds of cattle and buffaloes, development of Elisa-based immuno-diagnostics for classical swine fever, exploitation of metabolic diversity for isolation of genes involved in lipid biosynthesis, sustainability of watersheds in rainfed regions of peninsular India using GIS and remote sensing, senescence: mechanism in crops in relation to abiotic stresses, sink strength and their interaction, molecular characterization of Indian maize landraces and allele mining for agronomically important traits, improvement of strain of *Chaetomium globosum*, a potential antagonist of fungal plant pathogens and developing molecular markers for its identification, textile articles through processing of wool with silk waste and cotton to create entrepreneurial skills in rural women, Genome analysis of indigenous breeds of cattle, buffalo and goats, study of gene interactions in developing *Drosophila* embryo, identification and quantification of phosphatase hydrolysable organic Phosphorus sources for plant nutrition and refinement of a non-destructive technique for phosphatase estimation, decontamination of pesticide residues from edible commodities, assessing soil quality key indicators for development of soil quality index using latest approaches under predominant management practices in rainfed agro-ecology, development of technology of seed production and culture of feather back, *Notoprerus chitala* and two medium carps, *Labeo gonious and* L. *fimbriatus* for diversification of freshwater aquaculture, and efficient design of experiments for quality agricultural research. Some of the salient achievements are the following:

- A method for Farnesene, which induces repellency to aphids, in mustard (*Brassica Juncea*) by GC/MS/MS was developed.

A set of 43 accessions, including some unique maize landraces collected from the North-Eastern Himalayan region were deposited in NBPGR (IC 565865 to IC 565907). A set of **133 accessions** from NEH and other regions in India were characterized at phenotypic and molecular levels.

- **Genetic polymorphisms** was studied on leptin, DGAT (DGAT1, DGAT2 and MOGAT2) and butyrophilin candidate genes in Murrah, Surti and Bhadawari buffaloes revealing polymorphism, SNPs, allelic variants sequences' identification, taxonomic relations etc. Information has been generated to identify genetic polymorphism in alleles of milk and fat genes.
- Eight micro-watersheds were surveyed and evaluated for sustainability aspects. For evaluating *Livelihood Security, economic viability, agricultural productivity and social acceptability,* the most critical indicators were identified.
- Developed an *in situ* resin-bag-technique to measure relative efficiencies of P in different crops under arid agro-ecosystem where P mineralization rates are exceptionally low.

Strongly basic anion exchange resin in chloride form was found best under arid conditions. The amount of saponin accumulated in safed musli tubers (*Chlorophytum borivilianum*) was found to increase with growth. Mycorrhizal inoculated plants resulted up to 25 fold improvement in saponin content at 45 days growth stage and up to four fold improvement at crop harvest. There is a possibility to increase saponin content of safed musli by mycorrhizal fungi. Phytase (IP_6) degradation studied in cowpea, horsegram, mothbean, mung-bean, soybean and pearl millet seeds demonstrated that solubility of minerals was higher in soaking and germination than in boiling.

- Design Resources Server was developed to disseminate research in design of experiments among experimenters in agricultural and allied sciences and industry in planning and designing experiments.
- A genomic sequence encoding complete gene of lysophosphatidic acid acyl transferase gene of 1288 base pair was PCR amplified cloned and characterized from *Brassica juncea*. It is designated as BJLPAATG. A cDNA sequence of *LPAAT* gene was isolated, cloned and characterized from *B.juncea*.
- Studies on *in vitro* heat tolerance of antioxidant defense enzymes from leaf and inflorescence revealed differential sensitivity of the enzymes. It was observed that there was a faster rate of senescence under heat-stress environment (HSE) than non-stress environment (NSE) in Hindi62 (heat tolerant) and PBW343 (heat susceptible) wheat, which were allowed to suffer maximum heat stress under late sown conditions. Heat tolerant Hindi62 exhibited a slower rate of senescence than heat susceptible PBW343 during HSE. Presence of multiple and heat stable isoforms of antioxidant defense enzymes in the leaves and inflorescence of *C. album* may help to ameliorate oxidative stress due to high temperature stress induced senescence.

QUALITY ASSURANCE AND REFORMS

Accreditation: The Board in its IX meeting that was held on 29 July 2008 granted accreditation to the additional eight State Agricultural Universities (SAUs)/Deemed-to-be Universities (DUs) and their programmes. Accreditation to two ICAR-DUs (IARI New Delhi and NDRI Karnal) and four SAUs (OUAT Bhubaneswar, MAU Parbhani, PDKV Akola and MPKV Rahuri) was granted for five years and it was for one year to the CSAU&T Kanpur and for two years to the RAU Bikaner. Accreditation of the five SAUs, DUs, namely ANGRAU Hyderabad, CCSHAU Hisar, TNAU Coimbatore, TANUVAS Chennai and CIFE Mumbai has been extended for five years from the date of expiry of their earlier accreditation. The accreditation pertains to specific colleges and programmes and has been granted with suggestions on which the Universities should complete action and submit the report to the Council on annual basis. Also, a one day workshop was organized on September 20, 2008 at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to sensitize the senior officers of the four state agricultural universities of Gujarat about the accreditation process. Accreditation of some other agricultural universities of the country is in process.

Revision of ICAR Model Act for Agricultural Universities: For enhancing the uniformity of structure, governance and efficiency of the agricultural universities in the context of emerging challenges, the ICAR revised Model Act for Agricultural Universities in India through a Committee. In the revised Model Act, the provisions of all chapters including definitions, territorial jurisdiction, admissions to the universities, powers and functions of the university, its councils/bodies and officers have been rationalized; composition of the Board of Management modified; in the three member Search Committee for Vice Chancellor, one nominee of the Government included replacing Chairman, UGC or his nominee. Similarly, Academic, Research

New AUs Accreditated

National Dairy Research Institute (NDRI), Karnal	Granted accreditation for five years
Indian Agricultural Research Institute (IARI), New Delhi	Granted accreditation for five years
Chandra Shekhar Azad University of Agriculture & Technology (CSAUA&T), Kanpur	Granted accreditation for one year
Orissa University of Agriculture and Technology (OUAT), Bhubaneshwar	Granted accreditation for five years
Rajasthan Agricultural University (RAU), Bikaner	Granted accreditation for two years
Marathwada Agricultural University (MAU), Parbhani	Granted accreditation for five years
Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola	Granted accreditation for five years
Mahatma Phule Krishi Vidyapith (MPKV), Rahuri	Granted accreditation for five years

and Extension Councils have been modified and the Registrar and Comptroller included as permanent invitee; integration of education, research and extension emphasized and the composition and objectives of State Coordination Committee/ Council for higher Agricultural Education in the States having more than one AU have been redefined.

Restructuring Post-graduate Course Curricula and Syllabi: In the Meetings of the National Core Group, Broad Subject Matter Area Committees (BSMACs), separately as well as together, and the workshops of the BSMACs with all stakeholders including the private sector and industry, the extensive discussions were held, and the common academic regulations and the curricula and syllabi for different M.Sc. and Ph.D. programmes were revised/developed for improving standards, quality and relevance of education.

Modernization of Agricultural Universities Farms: It is a new activity to provide a one-time grant to all the State Agricultural Universities and Central Universities with Agriculture Faculty for renovation and modernization of farm infrastructure and facilities. Revitalization/modernization of the laboratories and infrastructure of AU farms will enhance their capacity for undertaking globally competitive research and education activities.

INDO-US AGRICULTURAL KNOWLEDGE INITIATIVE (AKI)

The Sixth Meeting of Indo-US AKI Board was held in New Delhi on 15-16 April, 2008 in which the progress was reviewed and joint deliverables identified.

Fifteen scientists of NARS were selected for training in USA during 2008-09 under the Indo-US Borlaug Fellowship Programme and a joint workshop on sanitary and phyto-sanitary (SPS) Regulation was organized in New Delhi. Salient achievements of the ongoing projects are as follows.

Pigeonpea Genomics Initiative: More than 16,000 Expressed Sequence Taggs (ESTs) developed, mapping population are being screened for DNA polymorphism, and about 80,000 BAC-end sequences have been generated.

Teaching and Learning Excellence: A Capacity Building Model: Eleven scientists/faculty members from four AUs/Institute had an exposure in students centered teaching – learning practices, leadership development, career counseling including internships, and managing and institutionalizing transformational change to achieve professional excellence, at the Ohio State University, USA. One day workshops have been organized at Kanpur, Bhubaneswar and Ludhiana.

Water Harvesting for Ground Water Recharge and Bio-drainage for Salinity Control: Distance learning classrooms were established at UAS Bangalore, PAU Ludhiana and GBPUA&T Pant Nagar. Using this facility, a course each on Landscape Hydrology and Water Quality and Water Resource Economics were taught at PAU Ludhiana both by the US and Indian Faculty. Two US students completed three months training at CSSRI, Karnal.

Sustainable Water Resources Management: A detailed wetland construction, monitoring and implementation site plan for Mewat (Haryana) for remediation of poor quality surface water was prepared. Baseline soil survey and preparation of thematic maps of land use, geomorphology, soil and cropping pattern for the micro- watershed at Birmi, Ludhiana (Punjab) and Wargal, Medak (Andhra Pradesh) were carried out.

Students from USA at CSSRI, Karnal

Information and Communication Technologies for Efficient Water Management: US-India Collaborating Extension / Outreach and Distance Education: Finalized 39 Reusable Learning Objects (RLOs) on Water Management on different aspects like Drip Irrigation, rainwater harvesting, water quality, remediation of salt affected soils, water balance, irrigation scheduling, soil moisture measurement, watershed management etc. The RLO's have been posted on the "EcoLearnIT website" of the University of Florida, Gainesville. A website: http://www.gsgk.org.in in Hindi has been developed.

On farm water management for Rainfed Agriculture on Benchmark watersheds in diverse eco regions of India: Detailed benchmark survey on physio-chemical properties of soil, socio-economic, present agricultural practices, constraints (bio-physical) and socio- economic aspects completed in two watersheds in village – Bandha, Jabalpur and one in Kandi, Punjab and the Water User groups were formed.

Five new joint projects were initiated (i) Capacity building for Libarary professionals;

(ii) Genetic Engineering for abiotic stress tolerance in the crops on papaya, tomato, banana and potato; (iii) improving the capacity for Integrated Pest Management of insect-borne viral diseases in Indian vegetable production; (iv) Technology for plant and dairy ingredients based formulated and functional foods using extrusion technology, and (v) Development of vaccines and diagnostics for control of onion influenza in poultry.

NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT

Training: A total of 61 such programmes including training programmes, workshops and orientation meetings were organized with 1,766 participants.

Type of programme	Programmes
	(Nos.)
Foundation Course for Agricultural Research Service (FOCARS)	03
Refresher Courses/Summer /Winter Schools (21 days)	10
Senior Programmes	19
Workshops	13
Executive Development Programmes	02
Demand Driven Off Campus Programmes for CARI, Port Blair, IGFRI Jhansi, CRIDA, Hyderabad, ICAR Res. Complex, Goa and CIFE Mumbai	11
International Programmes	03
Total	61

Research and Consultancy: The Academy undertakes research studies on management problems faced by agricultural research and educational institutions in the NARS.

World Bank Supported Project: Under the aegis of the World Bank supported National Agricultural Innovation Project (NAIP), the Indian Council of Agricultural Research (ICAR) has awarded a major project on Learning and Capacity Building (L&CB), to a consortium led by the Academy, with a budgetary outlay of Rs 24.09 crore.

APAARI CLAN Executive Committee Meeting was attended by more than thirty APAARI member countries

NAARM-Now an academic unit as well: The Academy has embarked upon becoming an academic unit besides being a training unit. Two post-graduate diploma programmes on (i) information technology management, and (ii) IP-management have been commenced.

Support/Policy Support: The academy continued to provide policy support to NARS in general and ICAR in particular through its interactive policy dialogue meetings and workshops. Significant ones in this category included the APAARI CLAN Executive Committee Meeting on 8 October 2007. The Academy has established a Help Desk under the NAIP, which extends on-line help to all prospective institutions/ individuals preparing winning research proposals and in sensitizing potential partners.

13

Agricultural Economics, Marketing and Statistics

AGRICULTURAL ECONOMICS AND MARKETING

Total factor productivity in livestock sector of India

India's livestock sector has grown at an annual rate of 4.3% as against the annual growth of 2.7% in the crop sector during 1970-71 to 2003-04. It has provided a cushion to the agricultural growth and livelihood of poor farmers, for whom livestock are important source of income and employment. Robust growth in the livestock sector has been the result of interplay of several factors public investment in dairying, private investment in poultry, technological change in breeding, feeding and health, and market infrastructure. Facilitated by investment and expanding markets, technology played a critical role in boosting growth of livestock sector. The total factor productivity (TFP), grew at an annual rate of 2.3% during the period, and accounted for over half of the growth in livestock sector. The TFP-led growth in livestock sector would sustain agricultural growth, reduce rural poverty and alleviate pressure of number-led growth on natural resources, which are already facing quantitative and qualitative deterioration.

Growth crisis in Indian agriculture

The growth of Indian agriculture during the post-WTO period declined sharply in almost all sub-sectors and commodity groups. Agriculture and non-agriculture sectors are also on a disparate growth path. The main reasons for deceleration and stagnation in agricultural output after 1995-96 are–slowdown in growth of use of fertilizers, irrigation, and energy (electric power) in some cases, stagnation or even decline in other cases. Crop intensity and area under cultivation also showed either poor growth or decline. Diversification towards high-value crops slowed down and in some cases, farmers were found diversifying away from high-value crops towards low-value, less-risky and less-input demanding crops. Terms of trade for agriculture showed deterioration, and agricultural incomes were highly unstable in recent years. Low level of input-use and low-productivity in most of the states offer scope for revival of agricultural growth, but it would require simultaneous efforts on several fronts. These include: (a) stepping-up investments and putting in place suitable institutional mechanisms to exploit irrigation potential that exists in most of the states, (b) increasing power supply to agriculture sector, (c) promoting fertilizer-use by expanding distribution network and improving credit facilities for farmers, (d) establishing competitive seed markets and ensuring attractive prices for seed; (e) improvement in terms of trade for agriculture, and (f) evolving measures to mitigate risk in farming.

Diversification of agriculture towards high-value crops: Role of smallholders

Gradual diversification of agriculture towards high-value crops exhibits a pro-smallholder bias, with smallholders playing a proportionally larger role in the cultivation of vegetables versus fruits. The observed patterns are consistent with simple comparative advantage-based production choices. The comparatively high labour endowments of the small farmers, as reflected in their larger family sizes, induce them to diversify towards vegetables. Although fruit cultivation is also labour-intensive (as compared to cultivation of staples), it is highly capital-intensive, making it a less advantageous choice for smallholders who tend to have low capital endowments. Small or medium holders do not appear to allocate a greater share of land to fruits or vegetables. However, the share allocated to vegetables is significantly higher if the family size is bigger, while reverse is true in case of fruits.

Demand for foodgrains towards 2011 and 2020

Per caput production of foodgrains had increased from 183 kg during early 1970s to 207 kg by mid 1990s, even though country's population increased by more than 50%. However after mid 1990s, foodgrains production could not keep pace with the population growth. Per caput production of cereals declined by 17 kg and pulses by 3 kg during the past decade. This could create a serious threat to food security, as the country identifies its food security with foodgrains security. Direct, indirect and total demands for foodgrains in India towards 2011-12 and 2020-21 were estimated by taking into account population growth, composition of rural and urban population, growth in per caput income in rural and urban areas and changes in taste and preferences. Total demand for cereals would grow to 218.9 Mt by 2011-12 and would reach 261.5 Mt by 2020-21. Demand for pulses during this period would grow to 16.1 Mt and 19.1 Mt, respectively. Domestic demand for foodgrains is projected to reach 235.0 Mt by 2011-12 and 280.6 Mt by 2020-21. It is important to mention that these projections do not include export demand.

Economic losses from avian flu

The impact of 'bird flu' outbreak in Manipur state in July 2007 was analyzed. It caused a massive economic loss due to culling of nearly 3.4 lakh birds after the Government of India notified it.

Impact of avian flu

Poultry farmers: The producers lost about Rs 316 lakh, as against of Rs 99.13 lakh given to them as compensation. Inadequate compensation may have two consequences: (i) it would affect the livelihood and sustenance of poultry farmers and their families, particularly in Manipur, which is already experiencing internal disturbances on account of economic reasons, and (ii) it might lead to poor compliance in culling and disinfection operations and hence lack of eradication of disease outbreak, which will have more serious implications.

Consumers: The price of chicken dropped after the outbreak of avian flu. The overall financial impact on the poultry sector in Manipur was estimated to be of around Rs 2,455.17 lakh on account of avian flu outbreak, which amounted to 14% of total value of livestock outputs and 0.5% of State Gross Domestic Product.

Exploring market opportunities for fisheries sector in India

Survey work was attempted in major fish markets and a mini consumer survey in Chennai metro city to explore the possibilities for developing

Economics and marketing of goat enterprise

The large and progressive farmers, businessman and industrialists have adopted the commercial goat farming, and their entry into this activity would help in realizing the potential of goat enterprise as they have better access to technical knowledge, resources and market. Goats were economically viable under intensive system of management on 46% of commercial goat farms. This fact that the commercial goat farming could be taken up under intensive system of management would encourage the aspirant commercial goat farmers not having access to grazing resources. Majority of the commercial goat farms are operating with positive net returns, 39% are earning good profit, and their annual net returns per goat ranged from Rs 968 to 2,069. Intensification and commercialisation of goat enterprise is also important because of shrinking resources for grazing. The marketing of goats suffers from involvement of middlemen garnering high margins, avoidable marketing costs, unnecessary transportation, and mortality of animals during transit. The poor farmers had to sale their goats per head, per pair or per group basis. With the awareness building by the institute, the goat farmers in the adopted villages could have better understanding on appropriate marketing strategy viz., the type of goats to be sold, place of sale, right time and age of sale and right method of sale of goats. A number of farmers started preparing castrated male goats for selling then during the festival season. The average price realization during Eid for a male of 1-2 years of age was about 70% higher than the price realized during normal sale in the villages

Initial linkages were created among the commercial goat farmers of different states resulting in creation of large demand of good quality breeding goats for breeding purpose. Consequently the farmers who earlier got market rate of Rs 55 to Rs 65/kg live body weight for their goats started getting Rs 110 to 150/kg live body weight. At the same time the traders were not paying premium price even for the purebred goats. The increased prices of breeding goats due to strengthened linkages created large opportunities and interest for private investment in commercial goat farming projects. And also encouraged the existing commercial goat farmers to produce good quality pure breed animals (germ plasm) of different goat breeds, which would be critically important for goat enterprise development in the country.

Asynchronous e-learning module on aquaculture

Asynchronous e-learning module on mud crab fattening (*Scylla tranquebarica*) for diversification in brackishwater aquaculture was developed. This module offers selected topics on mud crab fattening to users, viz. culture systems and contact addresses.

domestic fish markets in India and compilation of fish marketing policies of Tamil Nadu State government. Chennai wholesale markets source fish from across the country's major fish markets like Howrah and Calicut to fill the demand supply gap for particular fish varieties arising due to ban on fish capture from the seas of east coast. These markets also source their fish from fish farms of Andhra Pradesh (Indian Major carps, Shrimp), Tamil Nadu and Kerala. Chennai has presently five major wholesale cum retail fish markets and 150 medium and small size neighbourhood fish markets. The consumer survey indicated that the performance of these markets could be considerably improved if sanitation, parking facilities, proper weighing and icing facilities are introduced. Share of these markets is slowly being taken away by modern chain stores as these suit the busy schedule of consumers' lifestyle.

Evaluation of e-marketing and traditional marketing systems

E-marketing systems like e-*choupal* are fresh initiatives in aquaculture as it helps in reaching out to the unreached via this initiative. The *aquachoupal* model received the highest priority of 64% and traditional system received 36% of priority within the priorities set for assessment of the marketing system. Further, efforts should be made to incorporate information modules targeted specially towards women farmers.

AGRICULTURAL STATISTICS AND COMPUTER APPLICATION

- A window based *software for survey data analysis* was developed for the selected sampling schemes. It includes methods for various sampling schemes such as simple random sampling (SRS), probability proportional to size (PPS), stratified, cluster, two stages and stratified two stage. It considers both types of cases i.e., when the units have been selected with or without replacement. This software also estimates the parameters in the situation when units are selected with unequal probability and with replacement. Ratio method of estimation for the population mean was also included in the software for the simple random sampling and stratified random sampling. The results of the schemes are presented in the form of crystal reports available under Visual Studio, 2005 (IDE).
- The *estimates of area and production of important fruits and vegetables* are being obtained under the scheme on *Crop Estimation Survey on Fruits and Vegetables* (CES-F&V). To improve the methodology, a project entitled "Pilot study to develop an alternative methodology for estimation of area and production of horticultural crops" was undertaken. The study was conducted in Maharashtra and Himachal Pradesh covering important fruits and vegetables. This alternative methodology is cost effective, less time consuming and its survey procedure is more simple. It is easy to implement and provide estimates for more than one fruit/vegetable at district level. Market arrival data was used for obtaining state level estimates. There is a significant decrease in sample size i.e., from 150-200 villages per district (under CES-F&V) to either 80 or 43 villages per district depending upon the desired precision. This methodology is required to be tested in few more states before actually implementing it on a large scale.
- The institute initiated a study to examine the feasibility of the developed *sampling methodology* for estimation of crop yield at Gram Panchayat level for large scale adoption. The field work of the study was undertaken in one district per state of Uttar Pradesh, Karnataka, Andhra Pradesh, Punjab and Rajasthan. The farmer appraisal data about crop produce and crop cutting experiments data as obtained from general crop estimation survey (GCES) were analyzed using small area crop estimation methodology (SACEM) to develop estimates of crop yield at GP level. The GP level estimates were very precise.
- Under the project *weather based models for forecasting potato yield*, weather indices (W 1) based regression models were developed by taking combinations of linear and square indices with yield/detrended yield. Complex polynomial (CP) models, using GMDH technique, were developed.
- *Design resources server* (www.iasri.res.in/design) was developed to popularize and disseminate research in design of experiments among experimenters and research statisticians were strengthened by adding the following material/links:

The material available on the server has been partitioned into four main components:

- *Useful for experimenters*: Electronic books, online generation of randomized layout of designs, online analysis of data and analysis of data using various softwares.
- *Useful for research statisticians:* Literature and catalogues of BBB designs, designs for making test treatments-control treatment comparisons, supersaturated designs, online generation of Hadamard matrices, MOLS and orthogonal arrays.
- *Other useful links*: Discussion Board, Ask a Question, Who-is-where and important links.
- *Site information:* Feedback, how to quote design resources server, copyright, disclaimer, contact us and site map.

The design resources server www.isari.res.in/design is like a mobile library on design of experiments in particular and statistics in general. It provides useful information both for active researchers in statistics as well as stakeholders like scientists in NARS and others all over the globe. The server is dynamic in nature and new links on various topics are added to it regularly.

Developed a method of construction of designs for *incomplete multi-response experiments*. The designs were economical from resource point of view. Developed a step-wise procedure of analysis of incomplete multi-response designs.

14

Information, Communication and Publicity Services

Directorate of Information and Publications of Agriculture has developed on-line global visibility through scrolling day-to-day news, and *ICAR Reporter*, *ICAR News* on ICAR web page. The ICAR web site users have increased and their number reached to 753,039 by December 2008. ICAR readers browse information from scrolling news as well as publications available in open access on www.icar.org.in. English and Hindi Editorial Units have brought out 100 publications. Research articles (1,500) were received from home and foreign countries, viz. Australia, Bangladesh, China, Germany, Egypt, Ethiopia, Iran, Japan, Korea, Mexico, Pakistan, Nigeria, South Africa etc. According to the Status of India in Science and Technology as reflected by its Publication output in *Scopus International Database, 1996-2006*, brought out by National Institute of Science, Technology and Development Studies, ICAR journals are in top 12 most productive journals. *The Indian Journal of Animal Sciences* has got 2nd position while *The Indian Journal of Agricultural Sciences* stood 12th out of the top 25 most productive domestic Indian journals. The National Academy of Agricultural Sciences has increased the rating of *The Indian Journal of Agricultural Sciences* which is now 7.20. The circulation of both the journals has improved considerably. Projects on e-Publishing and knowledge system in Agricultural Research – development of on-line electronic publishing and hosting of ICAR publications integrated with e- commerce', and 'Agro web – digital dissemination system for Indian Agricultural Research has approved by NAIP for greater visibility of ICAR technologies through its information products.

Media and Information Unit prepared Documentaries (40) and compiled ICAR Vichar Manch Series. Media unit prepared special training programmes for Assistants, Section Officers, LDCs E Batch 2007; and technical as well as professional guidance of all IP Telephony facilities, video conferencing, etc.

The Production quality is well reflected through its publications by implementing the computerized print control and Computer to Plate technologies. The unit has conceptualized and designed new layout for magazines and books. Technical support was provided to ICAR Hqrs., ICAR Institutes and State Agricultural Universities for production of their publications and for framing technical and financial bid tender documents for printing by Production Unit. The quality publications for SAARC Agriculture Ministers Meeting and ASRB Foundation Day celebration were executed through Production Unit in a time frame manner. ASRB modified logo was also developed by this unit. Special issue of Kheti, Phal Phool, Indian Farming and Indian Horticulture were brought out on World Potato Congress-2008 with new layout design maintaining high production quality within given stipulated time. Training on Production Management of publications and Secretarial Practices was provided to staff ICAR Institutes and students of Polytechnic respectively. Posters were brought out on several occasions, viz. Vigilance Awareness, IVth World Congress on Conservation in Agriculture. Photographs related to activities in ICAR System were taken; and used for press release, scrolling news, periodicals.

Agricultural Research Information Centre gave output as Data Management Work, viz. AGRIS Database of FAO, AICR database, database of Multimedia Products developed by ICAR Institutions. DIPA has generated more than Rs 4.5 million (up to December 2008) through sale of journals, periodicals, books, e-books and procurement of advertisements. Thematic information display and sale-stalls were put in Conferences/Summits/Meetings/etc. for

Special issue brought during Global Potato Congress

Selected titles brought out during the year

dissemination of knowledge and publicity. Agricultural Research Information Centre gave output as ICAR Telephone Directory, 2009; Publications in print (7) as well as electronic media (4) including on-line version (7); and Selective Dissemination of Information services. ARIC organized workshop (1) and trainings (3). E- library facility has been started at ICAR(Hq). It is using latest information and communication technologies. ICAR Library has been modernized with Information KIOSKS, internet surfing, on-line catalogue etc. using latest ICT tools. The mandatory housekeeping activities of library have been automated by use of *e-Granthalaya* software. The developed bibliographical details of publications available in ICAR, Krishi Bhavan, were made available through on-line OPAC (on-line catalogue).The circulation process was started by using bar-coding library publications and membership cards. Services provided by the library include:On-line Catalogue, Access to British Council Library and DELNET,CD-ROM Databases,On-line Portal/Journals through Cera (NAIP), Springer link, Annual Reviews, and CSIRO.

15

Technology Assessment, Refinement and Transfer

The Council has created a vast network of Krishi Vigyan Kendras (KVK), aiming at assessment, refinement and demonstration of technologies/ products. At present, there are 562 Krishi Vigyan Kendras which include 379 under Agricultural Universities, 41 under ICAR Institutes, 90 under NGOs, 33 under State Governments and 19 under other organizations.

KRISHI VIGYAN KENDRA

Technology assessment and refinement

During the year, 520 technologies were taken up for assessment and refinement in 2,044 locations with 20,002 on-farm trials. There were 389 technologies in 1,647 locations with 14,349 trials on improved cultural practices of various crops (4,560), varietal evaluation (2,502), application of bio-fertilizers and bio-control agents (911), crop diversification including cropping systems (755), plant protection (3,441), protected cultivation for production of seeds and planting material (230), farm machinery and equipment (507), resource conservation (708), and processing, value-addition and quality improvement (735).

Similarly, 32 technologies in 158 locations with 3,331 trials were taken up for assessment of technologies related to control of diseases; improved breeding; nutrition including feeds and fodder in cattle, pig and poultry; and production and management in fishery.

A total of 67 technologies in 170 locations with 1,031 trials were taken up for assessment and refinement related to improved cultural practices of various crops (529), application of bio-fertilizers and bio-control agents (58), plant protection (224), protected cultivation for seed production (16), farm machinery and implements (63), resource conservation (43), and processing, value-addition and quality improvement (98).

Thirteen technologies were taken up in 18 locations with 258 trials for assessment and refinement related to health of cattle, sheep and goat (102), improved breeding of cattle (56), nutrition including feeds and fodder of cattle, sheep, goat and poultry(81), and production and management of sheep, goat and fishery (19).

Besides, 19 technologies related to entrepreneurship development and improving family health and nutritional status were also taken up with 1,033 trials in 51 locations.

Frontline demonstration

Frontline demonstrations were conducted to demonstrate the production potential of improved technologies on farmers' fields in different farming systems. A total of 75,825 frontline demonstrations were organized including oilseeds, pulses, cotton, farm implements and other crops including cereal, millet, fibre, fodder and commercial crops; vegetable, fruit, flower, plantation and medicinal crops, and spices and condiments, covering an area of 31,627 ha; including 3,791 demonstrations on hybrids of different crops. Besides 2,168 demonstrations on livestock and fishery, 109

Frontline demonstration on *safed musali*

demonstrations were conducted on various other enterprises.

Oilseeds: During the year, 18,949 demonstrations were conducted covering 6,379ha on oilseed crops including castor, groundnut, linseed, mustard, niger, safflower, sesame, soybean, sunflower, *toria*, and *gobhi sarson*. The percentage increase in yield varied from 21.86 in *raya* to 52.70 in rapeseed, and on an average oilseed crops under demonstration gave 33.17% more yield than under local practice.

Pulses: There were 17,301 demonstrations were conducted covering 5,433 ha on pulse crops including blackgram, chickpea, cowpea, field pea, french bean, greengram, horse gram, lentil, mash, moth bean, pigeonpea and *rajmash*. The increase in yield varied from 34.88% in chickpea to 50.93% in horse gram, and on an average pulse crops under demonstration gave 41.14% more yield than under local practice.

Cotton: The frontline demonstrations on cotton were conducted in major cotton-growing areas of 11 states (Andhra Pradesh, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu and West Bengal), in an area of 8,347 ha involving 11,613 farmers on production technology (4,211 in 1,754 ha), integrated pest management (1,774 in 1,420 ha) and farm implements (5,628 in 5,173 ha).

Production technology: The average yield of demonstration plots varied from 243 kg lint/ha in West Bengal to 745 kg lint/ha in Rajasthan, with the cost of production varying from Rs 5,000/ha in West Bengal to Rs 24,107/ha in Tamil Nadu. Due to variation in cost of production, yield levels and market price received for the cotton, the benefit: cost ratio also varied from 1.9 in Jharkhand and West Bengal to 4.5 in Haryana.

Performance of BT hybrids, non-BT hybrids and other varieties: Demonstrations on hybrids were conducted involving 2,991 farmers. Besides Bt hybrids, *desi* hybrids, *hirsutum* × *barbadance* hybrids, *hirsutum* × *hirsutum* hybrids were also demonstrated in several locations along with *hirsutum*, *arboreum* and *herbaceum* varieties.

Irrigated: A total of 2,257 demonstrations were conducted in 10 states under irrigated situations in an area of 952.6 ha. Average yield of demonstration plots ranged from 319 kg lint/ha in Jharkhand to 836 kg lint/ha in Karnataka. An increase in yield of demonstration plots over local plots was the highest in Madhya Pradesh (32.42%), followed by Tamil Nadu (30.39%). Overall increase in yield was 9.86%. The difference of demonstration yield in Punjab was –0.72 because the demonstrated Bt hybrids MRC 6301, MRC 6304 and RCH 713 did not perform better than check hybrid RCH 134 Bt.

Rainfed: Under rainfed situations, 2,120 demonstrations were conducted in nine states covering 895 ha. Demonstration yields ranged from 243 kg lint/ha in West Bengal to 696 kg lint/ha in Madhya Pradesh and 812 kg lint/ha in Rajasthan under partial irrigated condition. The average increase in yield was 32.64%. Benefit : cost ratio was 3.10 in irrigated situation as compared to 2.2 in rainfed.

Integrated pest management: The integrated pest management (IPM) demonstrations were implemented in seven states, viz. Rajasthan, Andhra Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Madhya Pradesh, in an area of 1,420 ha in 50 blocks (50 ha per block) with the involvement of 1,774 farmers including 331 women farmers. The maximum yield of 1,305 kg lint/ha was reported from Guntur (Andhra Pradesh), and the lowest (310 kg lint/ha) from Amaravathi (Maharashtra). The overall increase in yield from IPM plots was 18.63% higher than non-IPM plots.

Farm implements: Demonstrations of farm implements, viz. tillage (rotavator, furrow maker, harrow, plough, tiller, stalk uprooter and stalk shredder), sprayers, weeders, dibblers and planters, and ginning and delinting on cotton were conducted in an area of 5,173 ha involving 5,628 farmers.

Performance of cotton hybrids and other varieties in frontline demonstrations

Hybrid/variety	No. of farmers/ demo	Area (ha)	Demo yield (lint kg/ha)	Local yield (lint kg /ha)	Increase (%)	Demo cost (Rs/ha)	Local cost (Rs/ha)	Demo benefit: cost ratio
Bt hybrid	2,257	952.6	744	610	25.7	1,660	15,077	2.9
Desi Hybrid	120	74.0	683	622	11.3	5,790	5,244	3.6
H × B hybrids	355	125.2	528	447	17.5	18,496	16,153	1.9
H × H hybrids	259	108.4	651	529	23.1	12,808	12,060	3.1
G. herbaceum variety	97	38.8	210	181	15.9	5,467	4,925	2.5
G. hirsutum variety	446	180.8	487	414	23.2	10,654	10,212	3.2
G. arboreum variety	45	18.0	326	224	37.8	7,701	4,393	2.5

H, *hirsutum*; B, *barbadense*

Frontline demonstrations on other crops

Category	No. of demonstrations	Area (ha)	Yield (tonnes/ha)		
			Demonstration	Local	Increase (%)
Cereals	11,655	3,847.77	4.18	3.37	24.18
Vegetables	4,074	874.16	16.58	12.71	30.37
Spices and condiments	2,352	473.51	14.56	11.61	25.44
Millets	1,167	414.70	2.07	1.56	32.80
Fodder crops	705	132.60	35.67	28.73	24.15
Tuber crops	538	65.08	23.15	16.86	37.29
Fruit crops	515	131.80	25.30	18.96	33.39
Fibre crops	509	120.00	1.43	0.98	44.74
Flower crops	335	95.85	13.02	9.63	35.26
Commercial crops	204	59.50	59.37	48.44	22.56
Plantation crops	129	35.90	5.74	3.82	50.26
Medicinal crops	57	27.00	1.14	0.71	23.01
Other crops	94	17.40	4.11	3.26	26.00
Total	22,334	6,295.27			

Frontline demonstrations on hybrids of crops

Crop	hybrid	No. of farmers	Area (ha)	Yield (kg/ha)		
				Demonstration	Local	Increase (%)
Brinjal	PKM 1	20	4.00	3,025	2,820	7.27
Cabbage	Quisto	25	0.20	3,403	2,500	36.12
Castor	DCH 32, GCH 4, TMVCH 1	89	23.50	1,817	980	85.51
Chilli	HCH 9646	11	0.44	3,120	1,810	72.38
Cucumber	Century Hyb 1	4	0.04	4,600	3,800	21.05
Maize	Co MH 5, KH 9451, Shaktiman 3, Shaktiman 4	150	46.20	5,763	3,160	82.42
Rice	Co RH 3, KRH 2, Ranjit	48	23.10	6,539	5,169	26.51
Soybean	JS 335	63	21.00	1,280	870	47.13
Sunflower	KBSH 41. MSFH 17,MSFH 8, PAC 36	380	172.80	1,743	1,296	34.48
Tomato	TCS 212	10	4.00	30,100	18,400	63.59
Grand total		800	295.28			

Besides, a total of 70,111 cotton farmers were benefited from various extension activities including training of 13,759 farmers and 1,214 extension personnel to facilitate dissemination of technology among them. In addition, newspaper coverage (33), publication of extension literature (67) and radio/TV talk (66) were also organized.

Other crops: During the year, 22,334 such demonstrations were conducted covering 6,295 ha on cereals, vegetables, spices and condiments, millets, fodder crops, tuber crops, flower, commercial crops, plantation crops, medicinal and other crops. The increase in demonstration yield over local plots ranged from 22.56% in commercial crops to 50.26% in plantation crops.

Dapog method of nursery raising of rice

Crop hybrids in cereals, oilseeds and vegetables: During the year, 800 demonstrations on hybrids were conducted, covering 295 ha on maize, rice, soybean, sunflower, castor, brinjal, cabbage, chilli, cucumber and tomato.

Farm implements: During the year, 2,258 demonstrations were organized on various tools and implements related to tillage operation, planting, inter-culture operation, plant protection, harvest, post-harvest and drip irrigation on several crops covering an area of 1,914 ha.

Livestock and fishery: During the year, 1,739 demonstrations comprising 6,362 units on health, nutrition and other production practices of dairy, poultry, piggery, sheep and goat were conducted. Besides, 429 demonstrations comprising 181 units were conducted on carp culture, composite fish

culture, integrated fish farming, prawn culture, and fish seed production.

Other enterprises: A total of 109 demonstrations on various other enterprises, namely bee keeping, mushroom, nutrition, garden, sericulture and vermicompost were conducted.

Training programmes

During the year, 51,774 training programmes were organized with the participation of 12.42 lakh farmers including rural youth, and in-service extension personnel.

Farmers: A total of 35,533 training programmes were organized for the benefit of 966,142 farmers and farmwomen on various technologies to update their knowledge and skill. Total number of beneficiaries including women farmers were 159,008 in production and productivity enhancement of crops; 132,495 in plant protection; 107,537 in production of inputs at site; 58,935 in household nutritional security; 53,926 in animal production and management; 53,067 in soil health and fertility management; 46,142 in commercial production of vegetables; 40,419 in processing and value-addition of produce; 45,523 in capacity building and group dynamics; 30,731 in integrated farming system; 28,844 in orchard management; 28,220 in entrepreneurial development; 22,360 in farm machinery, tools and implements; 27,536 in management of fruit crops; 29,576 in resource-conservation technologies; 21,071 in animal nutrition; 18,811 in fisheries; 20,656 in water management; 16,520 in animal health; 9,428 in grading and packaging; 6,283 in ornamental plants; 2,446 in tuber crops; 1,888 in agro-forestry; 1,119 in plantation crops; 1,095 in spices; and 506 in economic empowerment of women.

Training programmes for in-service extension personnel

Thematic area	No. of courses	Male	Female	Total
Production, productivity and value-addition of crops	1,113	27,337	4,026	31,363
Production of input at site	214	3,859	1,375	5,234
Plant protection	433	9,523	638	10,161
Resource conservation, soil health and fertility management	287	6,251	504	6,755
Integrated farming system	47	1,360	363	1,723
Livestock production and management	354	6,025	1,551	7,576
Farm machinery tools and implements	73	1,449	209	1,658
Economic empowerment of women	153	1,742	2,410	4,152
Capacity building and group dynamics	177	3,855	785	4,640
Capacity building for ICT applications	296	6,643	1,673	8,316
Household nutrition security	340	1,961	6,859	8,820
Total	3,487	70,005	20,393	90,398

Rural youth: As many as 12,754 skill-oriented training programmes were organized for 187,304 rural youth. The beneficiaries in different areas were 12,657 on increasing production and productivity of crops; 1,212 in orchard management; 26,157 in production and value-addition; 25,226 in livestock production and management; 29,420 in economic empowerment of women; 4,983 in farm machinery, tools and implements; 6,571 in fisheries; 42,875 in production of inputs at site; 2,018 in capacity building and group dynamics; 23,743 in entrepreneurial development; and 12,442 in commercial horticulture.

Training programmes (vocational): Out of 12,754 training programmes conducted for rural youth, 6,073 were conducted for 49,176 rural youths on various vocations including orchard management; production of inputs at site; economic empowerment of women; livestock production and management; value-addition; entrepreneurial development; commercial horticulture; capacity building and group dynamics; fisheries; and farm machinery, tools and implements.

Extension personnel: A total of 3,487 training programmes were conducted covering 90,398 participants. These were organized for extension functionaries working in government and non-governmental organizations related directly or indirectly with the development of agriculture. The training was imparted to upgrade their knowledge and skills in frontier areas of agriculture technologies.

Training programmes (sponsored): Of the 51,774 training programmes (12.44 lakh participants) conducted by the KVKs, 6,099 were

Seeds and planting material

During the year 201,675 q seeds including cereal, oilseed, pulse, commercial, vegetable, flower, spice, fodder and fibre crops were produced and made available to 1.39 lakh farmers. In addition, KVKs produced 133.20 lakh seedlings and saplings of vegetables, fruits, ornamental, medicinal and aromatic plants, plantation crops, spices, tuber crops, fodder and forest species and provided to 1.89 lakh farmers.

Demonstration on rain-water harvesting with micro-irrigation system

The demonstration units on rainwater harvesting with micro-irrigation system have been established in 100 KVKs. These KVKs conducted 240 training programmes and 128 crop demonstrations, benefiting 21,392 farmers and 1,384 extension personnel. The KVKs have also utilized such facility for production of 2.71 lakh planting material.

conducted on sponsorship by various organizations covering 232,951 participants.

Extension activities

The KVKs organized 264,485 extension programmes involving 8,069,061 farmers and extension personnel to create awareness about improved agricultural technologies. The activities include advisory services , diagnostic visits, field days, group discussions, *kisan ghosthi*, film show, self-help group conveners meetings, *kisan mela*, exhibition, scientists' visit to farmers' field, plant/animal health camps, farm science clubs, ex-trainees *sammelan*, farmers' seminar/workshop, method demonstrations, special day celebration, and exposure visits.

Other important extension programmes organized by the KVKs include publication of 28,224 extension literature, 11,224 newspaper coverage, 4,847 radio and TV talks, 1,409 popular articles and 8,220 lectures were delivered.

Production of technology products

The KVKs produced various technological products like seeds, planting materials, bio-products, livestock strains and fingerlings to a tune of Rs 2,194.62 lakh, benefiting 4.15 lakh farmers.

Bio-products: The KVKs produced various bio-products and made available to 74,846 farmers. These include 11.97 lakh kg biofertilizer including *Azolla*, *Azospirillum*, *Azotobactor*, compost and vermicompost, phosphobacteria and rhizobium and 1,857 litres vermi-wash; besides bio-pesticides including botanicals, NPV, various pest repellants and pheromone traps; bio-fungicides including *Pacelomyces* and *Verticillium*; and bio-agents including beetles, decomposing fungus, earthworms and parasitoid (*Trichogramma chilonis*).

Livestock, poultry and fingerlings : The KVKs produced 5,102 improved livestock strains of dairy animals, piglets, sheep and goat, and rabbit benefiting 916 farmers; 72,255 improved chicks of poultry, turkey, quail and duck benefiting 10,963 farmers and 60.47 lakh fingerlings benefiting 630 farmers.

Diagnostic services

A total of 1.52 lakh samples including 1.30 lakh soil samples, 19,714 water samples, 2,256 plant samples, and 504 other samples were analysed, benefiting 10,963 farmers from 18,893 villages.

Technological backstopping to KVKs

The Directorate of Extension of the State Agricultural Universities conducted 99 programmes for providing technological and methodological backstopping to 2,827 KVK staff. The Zonal Co-ordinating Units conducted 52 programmes with the participation of 2,060 KVK staff.

District-level interface programmes

The KVKs organized 480 Interface programmes through the meetings of Scientific Advisory Committee, sponsorship of special programmes and developing functional linkages.

16

Gender Issues for Technological Empowerment of Women in Agriculture

The mandate of National Research Centre for Women in Agriculture is to — conduct basic, strategic and applied research to identify gender issues and test appropriateness of available farm technologies/programme/policies with women perspective; carry out training and consultancy 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 farmwomen.

Gender roles in household activities: An analysis of household activities carried out among women indicated that 26% of their time was devoted for household chores and 17% accounted for fuel wood collection with evidences of inter-generational changes in the pattern of gender work participation. A tendency was noticed among 15% of farmwomen to shy away from wage earning activities in agriculture as influenced by level of education.

Impact of mechanization: Mechanization in rice farming led to a loss of about 57.1 human days in irrigated and 22 days in non-irrigated situation while creating additional space for women and restructuring of gender roles. Introduction of thresher created on an average, 18 additional days of employment for women in irrigated areas and 5.2 days in non-irrigated areas. In the absence of male members, 20% of women managed the farm operations by custom hiring of machines.

Livelihood security through entrepreneurial activity among farm families: Women self-help groups are very effective in capacity building of rural women. However many such SHGs lack entrepreneurial skills for income generation. Development of rice and pulse-based agro-enterprises among farmwomen in Pipili and Sakhigopal villages of Puri district, Orissa were very useful in helping the SHGs to generate income and also in improving leadership qualities and confidence among rural women. Two SHGs were trained in agro-processing and value addition.

Technology testing and refinement in gender perspective: Application of non-hazardous pesticides such as nuxvom, tobacco-soaked water, neem oil and calotropis and hanging of camphor and naphthalene balls from the plant combined with pheromone trap, light trap and maize and marigold barrier at the time of transplanting were effective in the management of brinjal shoot and fruit borer and maintaining higher population of predator such as spider. Maize barrier and marigold intercrop provided favourable cost benefit ratio followed by calotropis powder. Termite traps made of earthen pots were also effective for termite control. The above techniques were easily accessible to and affordable by farmwomen.

Robusta and G-9 varieties of banana were evaluated for low input homestead cultivation using indigenous organic and inorganic inputs. An application of 5g ammonium sulphate and 10g sulphate of potash blended with 500g of fresh cow dung to the distal end of bunch showed significant enhancement in fruit weight yield and

Capacity building of farmwomen

The action research for capacity building of women agricultural labourers (WALs) for increasing the efficiency in agro-enterprises taken up among 60 women in blocks Tangi and Salepur, showed that WALs preferred poultry rearing, mushroom cultivation, rice processing, solar drying and bee keeping for development of enterprise and capacity building. Training programmes, demonstrations, field visits and group discussions were organized on the selected enterprises. Demonstrations of four-row rice transplanter designed by the CRRI, raising of mat type seedlings and mechanical transplanting were carried out.

SUCCESS STORY

Profit earning self-help group

Sangram Vikram Self-help Group in Konjar village in Orissa, came into existence with the effort of a research team of NRCWA, Bhubaneshwar. The group opened a bank account with the State Bank of India, Pipili in September 2002. The group members leased a land area of 0.2ha for 3 years @ 650/year for carrying out the farm-based activities. In November 2002 they grew tomato, cauliflower, beans, potato and greens. With an investment of Rs 320 they could earn a gross amount of Rs 1,278 with a net profit of Rs 958 after two months. The NRCWA trained them in the preparation of lime and orange squash, and with Rs 1,120 they could earn a profit of Rs 950. The group was also trained in the preparation of *baddi* with blackgram. With Rs 280 they could earn a profit of Rs 60/kg. Thus within a year the SHGs could earn a net profit of Rs 2,368. With the initiative of the President of the group they established contact with a private company, which was impressed by the quality of the product, and it placed order for 40 bottles of lime squash. Inspired by this the group secured a loan of Rs 50,000 from the State Bank of India for expanding their business. The group prepared 2,000 bottles of lime squash and 50 bottles of tomato puree and different types of spices including haldi powder, which they sold in the exhibition organized by Orissa State Government and earned a net profit of Rs 28,000.

maturity. The cost of treatment worked out to be Rs 4 per plant as compared to Rs 8 per plant in soil application of recommended dose of NPK indicating cost effectiveness and ease of adoption by women.

Animal health camps were organized and practices such as supplementation of mineral mixture in the concentrate ratio, cultivation of improved forage and vaccination and de-worming were taken up. Castration and replacement of males among farmers' flock for breed improvement, vaccination and de-worming to reduce mortality and morbidity and supplementary feeding of concentrate made from locally available feed resources were introduced for increasing productivity of small ruminants. On an average 20% gain in body weight of lambs/kids was recorded due to supplementation of homemade concentrate as compared to farmers' practice. Replacement of male buck/ram resulted in better stock. Castration of male lambs/kids resulted in body weight gain and these fetched 20-25% higher price than un-castrated ones due to consumer preference.

Implementation of scheduled prophylactic health measures reduced mortality from 33 to 7% and increase in growth rate of 25-30% in the animals between 6 and 12 months of age in their flocks. Women accepted the improved practices, as these were easy to follow.

Drudgery assessment and reduction

Introduction of women friendly improved farm tools and implements: Out of 20 farm operations, the ten critical areas of involvement of women are interculture, harvesting, cleaning and grading, drying and storage, preparatory work in field for sowing, winnowing, ridge/furrow making, maize shelling, vegetable plucking and groundnut decortications. The critical areas of operations for men were ploughing, preparatory work in the field for sowing, harvesting, sowing of seeds, threshing, carrying grain after threshing, ridge/furrow making, carrying fertilizer and its application, carrying FYM and its application, and carrying harvested crop. Most of the farm operations which farmwomen carried out are either by their own hand, feet or using traditional tools, such as sickle, spade, supa, chalani etc. Women's involvement index in farm operation (WII fo) was developed. Women involvement index (WIIfo) in farm operations was 0.42, which varied from 0.36 to 0.53 across the selected villages. The highest WIIfo of 0.53 was in the village having vegetable production. The operations that showed WIIfo of more than 0.50 were drying and storage, cleaning, grading, interculture, vegetable plucking, maize shelling, harvesting, groundnut decortications, and preparatory work in field for sowing. Fourteen equipments namely seed treatment drum, hand ridger, fertilizer broadcaster, Naveen dibbler, twin wheel hoe, PAU weeder, grubber weeder, sitting type groundnut decorticator, hanging type cleaner with five sieves and sack holder, PAU seed drill, pedal cum power operated cleaner grader, knapsack sprayer and groundnut stripper with four stools were introduced in the selected villages and farm women were given training in their operation and maintenance. Most of these tools and implements had the potential to reduce the cost of operation as well as drudgery per unit output due to increased work efficiency. PAU wheel hoe and twin wheel hoe saved Rs 1,563/ha and 1,514/ha (over traditional method), respectively, in the cost of weeding and interculture operations. Use of hand ridger saved labour cost to the extent of Rs 333/ha. Use of tubular maize sheller, groundnut decorticator and groundnut stripper saved Rs 21.85, Rs 123.20 and Rs 63.40/q, respectively, in cost of operation due to labour saving.

All India Coordinated Research Project on Home Science

The All India Coordinated Research Project on Home Science, that was merged with NRCWA

Gender sensitive extension model

The concept of Village-level Para Extension Workers (VPEW) was tested for development of a logical model for gender mainstreaming in extension. This is being tried by building their capacity for identification of the needs and problems of farmwomen and training them to help in increasing the productivity in agriculture, income and living standards of rural households. Under the study being implemented in two rainfed villages of Khurda, Orissa, training programmes were conducted on mushroom cultivation, agro-processing, eco-friendly storage pest control, seed production, result demonstration on cultivation of rice, colacasia and mushroom. Demonstrations were laid on 50 homestead nutritional-cum-seed production units of 75m^2 each, eight mushroom units of 25 beds each, culture of fish in two community ponds of 3,000m^2 and high yielding scented rice in four acres as interventions for capacity building. Women belonging to SC and weaker sections and self-help groups derived more benefits from VPEWs.

is in operation at nine Centres/SAUs, viz. CCSHAU, Hisar; PAU, Ludhiana; UAS, Dharwad/ Bangalore; MPUAT, Udaipur; ANGRAU, Hyderabad; GBPUAT, Pantnagar; MAU, Parbhani; AAU, Jorhat; and CSKHPKV, Palampur. Empowerment of rural women for enhancing the quality of life is the main objective of the Project.

Gender disaggregated data have been collected from 1,800 households covering 3,600 respondents from nine states (400 respondents from each centre and one male and female from each household). The gender specific information included role and responsibility, access to and control over resources in farming, post harvest, horticulture, homestead garden, livestock management, fisheries and availability of extension services. The pooled data of all the states indicated that, the extent of independent participation of women was highest (29.9%) in livestock management and least in horticulture (6%). About 34.1% of women have complete responsibility of livestock management followed by 17.19% in horticulture and 16.4% farm related activities. Compared to women higher percentage of men have taken complete responsibility in performing various activities. About 15.8% women have complete access to farm related resources. Greater access was in livestock (28.2%) followed by homestead resources (27.4%) and horticulture (25.5%). The relative frequency of women who had control over the resources was lowest (7.3%) in farm related resources and highest (21.5%) in livestock related resources. In general, the extent of access to and control over the resources in agriculture and related activities were biased in favour of men.

Based on the multi-location field trials, drudgery reduction technologies including, ring cutters for harvesting vegetables and flowers, improved sickle for harvesting paddy, harvest bag for cotton picking, improved weeders, maize shellers for maize threshing, hand wheel hoe, long handled scrubbing brush, hand rake, paddy row seeders, water fetching trolley, potato picker and vegetable peelers were transferred to women. Head load manager technology was developed at the ANGRAU, Hyderabad, for reducing drudgery in the manual head loading of vegetables while transporting.

Training on apiary for rural women

Empowerment programmes were conducted through group discussions, demonstrations and trainings in the adopted villages for women in the resource management practices such as fuel/ energy saving practices, alternative energy technologies and water management practices. A low cost solar dryer was fabricated using indigenous material for effective use of solar energy for household purposes, and the technology was transferred.

The concept of **nutrition garden** was promoted among selected families to create awareness and motivation about the role of micronutrients in diet. An iron rich product *Lehyam* from locally available unconventional green leafy vegetables was developed that helps in combating iron deficiency. The standardization of the developed product was completed by all the centers.

Intensive training programmes of three months duration were conducted at all the centres, and girls and married women in the age group of 11 – 25 years were trained to develop vocational skills, crèche organization and management, establishment and management of early childhood education centres, preparation of educational play materials, nursery rearing of vegetables and fruits, vermi compost preparation, color yielding and medicinal plants and mushroom cultivation. Adolescents have also become members of self-help groups and are involved in enterprise development.

Sisal plant (*Agave americana*), grown as edge plant around the fields, is usually discarded as agricultural waste. This plant is a good source of non-conventional fibre and was identified as source for hand-made paper making.

17

Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through its institutes located in North-west Himalayas, North-east Himalayas and Islands evolved 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, horticulture, animal husbandry, poultry and fisheries.

NORTH-WEST HIMALAYAS

The salient achievements of institute located

New Releases

Variety/hybrid/ composite	Adaptation region/ agro-ecology	Duration	Salient features
Vivek QPM 9	Zone I and Zone IV	Extra-early (85-90 days)	Yellow, single cross hybrid showed more yield, tryptophan, lysine, Fe and Zn than best check Vivek Maize Hybrid 9
Vivek Maize Hybrid 25	Zone I	Extra-early (85-90 days)	Single cross hybrid yielded more than the best check HIM 129. Also showed a high degree of tolerance to turcicum blight and better response to low dose of N (40 kg/ha)
Vivek Maize Hybrid 27	Zone III and Zone IV	Extra-early (80-85 days in Zone III and 85-88 days in Zone IV)	Single cross hybrid yielded higher than HIM 129, exhibited moderate tolerance to turcicum and maydis leaf blight and better response to higher doses of N
Vivek Sankul Makka 31	Uttarakhand hills	Early (90-95 days)	In spite of being a composite it yielded higher than popular hybrid HIM 129 and composite Surya. Also showed high tolerance to turcicum blight and better response to higher N doses in hills
VL Gehun 892	Late sown, restricted irrigation conditions of hills Uttarakhand and Himachal Pradesh	Early (140-150 days)	Variety showed yield superiority to checks Sonalika, HS 420 and HS 295, and resistance to brown and yellow rusts. Also possesses resistance against most virulent yellow rust pathotype 46S119 and 78S84. It is nutritionally rich
VL Matar 45	Rainfed, timely sown onditions of Uttarakhand hills, Jammu and Kashmir and Himachal Pradesh	160-165 days	Field pea variety possesses resistance to wilt disease and yellow round grains with higher 100-grain weight
VL Rajma 125	Rainfed, timely sown conditions of Uttarakhand hills	75-100 days	It possesses resistance to bacterial blight and root rot. Grains are yellow with higher 1,000-grain weight

in North-west Himalayas are:

Varietal release

Seven varieties/hybrids/composite of crops were released for different agro-climatic regions of country.

Seed production

Around 23.2 tonnes breeder seed of 47 released varieties/inbred lines was produced. A total of 20.2 tonnes breeder seed was supplied to different seed-producing agencies to take up further multiplication. Besides, 1.57 tonnes nucleus seed of 35 released varieties was also produced.

High frequency plant regeneration

A robust callus induction and high frequency plant regeneration system was observed from the mature seed-derived nodes in VQL 2, parent of recently developed QPM hybrid, Vivek QPM 9.

The regeneration frequency was more than 25%. The healthy plantlets were grown in greenhouse.

Cold-tolerant plant growth-promoting bacteria

More than 1,000 cold-tolerant bacteria were isolated from the rhizosphere, rhizoplane, endorhizosphere and phylloplane samples collected from high altitude areas (1,800 to 3,800 m amsl) of Uttarakhand, with greater diversity among the isolates from Garhwal region compared to Kumaon region.

Almost all cold-tolerant isolates possessed more than two low molecular weight plasmids,

Diversity of cold-tolerant bacteria from North-West Himalayas

while high molecular weight plasmids were detected in few isolates. The 16S rRNA gene of plant growth-promoting bacterial isolates from high altitudes were sequenced at IMTECH, Chandigarh. The sequences were deposited at GenBank, USA and their accession numbers were obtained.

SUCCESS STORY

Cultivation of off-season cauliflower

A system of off-season cauliflower cultivation in mid-hills, which includes growing of seedlings in polyhouses during November-December followed by transplanting in open fields in January, was developed by the Institute. With this cultural manipulation, the crop is ready to be harvested by the end of March, when cauliflowers are not at all available in the market. Twenty-five farm families in two clusters of villages of Champawat district followed this practice and got an average yield of 17 tonnes/ha with a curd size of 0.75 to 1.50 kg. With such a production, farmers got an earning of about Rs 2.0 lakh/ha. Thus off-season cultivation of late cauliflower has become highly remunerative for the hill farmers.

SUCCESS STORY

Water harvesting and surface storage in Darim village, Uttarakhand

Supplemental irrigation is necessary to maintain the soil-moisture regime at optimal level for obtaining higher production. The geographical limitations and terrain conditions indicate possibilities of small water harvesting tanks, which can be well integrated with the hill farming system and household.

Water resources of 2,417 m^3 were developed at the farmers' fields under the outreach activities of the institute located at Almora, in two clusters of villages, namely Bhagartola (Almora district) and Darim (Nainital district). In village Darim 52 tanks were made. The capacity ranged from 10 m^3 to 288.75 m^3. Nearly one-third LDPE tanks (17) have capacity of 10 to 15 m^3 because of the smaller size of terraces and land holdings of the farmers. Twenty-seven poly-tanks are of 15-30 m^3 size and eight tanks above 30 m^3 capacity.

The aerial view of tanks in Darim cluster is partially shown. The image was captured from web resources and the water-harvesting tanks were located in the present scene

The harvested water, when utilized through micro-irrigation system for cultivation of vegetable pea and French bean resulted in pod yield of 12.8 tonnes and 10.5 tonnes/ha, respectively, and provided annual return of more than Rs 1.75 lakh/ha, with a benefit:cost ratio of 2.32. The payback period for water resources development came to be 3.35 years, considering the internal rate of return being 27%. Moreover, the use of micro-irrigation saved harvested water up to 40%.

SUCCESS STORY

Integrated pest management

The IPM technology developed at the Institute was propagated amongst farmers in four blocks of Almora district (Hawalbagh, Tarikhet, Takula and Dauladhevi) during 2004-05 to 2006-07. The technology adopted by 480 farmers in 972 fields (19.44 ha area) of 200 m^2 each in six vegetable crops. As a result, germination in IPM-treated plots significantly improved (60-90%), being 20-30% higher than the local practice. Motivated by application of the bioagents *Trichoderma harzianum* using vermicompost as a delivering medium, the farmers prepared 84 tonnes vermicompost in 347 vermipits and applied it in the IPM fields.

The IPM adopting farmers realized higher yield of vegetables 20, 25, 15, 16.5, 20 and 14.5 tonnes/ha in bean, tomato, capsicum, cauliflower, cabbage and vegetable pea, respectively, which was 30-70% more than the local practice. Improved yield with reduced pesticide load through bio-intensive approach of IPM has become popular among the farmers. Encouraged by the success of IPM technology in getting healthy crop with higher yields, 43 farmers planted vegetable pea adopting IPM technology in the village Tipola Sera of Tarikhet block, where they obtained 65% higher pod yield (20 tonnes/ha). These farmers earned more than Rs 2 lakh/ha by selling their produce @ Rs 12-14/kg.

NORTH-EAST HIMALAYAS

The research work carried out at the institute located in North-East Himalayas includes:

Promosing genotype of Indian bean

RCDL 10, A bush type, photo-insensitive, short duration, high-yielding genotype of Indian bean (*Dolichos lablab*) tolerant to aphids, leaf spot and powdery mildew disease was identified for NEH Region. It has yield potential of 14-15 tonnes/ha and can be grown from April to November at a spacing of 80 cm × 40 cm. First harvesting can be done 75 days after sowing. Average pod weight is 4.0- 4.5 g and pod yield varies from 95 to 100 g/vine.

High yielding crossbred cattle

The productive and reproductive performance of Holstein-Friesian (HF) crossbred cattle having around 75% HF blood was assessed for eight years in North-eastern Region of India. The milk yield/ lactation (litre), lactation length (days), milk yield/ day (litre), milk yield/day in first 300 days (litre), age at first calving (days), calving interval (days), dry period (days), and days open (days) were 3,423 ± 134, 390 ± 16, 9.2 ± 0.43, 11.7 ±0.45, 811 ± 29.7, 437 ± 19, 50.4 ±4.14 and 155 ± 18.15 respectively. The results indicated that milk production under climatic conditions of NE region can easily be increased by rearing HF dairy cattle.

Rare and endemic butterflies of north-east India

Out of 125 butterfly species identified for the first time from North-Eastern Region of India, the following were found rare and endemic to the region.

Northern jungle queen (*Sticopthalma camadeva camadeva*)*:* It is a large butterfly, found in thick forests at an altitude of 800 m in Arunachal Pradesh and its larva feeds on bamboo.

Green duke (*Euthalia sahadeva sahadeva*): It is found in mid-altitude of about 1,800 m in Manipur, and its larva is a pest of *Quercus* sp.

Tawny rajah (*Charaxes polyxena hierax*): An active and stout butterfly confined to thick forest areas of Meghalaya. It is a polyphagous larva, feeds on *Tamarindus indicus*, *Aglaia elaeagnoidea, Saccopetalum tomentosum*.

Dark archduke (*Adolias khasiana khasiana*): It is a black butterfly found below 1,800 m altitude in Meghalaya.

A technique for identification of meat species

Species-specific DNA markers for pig, chicken, duck and pigeons were developed and validated by cross checking with the other meat species such as cattle, sheep, goat, rabbit, chicken, duck, pigeon and turkeys. The DNA markers developed can help identify the species of raw as well as cooked meat of the species mentioned. This process of identification is simple, economical and quick as compared to the PCR-RFLP method of species identification.

ISLANDS

The research findings of the institute located in Islands are:

Rice

At the Bloomslade research farm, long-duration varieties (Gayatri, Savitri, Ranjit and Varshadhan) performed better than medium-duration Taichung Sen Yu. Among long-duration varieties, Ranjit recorded highest grain yield followed by Savitri, Varshadhan and Gayatri. In farmers' fields also, long-duration varieties gave significantly higher grain yield than long-duration C 14-8 in spite of minimal management practices adopted by the farmers.

Azolla : a feed substitute for poultry

Azolla can be supplemented for backyard poultry along with other foodgrains and kitchen waste. *Azolla* supplementation did not have any adverse effect on egg production, and showed

SUCCESS STORY

Integrated watershed management for livelihood security of shifting cultivation areas of Nagaland

In Peren district of Nagaland, integrated watershed development programme was taken up covering an area of 1,032 ha during 2003-04. The watershed area comprised 40 villages having population of 28,680. To operate the scheme, 1,016 self-help groups (SHGs) were formed under the banner of Union Cooperative Societies (UCOS) – Peren, Jalukie. Passion fruit, maize, turmeric and ginger were selected as the priority crops for cultivation within the watershed area. About 610 SHGs are involved in passion fruit cultivation in an area of 212 ha, whereas maize is being cultivated in an area of 105 ha involving 386 SHGs. The UCOS is cultivating these two commodities since last 3 years. The upper ridges of the area were rehabilitated through agroforestry interventions to produce biomass for firewood and timber, besides soil and water conservation. Around 76 ha area was covered with banana, pineapple, cashewnut, Assam lemon, guava, jackfruit and litchi under agri-horticultural land-use system. The institute-released turmeric variety (RCT 1) is also being commercially cultivated by the farmers in an area of 100 ha since last year.

Integrated watershed management in shifting cultivation areas of Nagaland

Increased population of Vanaraja poultry birds

Five hundred poultry birds (Vanaraja breed) were distributed to 30 SHGs, covering 27 villages in 2004-05. The bird population has now gone up to 4,000 by which 800 farmers were benefited through the distribution system being adopted by UCOS. Thirty-six piglets of improved breed (Large Black X) were also distributed to 20 SHGs and, as of now, 90 SHGs are rearing the improved breed of pig covering 40 villages. Besides, in 2007, UCOS has sold 400 quality piglets to Wokha district of the state. In fishery sector, UCOS in collaboration with the ICAR is adopting integrated fish farming system with duck and fish in an area of 3.6 ha. The fish productivity has increased from 1.2 tonnes/ha to 5.4 tonnes/ha by adopting integrated fish farming system. An employment of 43,500 man-days was generated during the last 4 years under different activities taken up in the watershed area.

During 2002-03, the total area under shifting cultivation in the watershed area was 512 ha, which has come down to 31 ha during 2007-08. The integrated watershed development programme taken up by the ICAR has helped the farmers in reducing shifting cultivation and reap benefits of settled cultivation.

immunoregulatory role in poultry. It is highly palatable in both growing and laying quails. *Azolla* supplementation in quails @ 10-20 g/bird/day could replace 21.7-30% concentrated feed. The technology of *Azolla* feeding was successfully transferred to the farmers' fields and they have started supplementing *Azolla* in the quail feed up to the age of marketing.

Coconut husk burial for round-the-year vegetable production

The areas, which are close to the sea and left as a fallow due to the clayey soils and seawater entry in subsoil during high tide after tsunami, can be effectively converted into cultivable land by a raised bed method. In this, beds are raised to a height of 30 cm from the ground level. Coconut husks which are thrown as waste are chopped and covered over the beds as a layer. Above this layer, soil mixed with compost is applied before growing crops. High-value vegetable seeds and seedlings are taken on the surface of the raised beds. This facilitate survival of vegetable crops against the continuous and heavy rains and rise in the level of seawater. Coriander, capsicum, okra, tomato, French beans etc. can be taken on the beds, whereas *Tagetes* and swamp cabbage in furrows. An average net profit of about Rs 3.8 lakh can be obtained. These treatments also increased pH to 6.88 which was earlier in the acidic range (pH 5.24).

Microbial diversity and identification

Agriculturally important micro-organisms, i.e. 33 fungal pathogens, 31 bacterial pathogens, 434 bacterial antagonists and 83 fungal antagonistic isolates, were isolated from infected plant parts and rhizosphere soil samples of vegetable and spice crops cultivated in Andaman and Nicobar Islands. Two types of leaf anthracnose symptoms were observed on black pepper. The first symptom was consistent with the disease previously reported on pepper as *Colletotrichum gloeosporioides*. The second symptom was similar to that caused by *C. dracaenophilum*, a species identified as a pathogen on lucky bamboo (*Dracaena sanderiana*), and internal transcribed spacer region of the fungal DNA was amplified, sequenced and submitted to NCBI GenBank (Accession No EU744584). BLAST searches of GenBank using the ITS sequence revealed that this fungus was a member of the genus *Colletotrichum*, but a species level identification could not be made with this data. The fungus was mostly similar in sequence to phytopathogenic isolates of *C. dracaenophilum* (93% sequence similarity).

Renewable energy-based dryers

Renewable energy-based solar dryers and biomass fired dryer were tested and evaluated for product drying quality and were compared with natural sun drying method. Coconut, black pepper, chilli, jack fruit bulb, mushroom and fish were dried in these dryers. The drying under solar dryers saved 33.3% time in model-1 (bamboo/wooden frame) and 37.5% time in model-2 (steel frame with trays, doors and ventilators**)**. The quality of the copra obtained from solar dryers was at par with the quality of edible copra, and moisture content of product was between 6 and 10% (wb). These dryers are designed to work in wind speed of up to 45-60 km/hr.

Renewable energy-based solar dryer to improve the product quality of plantation crops

Under biomass fired dryer, drying of coconut and fish was done using coconut shell as fuel. Drying rate was higher under biomass fired dyers than solar dryer. Biomass fired dryer can be used for dying of coconuts and fish during rainy season.

18

Organization and Management

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December, 1973. Subjects allotted to the DARE as per the Government of India (Allocation of Rules) are specified in Appendix I of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India in the DARE functions as the Director-General of the ICAR. The Financial Advisor of the DARE is the Financial Advisor of the ICAR. Generally single-file system is followed between DARE and ICAR.

The Department has one more autonomous body viz. the Central Agricultural University, Imphal under its administrative control. The University, which was established in 1993, has its jurisdiction over Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim and Tripura and is wholly financed by the Government of India.

The DARE has 17 Group A, 14 Group B, 6 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 Castes, Scheduled Tribes and Other Backward Classes. Presently, DARE has 6 Scheduled Caste and 2 Scheduled Tribe 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 Estimate (BE) and Revised Estimate (RE) of DARE and ICAR (Plan and Non-Plan) 2007-2008 respectively and BE for 2008-09 (Plan and Non-Plan) . 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 Science and Technology Programmes in the agricultural research and education.

The ICAR was set up on 16 July 1929, as the Registered Society abide by the Societies Registration Act 1860, on the recommendations of the Royal Commission of Agriculture. It was reorganized twice, in 1965 and 1973. The ICAR (Hq) is located at Krishi Bhavan and its other buildings are Krishi Anusandhan Bhavan I and II, and NASC Complex, all in New Delhi.

The Union Minister of Agriculture is the President of the ICAR. The Principal Executive Officer of the ICAR is the Director-General, who is also the Secretary to the Government of India in the Department of Agricultural Research and Education.

The General Body (GB) of the ICAR Society is the supreme authority of the ICAR, and the Minister for Agriculture, Government of India, heads it. Its members are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the Senior Officers of the various state governments, representatives of Parliament, industry, educational institutes, scientific organization and farmers (Appendix 1).

The Governing Body (Appendix 2) is the chief executive and decision-making authority of the ICAR. It is headed by the Director-General. It consists of eminent agricultural scientists, educationists, legislators and representatives of

the farmers. It is assisted by the Standing Finance Committee, Accreditation Board, Regional Committee, Policy and Planning Committee, several Scientific Panels, and Publications Advisory Committee. In the scientific matters, the Director-General is assisted by 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 Deputy Directors-General are responsible for the Institutes, National Research Centres, and the Projects Directorates in their respective fields. The Senior Officers, posted at the ICAR (Hq), are listed in Appendix 3.

The ICAR received 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 economics status.

The Research set-up of the ICAR includes **48** Institutes (Appendix 4), **5** National Bureaux (Appendix 5), **12** Project Directorates (Appendix 6), **30** National Research Centres (Appendix 7), and **77** All-India Co-ordianted Research Projects (Appendix 8).

The Directorate of Information and Publications of Agriculture is working independently with the approval of the Competent Authority. The Media and Information Unit, ARIS Unit and Library at ICAR (Headquarters) which were earlier functioning separately, are now working under the supervision of the Project Director (DIPA).This integration of various units under DIPA will provide organized strength and efficient use of human, financial and infrastructural resources for creating public awareness through dissemination of information globally by print media as well as electronic media.

The ICAR promotes research, education and extension education in **41** 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 forms (Appendix 9).

For effective communication of research findings among farmers, the ICAR maintains an effective network of Krishi Vigyan Kendras and Trainers' and Training Centre along with Zonal Co-ordinating Units.

The total sanctioned as well as existing strength of the employees of the ICAR system, including scheduled castes, scheduled tribes and other backward classes, is given in Appendix 10.

Thus with an extensive network of research infrastructure, backed by an excellent team of scientists and other employees, the ICAR is making rapid strides in agricultural research, and provides support to the national efforts in achieving food security and self-sufficiency.

IPR AND POLICY

IPR titles on inventions/innovations

Patents: The ICAR's intellectual property (IP) portfolio has been firming up since the implementation of its management guidelines w.e.f. 2 October, 2006. This visibility has further enhanced with the release of some global and national IP databases and search tools. The patent search database of 'Intellectual Property India'

Table 18.1 Granted Indian Patents

Field of Invention	Patent Number	Title of Invention
Veterinary Medicine	IN210526	A process for preparing a novel herbal formulation for the treatment of mange in animals.
Processing (Feed Industry)	IN210528	Cold process technology for the preparation of urea molasses mineral block.
Pharmacy/ Biopesticides	IN211204	Process for purification of solanesol (95%) from crude/enriched extracts of tobacco green leaf/ tobacco cured leaf/ tobacco waste.
Pest Management/ Research Tools	IN213744	Egg cleaning device.
Processing in edible oil industry	IN216982	Development of a process for conversion of paddy husk ash into bleaching material for edible oil.
Processing in edible oil industry	IN217106	Pre-grinding of oilseeds prior to mechanical expelling – a new process of energy saving.
Biopesticides	IN217763	Process for the preparation of pesticidal oxime esters.
Biopesticides	IN218031	Process for the preparation of mono/di/polyol ester pesticides.
Processing fibre industry	IN220787	Method of degumming of decorticated ramie fibre by recycling of degumming liquor.
Dairy beverages/ Processing in dairy industry	IN222587	Process for the manufacture of shelf-stable whey-mango beverage.
Hybrid seed production – research tools	IN223253	A composition for hybrid seed production.

(http://www.ipindia.nic.in/), which is an upcoming site maintained by the Indian Patent Office where uploading of records is in progress, has published under the head 'patent search for public (new records)'eleven patents granted to ICAR in various fields of invention (Table 18.1). There is a listing as well of some previously granted ICAR patents on the same site, which mainly covered the fields of cotton, jute and shellac processing.

Besides, the world patent search for ICAR as the applicant, at the European free search facility (http://ep.espacenet.com/), revealed 35 patent records, out of which 4 patents/patent families are at the stage of either international applications under the Patent Co-operation Treaty (PCT) or granted patents in various jurisdictions – USA, European Union, China, South Africa, Republic of Korea, and Mexico (Table 18.2). The recent national and foreign records of 16 inventions in ICAR covered the fields of biopesticides (4), biotechnology/ research tools (1), dairy beverages (1), hybrid seed production/ research tools (1), pearl culture (1), pharmaceuticals (1), processing industry for edible oils (2), fibre (1) and feed (1), transgene detection (1), and veterinary medicine (2).

Besides the Indian Patent Office issued 2 more letter patents to ICAR for the respective inventions in environmental sciences and agro-chemicals/ pesticides, viz. (i) 'A hyper-spectral data analyzing method for characterization and discrimination of natural/man made resources from air borne platforms', and (ii) 'A process for the preparation of mosquito larvicidal formulations based on *Rabdosia melissoide* ingredients'. Further, 80 Indian patent applications filed by ICAR were published in the official gazette for public information to facilitate the grant of patents abide by the law.

Plant varieties: The process of registration and protection of varieties under the law started in the country in May 2007 and presently varieties of only 14 crops (18 species) are notified for the purpose (ICAR has already standardized national test guidelines for 35 crops and recommended for notification thereof). By the middle of October, 2008, ICAR had filed applications for the protection of 546 extant and 27 new varieties of the notified crops and the process of registration is on. The pie diagram indicates that maximum applications have been filed for the extant varieties of rice (125) followed by that of wheat (83), maize (71) and pearl millet (53). The process of filing of applications of extant varieties of cotton has also begun; the

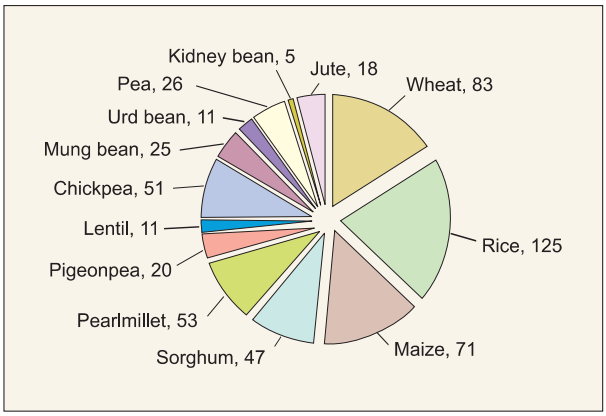


Fig. 18.1. Number of applications for the Registration of Extant Varieties filed

law provides 3 years for the completion thereof.

Other forms of IPR: Trademark protection for services and products of various institutes has been secured to enhance market goodwill and safeguard quality assurance. These included label PUSA by IARI, New Delhi; biopesticide formulations TRIVIR 1% WP (*Trichoderma viridae)* and KNOCK WP (*Bt* formulation) by DOR, Hyderabad; and antibiotic formulation CIFAX for use in fisheries and aquaculture, and label Jayanti Rohu by CIFA Bhubaneshwar. A part of Copy Right Protection for Softwares (developed at NRC for Soybean, Indore; NBFGR, Lucknow; and NBPGR, New Delhi) was secured.

Table 18.2 PCT applications at various stages and patents granted in other countries

Field of Invention	Patent/Application number	Title of Invention
Pearl culture	WO2008062248	*In-vitro* pearl production using marine organisms.
Veterinary Medicine	WO2008041047	An artificially synthesized peptide.
Transgene detection tool	ZA200410268 [South Africa], WO03102208 [PCT], MXPA04011769 [Mexico], KR20050026396 [Republic of Korea], CN1672049 [China]	Rapid detection of Bt-cry toxins.
Biopesticides	EP1734817(A1) [European Union], WO2006064511 [PCT]	A pesticidal composition containing thymol/ P-cymene.
Hybrid seed production – research tools	US2003192070 [USA]	Composition for hybrid seed production, process for the preparation of such composition and use thereof.

Capacity building

A new Plan Scheme is a unique in Public-Public Partnership mode (having total project outlay of Rs 486 million in XI Plan), has been initiated, which has a contribution (in 2:1:1 ratio) from the Central Government (Plan Funds), the National Agriculture Innovation Project, and the ICAR's internal resource generation. This Intellectual Property Management and Transfer Commercialization of Agricultural Technology Scheme broadly aims at up-scaling of existing component of IPR previously handled under

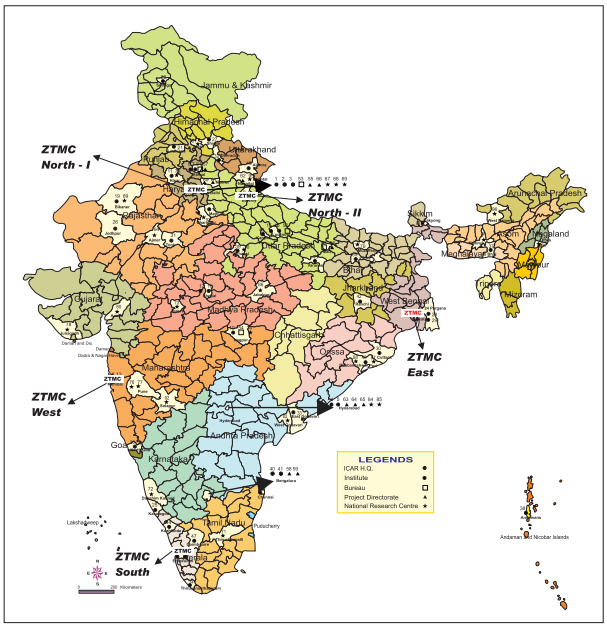


Fig. 18.2 Location of ICAR institutes and Zonal Technology Management Centres

the ICAR (Hq) Scheme on Management of Information Services.

More specifically, the scheme envisages setting up of the 3-tier institutional mechanism to protect/ manage the IP generated within the ICAR system, including that in the collaborative research. Accordingly, at the base level, 95 Institute Technology Management Units have been established and empowered by the appropriate delegation of powers to enhance the institutional IP management capacity. In the middle-tier, 5 Zonal Technology Management Centres have been established at the identified ICAR institutes in different zones for building capacity for business planning and development in association with NAIP (Fig. 18.2). The zonal centres and the central IPR and Policy establishment help the Institute Technology Management Unit on a case to case basis. In the initial phase, these units would use the resources allocates under the scheme to enhance their IP search and data management capacities.

Human resource development

The Central Technology Management Committee, the highest decision making body on IP matters in ICAR, recommended to lay emphasis on HRD in IPR and orientation with its Guidelines for IP Management and Technology Transfer/ Commercialization in 2008 so as to soon catch up with the national and global IPR regimes. IP management training-cum-workshops were also approved under the Indo-US Agricultural Knowledge Initiative in which ICAR further provided the entire logistic support. Thus, the IPR and Policy Unit, ICAR has conducted 12 such programmes all over the country for upgrading the knowledge base of 574 scientists and other concerned staff from ICAR institutes and State Agricultural Universities (including 132 participants in 3 Indo-US AKI programmes) and exposing them to the nuances of the overall subject of IPR. These programmes were structured to provide a special focus on various thematic areas (Table 18.3) within the IPR domain such as the protection of IPR in biotechnological innovations, or in microorganisms or patent writing or other forms of IPR etc. Besides, a due exposure was given to the participants of the core areas of IPR and technology transfer, as per *ICAR Guidelines, 2006.*

The programmes also helped in identification and consolidation of the team(s) of competent resource persons from within ICAR as well as outside the ICAR system, being from government departments, public sector research and development organizations, academia, law experts and attorneys, business experts, etc. for meeting the present and future HRD requirements in IP and Technology Management. Also, in the 3 programmes under the Indo-US AKI Project, contracted to CCS Haryana Agricultural University by ICAR, there was a good exposure of the IPR domains on reciprocal basis among the outside faculty from Michigan State University, United States Department of Agriculture, and Association of Universities for Technology Management of USA, and the core ICAR resource persons' team.

Further, to cater to the HRD needs in IP management, ICAR scientists and other concerned staff were nominated for training in Indian Institute of Science, Bangalore; Indian Institute of Management, Ahmedabad; Administrative Staff College of India, Hyderabad; Society for Technology Management, Ooty; and in foreign countries, viz. Cornell University, Ithaca, USA; and World Intellectual Property Organization, Geneva. The Deemed Universities of ICAR (IARI, New Delhi; IVRI, Izatnagar; NDRI, Karnal; and CIFE, Mumbai) have also started teaching courses in IPR at Post-Graduate level. NAARM, Hyderabad has initiated the process for launching one-year fully residential diploma course on 'IP and

Table 18.3 ICAR Training-cum-workshop on IP and Technology Management held in 2008

Thematic Area	Host Institute	Participants
Patenting/ IPR in Genetic Engineering	Indian Agricultural Research Institute, New Delhi	(68)
Essentials of Patenting	CCS Haryana Agricultural University, Hisar	(55)
Procedural requirements of Patents	National Academy of Agricultural Research Management, Hyderabad	(49)
Drafting Specifications and Claims	Central Institute of Fisheries and Education, Mumbai	(46)
Copyright Protection	National Institute of Research on Jute and Fibre Technology, Kolkata	(31)
Trademark Protection	Central Tuber Crops Research Institute, Thiruvanathapuram	(50)
Protection of IPR on Microorganisms	ICAR Research Complex for NEH Region, Barapani	(68)
Protection of Designs and ICs Designs	Central Institute of Agricultural Engineering, Bhopal	(35)
Protection of Geographical Indications	National Bureau of Fish Genetic Resources, Lucknow	(40)
*Training-cum-Workshops under 3 Indo-US-AKI CCSHAU, Hisar, NAARM, Hyderabad; and KAU, Thrissur		(132)

Technology Management' with campus placement facility in early 2009.

Policy issues

Guidelines for management of ICAR services and contracts: A Committee has been constituted in ICAR to review and recommend suitable improvements in the existing Rules and Guidelines for Training, Consultancy, Contract Research and Contract Services, 1997, and to harmonise these guidelines with the key policy elements, as per *ICAR Guidelines on IP Management and Technology Transfer/Commercialization, 2006*. The draft report is in circulation for discussion, finalization and making final recommendations to ICAR.

IPR clearance of collaborative research projects: Institutional streamlining of the process has been carried out and awareness has been created in harmony with the *ICAR Guidelines, 2006*, particularly its key policy element on the much-needed Joint Intellectual Property Management Plan.

Business Planning and Development: Besides identification and notification of the five zonal technology management centres in respective ICAR institutes, the IPR and Policy Unit of the ICAR (Hq), in close association with the NAIP, has facilitated for the setting up of their respective BPD Units and to take initiatives for greater interactions within the zones.

ADMINISTRATION

Filling up of vacant posts

A good number of vacant posts like Under-Secretaries, Senior Administrative Officers, Administrative Officers/Finance and Accounts Officers/Section Officers/Private Secretaries/Assistants/Personal Assistants/UDCs/ Stenographers /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/Assistant Administrative Officers/Assistant Finance and Accounts Officers/Assistant Directors (OL)/Stenographers/ Lower Division Clerks and Group 'D' employees.

Staff Welfare Fund Scheme

(i) As per the recommendations of the Managing Committee of ICAR (Hq) Staff Welfare Fund financial assistance of Rs 25000/- was extended to the family of one deceased employee of the ICAR (Hq). Further Rs17,000/- was also given as financial assistance in case of illness of two Temporary Status Labourers of Sugarcane Breeding Institute, Coimbatore.

(ii) An amount of Rs 4,70,000/- was transferred to different ICAR institutes that were not able to generate sufficient fund under the head "Staff Welfare Fund" to have a minimum balance of Rs 25,000/- under this fund.

(iii) Under Staff Welfare Fund Scheme 45 Scholarships (Rs 2,500/- each) were awarded to the meritorious wards of the Council's employees.

Total number of employees in the ICAR and its research institutes and number of Scheduled Castes, Scheduled Tribes and Other Backward Classes are given in Tables 18.4 and 18.5.

Table 18.4 Total number of employees in ICAR (Hq) and Research Institutes mentioning SC/ST/OBC

Categories/posts	Posts		Scheduled castes		Scheduled tribes		OBC	
	Sanctioned	In position	Number	% to total employees	Number	% to total employees	Number	% to total employees
Scientific Posts								
Scientists	3881	3258	432	13.2%	96	2.9%	352	10.8%
Senior Scientists	1651	510	62	12.1%	07	1.3%	54	10.5%
Principal Scientists	749	263	45	17.1%	05	2%	18	6.8%
RMP Scientists	147	134	03	2.2%	02	1.5%	07	5.2%
Total	6428	4165	542	13.1%	110	2.6%	431	10.3%
Administrative Posts								
Directors / Dy. Secretaries/ L.A. / Under Secretaries / Sr. Admn. Officer / Sr. Finance & Accounts Officer / Admn. Officer/ F&AO / Law Officer/ SA to Chairman, ASRB	181	160	22	13.75	11	6.87	7	4.40
AAOs / AF&AOs / AD(OL) / PS / SO / DO / JA(WS) / Protocol Officer	645	571	88	18.34	294	7.93	359	9.68
Assistant / UDC / PA / JAO / Steno / Sr. S.A. / UDC / LDC	4199	3706	680	18.34	294	7.93	359	9.68
Total	5025	4437	790	17.8	599	13.5	725	16.3
Supporting Staff in ICAR Institutes								
Grade I	3299	2567	696	27.11	179	6.97	508	19.78
Grade II	4025	3063	864	28.20	217	7.08	180	5.87
Grade III	1925	1773	526	29.66	141	7.95	90	5.07
Grade IV	966	889	247	27.78	104	11.69	46	5.17
Total	10215	8292	2333	28.13	641	7.73	824	9.93

Table 18.5 The total number of Group 'C' and 'D' employees and number of Scheduled Castes, Scheduled Tribes and Other Backward Classes (as on 31.3.2008) at ICAR (Hq)

Posts	Posts		Scheduled castes		Scheduled tribes		OBCs	
	Sanctioned	in position	No.	% to total employees	No.	% to total employees	No. among them	% to total employees
Lower Division Clerk	94	58	13	22.41%	5	8.62%	5	8.62%
Peon	76	66	21	31.81%	2	3.03%	5	7.57%
Farash	11	10	5	50%	2	20%	1	10%
Mali	5	4	-	-	-	-	-	-
Packer	5	4	1	25%	-	-	-	-
Studio Attendant	1	1	-	-	-	-	-	-
Store Attendant	1	1	-	-	-	-	-	-
Daftry	45	45	8	17.77%	1	2.22%	-	-
Head Packer	1	1	-	-	-	-	-	-
Jamadar	8	8	1	12.5%	-	-	-	-
Jr. Gestetner Operator	2	2	2	100%	-	-	-	-
Franking Machine Operator	1	1	1	100%	-	-	-	-
Library Attendant	2	2	-	-	-	-	1	50%
Despatch Rider	1	1	1	100%	-	-	-	-
Record Keeper	1	1	1	100%	-	-	-	-
Sr. Gestetner Operator	2	2	-	-	2	100%	-	-
Safaiwala	12	12	12	100%	-	-	-	-

Table 18.6 Budget estimate and Revised estimate of DARE (Rupees in lakh)

Items	Budget estimate 2007-08		Revised estimate 2007-08		Budget estimate 2008-09	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451' Secretariat 090	-	165	-	165	-	175
Major Head '2415' General International Co-operation 80 (010032) – India's membership Contribution to Commonwealth Agricultural Bureau	-	10	-	10	-	10
India's membership Contribution to Consultative Group on International Agricultural Research (020032)	-	380	-	380	-	380
Other Programmes (030032)	950	-	1470	-	*1100	-
India's contributions to Asia Pacific Association of Agricultural Institutions (040032)	-	5	-	5	-	5
India's contributions to NACA (050032)	-	12	-	12	-	9
India's contributions to CGPRT (060032)	-	5	-	5	-	5
India's contributions to Seed Testing Association (070032)	-	2.25	-	2.25	-	2.25
ISHS Belgium (080032)	-	0.75	-	0.75	-	0.75

*Includes Rs 10.00 crore for National Fund for basic and strategic research in agriculture.

Finance and Audit

The Budget estimate and Revised estimate of DARE and ICAR (Plan and Non-Plan) for 2007–08 are Rs 2,460 crore and Rs 2,337 crore respectively and Budget estimate for 2008–09 (Plan and Non-Plan) is Rs 2,680 crore (Table 18.6).

PROGRESSIVE USE OF HINDI

DARE

The Department of Agricultural Research and Education has an Official Language Section for the compliance and implementation of the Official Language Policy of the Government of India. It consists of one post each of Assistant Director (Official Language), Junior Hindi Translator and Hindi Typist. Besides the Hindi translation of the Budget, compilation and preparation of the Annual Report of the Department etc. also take place. The functioning of this section also includes holding Hindi workshops, meetings, reports, organizing *Hindi Pakhwada* to encourage the employees for doing their official work in Hindi.

ICAR

- ICAR observed 2008 as 'Hindi year' at ICAR (Hq) and organised several programmes for staff to promote the progressive use of Hindi in official business. Hon'ble Union Minister of Agriculture issued a message at this occasion. The Director-General (ICAR) also issued an appeal requesting the officers/staff to do their maximum official work in Hindi. ICAR Institutes/Research Centres also organized Hindi Day/Week/Month.
- ICAR Institutes/Research Centres (4) were notified in the Gazzette of the Government of India thus raising the total number of notified Institution to 108 under rule 10(4) of the Official Language Rule, 1976.
- Joint Official Language Implementation Committee of the DARE and the ICAR working under the Chairmanship of the Additional Secretary (DARE) and Secretary (ICAR) met fourth time in 2008. Similarly, Official Language Implementation Committees constituted at ICAR Institutes/ Research 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.
- In accordance with the recommendations made by the Department of Official Language and the Parliamentary Committee on Official Language, to assess the progressive use of Hindi at the ICAR (Hq) as well as its institutes during 2008, 34 offices were inspected and suggessions were given to improve the shortcomings. Second Sub-Committee of the Parliamentary Official Language Committee inspected 8 Institutes/Research Centres during 2008.
- Rosters were maintained for imparting training in Hindi, Hindi typing and Hindi Stenography and officials were accordingly

deputed for training during 2008. This year, 14 stenographers and 16 typists were nominated for Hindi Stenography and Typing respectively.

- Hindi Workshops (4) were also organised for officers/staff.
- During 2007-2008 cash awards will be given to 10 officials at ICAR (Hq) for doing their maximum official work in Hindi.
- *Rajshri Tandon Rajbhasha Puruskar* will be given in 2009 for doing maximum work in Hindi.
- *Ganesh Shankar Vidyarthi Utkrist Hindi Krishi Partika Purskar* includes Hindi publications, published during 2007-08 (assessment will be done in 2009).
- XI issue of the *Rajbhasha Alok* will be published shortly.
- The Council and its institutes are organizing regular training programmes for farmers in Hindi, and in other regional languages; and in Hindi speaking region remarkable progress has been made at Krishi Vigyan Kendras in the use of Hindi, and in the other regional languages in their day-to-day official work.
- Besides material regarding Parliament, 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 other meetings were prepared bilingually. The Hon'ble Agriculture 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.

ICAR AWARD CEREMONY, 2008

The 'ICAR Award, 2007' function was held at NAAS Complex, Pusa, New Delhi on 16th July, 2008. The Chief Guest of the function, Hon'ble Union Agriculture Minister, Shri Sharad Pawar, gave away the awards. Shri Kanti Lal Bhuria, Union Minister of Agriculture (State), graced the occasion. Dr Mangala Rai (Secretary, DARE and DG, ICAR) and several other dignitaries were also present on the occasion. In his address, Hon'ble Union Minister of Agriculture, Shri Sharad Pawar, said that the recognition through Awards should lead to enhanced zeal and creative work by the Awardees, enthuse confidence in them and encourage others to strive harder for greater accomplishment. One Hundred eleven awardees under twelve different categories were conferred awards. These comprised four Institutions, 103 scientists, 3 farmers and one journalist. Out of 103 scientists there were 13 women scientists.

TECHNICAL CO-ORDINATION

The Co-ordination work comprised the work of financial support to 57 journals for publication, 7 societies/associations/universities for holding National Seminars/Symposia/ Conferences and 9 societies/associations/universities for holding International Seminars/Symposia/Conferences. It also included work related to selection of Best Annual Report of Institutes, preparation of ICAR International Training Calender for conducting training, replies to Parliament Questions, VIP references and queries under RTI Act regarding Awards. Two Regional Committee meetings were organized during this period and proposals for organizing two more Regional Committee meetings were also finalized which were held in October and November, 2008.

Each month the Co-ordination Unit prepares monthly report of major breakthroughs achieved in research and other related matters at various ICAR Institutes/NRCs/Project Directorates which is submitted by the Secretary (DARE) and DG (ICAR) to the Cabinet Secretariat, Government of India. Copies were also circulated to various Ministries and other related Departments. The Co-ordination Unit prepared the monthly report timely in each month during the year.

Assistance of technical nature was rendered to DST, DSIR DAC and other Departments of the Government of India. The Co-ordination Unit assists in preparation of Memoranda of Understandings and formulation of Work Plans for technical co-operation between DARE and various collaborating partners from abroad. There are 36 such MoUs with Work Plans between DARE/ ICAR and foreign countries. Besides, the Co-ordination Unit made preparations for organizing Director's Conference which was held in 2008.

19

Partnership and Linkages

Activities of the International Co-operation in ICAR/DARE has been operating through the Memoranda of Understandings (MoUs)/ Agreements/Work Plans signed with foreign countries/International organizations etc. with ICAR/DARE as the Nodal Department and through participation of ICAR/DARE in the MoUs/Work Plans signed by the Department of Agriculture and Co-operation as the Nodal Department. Besides Ministry of Science and Technology has developed a Programme of co-operation with various countries and international organizations in which ICAR/ DARE is the participating agency in agricultural research. The Joint Commissions/Working Groups constituted by the Ministry of External Affairs and the Ministry of Commerce have the component of agriculture/agricultural research in which DARE participates directly or through the Department of Agriculture and Co-operation.

The Department is also organizing visits of foreign nationals under *ad hoc c*ategory. The Department also receives proposals for customized training courses for foreign nationals.

MAJOR EVENTS

- A 2-day VI Meeting of Indo-US Agriculture Knowledge Initiative Board was held from 15 to 16 April 2008.
- A 2-day Indo-ASEAN expert level seminar on Enhancement of Productivity and Profitability of Crops in India and ASEAN Countries was organized from 11 to 12 September 2008.
- A 2-day Organizing Workshop on Rural Development and II Indo-China Joint Working Group Meeting were held from 15 to 16 October 2008.

MoUs/WORK PLANS

- ICAR-ICARDA Collaborative Research Work Plan 2008-10 was signed on 1June 2008 in Aleppo, Syria.
- ICAR-IWMI Work Plan 2008-09 was signed on 21 July 2008.
- Indo- Australian Programme on Marker Assisted Wheat Breeding Work Plan was signed between ACIAR and ICAR in Australia on 1September 2008.
- Work Plan for Scientific and Technical Partnership on Maize and Wheat Systems was signed between ICAR and CIMMYT in New Delhi on 10 October 2008.
- A Work Plan between the Ministry of Agriculture, Government of the Republic of India and the Ministry of Jihad-E-Agriculture, Government of the Islamic Republic of Iran was signed on 2 November 2008 for 2009-2010.
- A Contract was signed between the Embassy of Sultanate of Oman and the Indian Council of Agricultural Research, New Delhi on 5 November 2008, to participate in Mango Tree Encyclopedia Project.
- A Memorandum of Understanding between the Government of the Republic of India and the Government of the Republic of Ecuador was signed on 17 November 2008 for co-operation in agricultural research and education.

FOREIGN NATIONALS STUDIES IN INDIA

The 208 foreign nationals of 20 countries, viz. Iran (31), Ethiopia (50), Sri Lanka (30), Namibia (2), Afghanistan (25), Sierra Leone (1), Sudan (2), Nigeria (4), Bhutan (17), Mongolia (2), Nepal, under NAF (8), Botswana (1), USA (1), Bangladesh

(25), Zanzibar (1), Canada (1), Iraq (1), Myanmar (1), Oman (5), and Norway (1) studied in India. The cases were processed for pursuing Ph. D. (40), M.Sc., (63), MVSc, (12), BSc, (11), BVSc/ B. Tech. (3), Training (77), and Post-doctoral programme (2).

Fund release to CG Institutions

India is donor member to CGIAR and contributes 0.75 US Million $ annually under un-restricted funding to CG Institute.

In 2007-08 US$2.00 million was contributed under restricted funding to C G Centers.

CENTRAL AGRICULTURAL UNIVERSITY

The Central Agricultural University, works under DARE, has recently started an inter-disciplinary College of Post-Graduate Studies at Umiam, Barapani and Meghalaya. This University has its Horticulture and Forestry Campus at Pasighat in Arunachal Pradesh. This college has started B.Sc. (Forestry) degree course from the session 2007-08. Altogether, 281 students were admitted during the year in different campuses for pursuing graduation and post-graduation.

The Central Agricultural University organized North-East Agricultural Fair, 2007-08 (sponsored by Ministry of Agriculture) at its Veterinary Sciences and Animal Husbandry Aizawl Campus, Mizoram. University also participated in All India Agricultural Universities' Sports and Games Meet, 2007-08 organized at MPKV, Rahuri.

Three Board of Management Meetings of the University were convened at Imphal (Manipur), Aizawl (Mizoram) and New Delhi on 5 May,10 September and 5 November respectively. This University also conducted V Academic Council Meeting at its Agricultural Engineering and Post-harvest Technology Campus, Gangtok, Sikkim on 1 September 2008.

Among groundnut genotypes, which were tested for their adaptation under local environment of Manipur, PBS 12160 (1 319 kg/ha), GPBD 54 (1,260 kg/ha) and UG 16 (1,191 kg/ha) were found best in IVT under Spanish group and were promoted to AVT, while under Virginia group the entry, CSMG 2001-02 with 1,756 kg/ha pod yield was promoted to AVT. Besides these, one recommended variety, ICGS 76 received from ICRISAT was the best for pod (1,958 kg/ha) and kernel (1,230 kg/ha) yield for *kharif*.

For soybean, among the IVT entries DS 2410 (2,232 kg/ha) showed 16% increase in yield than the best check JS 335 (1913 kg/ha). Under AVT 1 and 2 combined trials, none of the entry was surpass the yield over the best check in North-East Zone. However, JS 13 (1590 kg/ha) was found to be the best over the check JS 335 (1495 kg/ha) at our centre. The centre has collected and evaluated 78 soybean germplasm lines. The crossing programme was initiated at the centre. Eight F_1 with their parents were evaluated, and F_2 seed was collected for further evaluation and selection in the segregating progeny to select high-yielding short duration lines of soybean.

PROTOCOL ACTIVITIES

Foreign delegations

- His Excellency Mr. Javier Cevellos, (Vice Minister of Agriculture of Ecuador) met with Dr Mangala Rai (Secretary, DARE and Director-General, ICAR) on 8 April 2008.
- His Excellency the Rwandan, Minister of Agriculture and Animal Resources, visited NDRI, Karnal, and IARI, New Delhi on 11 November 2008.

Visits under collaborative projects of ICAR and CG centres

The following Scientists/Officers have gone on deputation and training of International level in 2008 which were funded by CG centres or covered under collaborative projects of ICAR and CG Centres.

- Dr C. Tara Satyawathi (Sr. Scientist, Division of Genetics, IARI, New Delhi) visited on deputation as visiting scientist to ICRISAT, Hyderabad for 2 months from 18 February to17 April 2008.
- Dr Mangala Rai (Secretary DARE and DG,ICAR) visited to attend 3rd Executive Board Meeting of Global Crop Diversity Trust on deputation for 2 days w e f 1April 2008.
- Dr N.Sarangi (Director, CIFA, Bhubaneshwar) visited on deputation WFC Malaysia for 6 days w e f 1 April 2008.
- Dr Rajendra Choudhary (Principal Scientist and In charge, Division of Environmental Sciences, IARI,New Delhi) visited on deputation to attend International Conferences on Food Security and Environmental Change at Oxford University, UK, for 3 days wef 2 April 2008.
- Dr S.Ayyappan (DDG,Fisheries) visited on deputation Malaysia to attend 36th BOT Meeting for 5 days w e f 3 April 2008.
- Dr J.S. Minhas (Principal Scientist) and Dr S.K.Kaushik (Sr. Scientist, CPRI Shimla) visited on deputation to attend International Potato Symposium,2008 held at Eliya, Sri Lanka for 2 days w e f 3 April 2008.
- Dr R.P.S Verma (Principal Scientist, DWR Karnal) visited to attend the International Barley Genetics Symposium in Egypt for 6

days w e f 5 April 2008 on deputation.

- Dr Y.S. Ramakrishna(Director, CRIDA) visited on deputation to participate in the National Dryland Agriculture Conference in Philippines for 2 days w e f 17April 2008.
- Dr R.K. Arora (Principal Scientist, CPRI, Shimla) visited to attend 3rd International Conference on Late Blight, held at Beijing, China, from 3 to 6 April 2008.
- Dr **S.** Edison(Director,CIP) visited on deputation to participate in the meeting of BOT at Lima Peru, from19 to 25 April 2008.
- Dr R.K. Batta (Director, ICAR Research Complex for Eastern Region, Patna) visited on deputation to Addis Ababa Ethiopia for participation in the Challenge Prog. Basin Working Group Meeting from 9 to11 May 2008.
- Dr S. Ramani(Principal Scientist and Head CPRS, Shillong), Dr S.K.Pandey (Director CPRI, Shimla) and Dr B. P. Singh(Jt. Director, CPCRI, Kasaragod) visited on deputation to attend Potato Workshop in Bhutan from 6 to 10 May 2008.
- Dr Mangala Rai (Secretary, DARE and DG, ICAR) visited on deputation to Ottawa, Canada for CGIAR Vision and Development challenges from 10 to 14 May 2008.
- Dr P.K. Joshi (Director, NCAP, New Delhi) visited on deputation to attend CGIAR Review Panel meeting and the Advisoary Committee meeting in Ottawa, Canada on 15 May 2008.
- Dr S. Kalawathi (Sr. Scientist CPCRI Regional Station, Kayamgulan) visited on deputation for participation in the IFAD Data Analysis Workshop and Project compilation meeting from 19 to 27 May 2008.
- Dr N. Shobha Rani visited on deputation to attend meeting of Aroma Task Force INQR (International Network for Quality Rice) to be held at Laos from 24 to 25 May 2008.
- Dr Sanjukta Das (Sr. Scientist**,** CRRI, Cuttack) visited on deputation to attend a meeting of Aroma Task Force of International Network for Rice from 24 to 25 May 2008.
- Dr K.V. Prabhu (Head, Division of Genetics, IARI, New Delhi) visited on deputation to Australia to participate in international programme on the UG 99 breeding in wheat from 26 to 30 May 2008.
- ICAR scientists (5) visited on deputation to the 7th CURE Annual Meeting,2008 from 10 to11 June 2008.Ref. IRRI
- Dr K.P.R Vittal (Director, CAZRI, Jodhpur) visited to participate in USAID Disaster Management Support Project Climatic System Component from 10 to 19 June 2008.
- Dr A.K. Singh(DDG, ICAR) visited on deputation to attend ICAR – IWMI steering committee meeting at Colombo Sri Lanka from 12 to 13 June 2008.
- Dr R.K. Batta (Director, ICAR Research Center for Eastern Region, Patna)visited on deputation to participate in ICAR – IWMI Steering committed meeting from 12 to 13 June 2008 in Sri Lanka.
- Dr B.C. Birakmath(Project Director) and Dr J.S. Bentur(Principal Scientist, Directorate of Rice Research, Hyderabad) visited on deputation to participate in the International Conference on Plant hoppers from 23 to 25 June 2008.
- Dr R.K. Arora (Principal Scientist, CPRS, Jalandhar) visited on deputation to Kabul as Resource person to provide IBM training on Potato from 23 to 28 June 2008.
- Dr P.K. Joshi (Director, NCAP, New Delhi) visited on deputation to London to attend CGIAR Review Panel Meeting from 24 to 25 June 2008.
- Dr S.Ayyappan (DDG, Fisheries) visited on deputation Laussale, Switzerland for 5 days w e f 30 June 2008 to participate in the 4th CGIAR Sr leadership Programme.
- Dr S.K. Soam (Sr. Scientist, NAARM, Hyderabad) visited on deputation to Rome to attend the meeting of CGIAR from 2 to 5 July 2008.
- Dr H.S. Gupta (Director, VPKAS, Almora) visited on deputation to Kumasi,Ghana to attend IV Maize Harvest Plus Meeting from 7 to 11 July 2008.
- Dr (Ms) Kanta Das Mahapatra, (Sr. Scientist, CIFA, Bhubaneshwar)visited on deputation to Colombo, Sri Lanka for training from 7 to 15 July 2008.
- Dr R.M. Sundram(Scientist,SS) visited on deputation for attending the confined field trial training workshop from13 to 19 July, 2008 in USA.
- Dr B. Mishra(Project Director, DWR) visited on deputation to CIMMYT and to discuss and prepare the ICAR-CIMMYT Workplan for wheat breeding from 14 to 18 July 2008.
- Dr Mangala Rai (DG, ICAR) visited on deputation to IWMI, Sri Lanka to attend Steering Committee of IWMI-ICAR from 21 to 22 July 2008.
- Dr P.K. Joshi(Director, NCAP, New Delhi) visited on deputation to Manila, Philippines to attend the Asian Pacific Regional Consultation on IFAD report from 22 to 24 July 2008.
- Dr R.K. Sarkar (Principal Scientist) visited on deputation for undergoing training at IRRI,

Manila, Philippines,from 20 August to 29 September 2008.

- Indian scientists (6) visited on deputation to Australia under the ACIAR funded collaborative project on Molecular marker technology for faster wheat breeding in India from 23 August to 17 September 2008.
- Dr G.P. Singh(Senior Scientist, IARI, New Delhi) visited on deputation Canberra to participate in a Project Development meeting from 23 August to 7 September 2008
- Dr S.C. Mishra (Wheat Scientist, ARI, Pune) visited on deputation to Canberra, Australia from 23 August to 7 September 2008.
- Dr B.M. Prasnna (Senior Scientist IARI, New Delhi) visited on deputation to CIMMYT, Mexico to attend the Harvest Plus Maize Biofortification programme from 24 to 30 August 2008.
- Dr B. Mishra (Project Director, DWR, Karnal) visited on deputation to participate in 11th International Wheat Genetics Symposium in Australia from 24 August to 17 September, 2008.
- Dr P L Gautam (DDG, Crop Science) visited on deputation Brisbane, Australia to attend the International Wheat Genetics Symposium from 24 to 29 August 2008
- Dr Mangala Rai (DG, ICAR) visited on deputation to ACIAR Canberra, Australia to attend the PAC meeting from 31 August to 7 September 2008.
- Dr S. S. Ranga(Sr. Scientist, PAU, Ludhiana) visited on deputation to Norway to attend 5th International Symposium on *Brassica* from 3 to 12 September 2008.
- Mrs B. Nirmala (Scientist,Agricultural Economics) visited on deputation to China to attend the 5th International Hybrid Rice Symposium from 11 to 15 September 2008.
- Dr V.C. Virakthmath (Director, Directorate of Rice Research, Hyderabad) visited on deputation to Changsha, Hunan, China to attend the Vth International Hybrid Rice Symposium from 11 to 19 September 2008.
- Drs Randhir Singh, R.K. Sharma and R.S. Chhokar (DWR, Karnal) visited on deputation to attend ACIAR Project Review Meeting and Australian Agronomy Conference at Adelaide, South Australia from 14 to 24 September 2008.
- Dr Mangala Rai(DG, ICAR) visited on deputation to Manila, Philippines to attend the IRRI BoT from 16 to 19 September 2008.
- Dr N.K. Singh (Principal Scientist, NRC on Plant Biotechnology, IARI, New Delhi) visited on deputation to attend the CGIAR GCP 2008 Annual Research Meeting at Bankok, Thailand from 16 to 20 September 2008.
- Shri S.V. Nagachand (Director, ICAR Research Center, Barapani) and Dr A.K. Tripathi (Sr. Scientist, Agricultural Economics) visited on deputation to Lao Vietnam under project Managing Rice Landscape from 20 to 30 September 2008.
- Dr P.L. Gautam (DDG, Crop Science) visited on deputation to IRRI, Philippines to attend the Steering Committee Meeting from 23 to 24 September 2008.
- Dr M.P. Pandey (Director, CRRI, Cuttack) visited on deputation to participate in a 2-day International Workshop on Research to Impact Case Studies for Natural Research Management of Irrigation of Rice in Asia in Philippines from 23 to 27 September 2008.
- Dr Mangala Rai (DG, ICAR) visited on deputation to Lisbon, Portugal to attend the Ex-Co meeting from 1 to 4 October 2008.
- Indian Scientists (19) visited on training in Marker Assisted Selection at ICRISAT for 19 days wef 6 October 2008.
- Dr M.A. Khan (Director, ICAR Regional Centre Eastern Region,Patna) visited on deputation to participate in 2- day workshop at Washington, USA organized by CGIAR CPWF from 9 to 10 October 2008.
- Researchers (6) from India visited on deputation to participate in the 8th Regional Cassava Workshop at Vientiane Lao from 20 to 24 October 2008.
- Dr M. Pandey (Director, CRRI Cuttack) visited on deputation to attend the 5th International Hybrid Rice Symposium in PR China.
- Scientists (3) of CRRI Cuttack visited on deputation to participate in the Review meeting of Project enhancing and stabilizing rice in submergence prone environments in Bangladesh from 1 to 8 November 2008.
- Dr P.K. Joshi(Director, NCAP, New Delhi) visited on deputation to Brazil to attend meeting on CGIAR Impact Assessment Focul Point Group from10 to 11 November 2008.
- Shri A.K. Upadhyay (Secretary, ICAR) visited on deputation to Ethiopia to be a part of policy and practice panel at 2nd CPWF International Forum on Water and Food from 10 to 14 November 2008.
- Dr K.K. Vass (Director, CIFRI, Barrackpore) visited on deputation to Addis Ababa Ethiopia to participate in CGIAR CPWF from 10 to 14 November 2008.
- Dr M.A. Khan (Director, ICAR Regional Centre Eastern Region, Patna) visited on deputation to Addis Ababa Ethiopia to

participate in CGIAR CPWF from 10 to 14 November 2008.

- Dr S.P. Das(Plant Breeder, ICAR Regional Centre, Tripura) visited on deputation to training course organized by IRRI from 10 to 18 November 2008 at Birsa, Jharkhand.
- Dr S.Uma (Sr. Scientist NRC Banana, Trichy)visited on deputation to attend GCG Workshop at France from 13 to 17 November 2008.
- Dr S. Edison(Director, CTCRI, Trivandrum) visited on deputation to ICARDA, Syria from 15 to 18 November 2008.
- Dr P. Ravichandran (Principal Scientist, CIBA,Chennai**)** visited on deputation for participation in Shrimp BMP Meeting from 17 to 21 November 2008 in Bangkok, Thailand.
- Scientists (13) visited on deputation from Maize programme in 10th Asian Regional Maize Workshop in Indonesia
- Dr M.L. Jat (Sr. Scientist, DMR, New Delhi) visited on deputation to attend the final review meeting of ADB Project on Enhancing Farmers Income and Livelihoods through Integrated Crop and Resource Management in the Rice Wheat System in South Asia in Kathmandu, Nepal from 25 to 26 November 2008.
- Dr Rajendera Prasad (National Fellow, IASRI, Pusa, New Delhi) visited on deputation to Nepal to attend Final Review Meeting of ADB Project from 25 to 26 November 2008.
- Dr S.K. Sharma (Director, NBPGR, New Delhi) visited on deputation to attend the Steering Committee Meeting at Bioversity International, Italy from 26 to 28 November 2008.

Delegations abroad

- Dr (Ms) Bhawana Mishra (Assistant Professor, CCS HAU, Hisar) visited Iowa State University, USA for training in Post-Harvest Technology for Fruits and Vegetables from 15 March to 26 April 2008.
- Dr Mohamed Akram, (Assistant Professor, CSA University of Agriculture and Technology, Kanpur) visited Cornell University, USA, for training in Plant Virology, Emphasizing Tomato Virus from 15 March to 26 April 2008.
- Dr Rajan Sharma (Senior Scientist, NDRI, Karnal) visited Cornell University, USA, for training in High Pressure Processing of Milk Monitoring Adultration of Milk from 15 March to 26 April 2008.
- Dr Bharat Shankar Sontaki (Senior Scientist, NAARM, Hyderabad) visited Ohio State University, USA for undergoing training programme under the project Teaching and Learning excellence : a Capacity Building Model under the Indo-US AKI from 28 March to 16 April 2008.
- Dr (Mrs.) Bindu J., Scientist (Sr. Scale, CIFT, Cochin,) visited Ohio State University, USA for training in High Pressure Processing of Fish.
- Dr H P Singh, DDG (Hort.) visited Israel from 2 to 7 April 2008, as part of Business Mission under Indo-Israel Action Plan 2008.
- Shri Ashok Kumar Bharimalla (Scientist, CIRCOT, Mumbai) visited Agricultural Research Centre, Egypt for training in Cotton Processing for Superior Quality Yarn from 12 April to 2 May 2008.
- Dr Darrick M. Denis (Assistant Professor, AAI, Allahabad) visited Alabama A&M University, USA, for training in Monitoring of Non-Point Source Pollution from 7 April to 17 May 2008.
- Dr Goiranga Kar (Senior Scientist, WTCER, Bhubaneswar) visited Michigan State University, USA for training in Drough Mitigation, Water Harvesting in May 2008.
- Dr Sachdeva R. Bodreddy (Senior Scientist, Agricultural Research Station, ANGRAU, Anantpur, Andhra Pradesh) visited Michigan State University, USA for training in the field of Water and Drought Management, Introduction of Drip Irrigation and Fertigation during May 2008.
- Dr S.P. Tiwari [Deputy Director-General (Edn.)] visited Cape Town, South Africa to attend the 3rd Meeting of the India-Brazil-South Africa Joint Working Group on Agriculture from 5 to 7 May 2008.
- Dr K.P.R. Vittal (Director, CAZRI, Jodhpur) visited Iran, from 10 to 11 May 2008, to attend the India – Iran Joint Commission as part of the delegation led by Joint Secretary (PAI), Ministry of External Affairs.
- Dr D.V. Sudhakar Rao [Senior Scientist (Hort.), IIHR, Bangalore] visited USA, from 19 to 30 May 2008, to participate in the workshop-cum-training programme on Capacity Building for Risk Analysis and Modeling to promote Agricultural Trade under Indo-US Agriculture Knowledge Initiative.
- Sh. Anil Kumar Upadhyay (Additional Secretary, DARE and Secretary, ICAR), Dr S.P. Tiwari, DDG (Edn.), and Dr S. Ayyappan, DDG (Fisheries) visited Sri Lanka Council for Agricultural Research Policy (CARP), Sri Lanka from 12 to 14 June 2008 and a Work Plan for 2008-2009 was signed.
- Dr K.S. Khokhar (ADG, PIM), visited Minsk,

Belarus to attend the meeting of the Joint Working Group from 11 to 14 June 2008.

- Dr S.C. Dubey (Joint Director, High Security Animal Disease Laboratory, IVRI, Izatnagar) visited Bangladesh from 24 to 25 June 2008 to discuss and concretize areas of bilateral co-operation relating to bird flu in Bangladesh.
- Dr A.K. Sahu (Principal Scientist, CIFA, Bhubaneswar) visited Agricultural Research Centre, Egypt from 16 to 29 July 2008 for training in Aquaculture.
- Dr S.K. Pandian (Principal Scientist, CIBA, Chennai) visited Agricultural Research Centre, Egypt from 16 to 29 July 2008 for training in Mari- culture.
- Dr B.K. Bhattacharyya (Scientist, CIFRI, Barrackpore) visited Agricultural Research Centre, Egypt from 16 to 29 August 2008 for training in Reservoir Fisheries.
- Dr Bhudeva Singh (Senior Scientist, DWR, Karnal) visited Agricultural Research Centre, Egypt from 1 to 14 August 2008 for training in Wheat Drough Salinity Resistance.
- Dr O.P. Chaturvedi [Principal Scientist (Forestry), NRCAF, Jhansi] and Dr L.N. Harsh [Principal Scientist (Forestry), CAZRI, Jodhpur] visited Agricultural Research Centre, Egypt from 16 to 29 August 2008 for training in Greening Deserts.
- Dr A.K. Nayak (Senior Scientist, CSSRI Regional Station, Lucknow) visited Agricultural Research Centre, Egypt, from 1 to 14 September 2008, for training in Salinity Control.
- Dr Viraktamath (Project Director, DRR, Hyderabad) visited Agricultural Research Centre, Egypt, from 25 August to 7 September 2008, for training in Rice Hybrids.
- Dr Pradyumn Kumar (Principal Scientist, DMR, New Delhi) visited Agricultural Research Centre, Egypt, from 17 to 30 September 2008, for training in Maize Biotic Stress.
- Dr H.P. Singh (DDG, Hort.) visited University of Georgia, USA from 27 September to 4 October 2008 to deliver a talk on the State of Horticulture Research in India.
- Dr (Mrs) P. Nila Rekha (Senior Scientist, CIBA, Chennai) visited Iowa State University, USA, from 10 October to 21 November 2008, for training in Assessment and Control of Non-point source pollution under Norman E. Borlaug Fellowship Programme.
- Dr A.K. Nayak (Senior Scientist, Soil Chemistry/Fertility, CSSRI, Karnal) visited Iowa State University, USA ,from 11 October to 21 November 2008, for training in Water Management under Norman E. Borlaug Fellowship Programme.
- Sh. Anil Kumar Upadhyay (Additional Secretary, DARE and Secretary, ICAR) visited Budapest, Hungary from 13 to 15 October 2008 to participate in the meeting of Indo-Hungarian Working Group on Agriculture.
- Dr D.V. Singh (Senior Scientist, Soils, CSWCR&TI, Research Centre, Udhagamandalam) visited Michigan State University, from 13 October to 21 November 2008, in Water Quality Management under Norman E. Borlaug Fellowship Programme.
- Dr A.K. Singh (DDG, NRM), visited Tehran, Iran, from 1 to 2 November 2008, to attend the meeting of the XV India-Iran Joint Commission Meeting.
- Dr Pitam Chandra (ADG, Agril. Engg.) visited Berlin, Germany from 10 to 14 November 2008 to attend the meeting of the Indo-German Joint Working Group on Agriculture.
- Dr B.L. Dhar (Principal Scientist, IARI) visited to Zhangzhou City, Fujian Province, China from 19 to 23 November 2008, to participate as a specialist in the Asian Forum on Edible Mushroom Quality Standard and International Trade.

Delegations hosted

- Dr Mohammed Yussef Ghoneim Mubarak and Dr Reda Mohammed Ali Al Sayed (Senior Researcher, Agricultural Research Centre, Egypt) visited CSSRI, Karnal from 11 to 25 August 2008 for training in Wheat Drought Salinity and Heat Tolerance.
- Dr Mohammed Mahmoud Ahmed Mohammed (Senior Researcher, Agricultural Research Centre, Egypt) visited CSSRI, Karnal from 11 to 25 August 2008 for training in Water Quality.
- Ms Manal Muhammad Attiya and Dr Muhammad Atef El-Shobky (Scientists, Agricultural Research Centre, Egypt) visited CIPHET, Ludhiana from 3 to 15 November 2008 for training in Pre-Cooling.
- Dr Muhammad Abdullfatah Abdul Khalek and Dr Ashraf Mahfouz Mashraky (Researchers, Agricultural Research Centre, Egypt) visited CIPHET, Ludhiana from 20 October to 2 November 2008 for training in Pre-Cooling.

Ad hoc visits

The following senior officers of the ICAR (Hq)/Institutes were approved to go on foreign *ad hoc* visits:

- Dr Gurbachan Singh (Director, CSSRI, Karnal) participated in the VI International

Congress on Cactus Pear and Cochineal and VI General Meeting of FAO-CACTUSNET, held in Brazil, from 21 to 27 October 2008.

- Dr Lal Krishna [ADG (AH), ICAR (Hq.)] was deputed to attend 76th Annual General Session of the International Committee o1f the OIE (World Organisation for Animal Health) held in Paris, France, from 25 to 30 May 2008.
- Dr V. Krishnamurthy (Director, CTRI, Rajahmundry) was deputed to attend Second Meeting of the Study Group on Economically Sustainable Alternatives to Tobacco Growing, held in Mexico City from 17 to 19 June 2008.
- Dr K.M.L. Pathak (Director, NRC on Camel) and Dr Narendra Sharma (Veterinary Officer, NRC on Camel, Bikner) visited Veterinary laboratory, Al-Ain City, UAE from 23 to 30 July 2008 to solve the problem of camel illness and deaths accompanied with high degree of leucopenia.
- Dr C.S.Prasad [ADG (AN&P), ICAR (Hq)], attended Compound Livestock Feed Manufactures Association Symposium, 2008 scheduled held at Colombo, Sri Lanka from 12 to 13 September 2008.
- Dr Gurbachan Singh (Director, CSSRI, Karnal) was deputed for attending the 20th Congress of ICID (International Committee on Irrigation and Drainage) and 59th International Executive Council Meeting, held in Lahore, Pakistan from 13 to 18 October, 2008.
- Dr Gurbachan Singh (Director, CSSRI, Karnal) was deputed to Mexico for participating in a Technical Peer Review for the Colorado Delta Project from 19 to 21 November 2008.

Scientists to foreign countries on deputation

- Dr A K Roy (Principal Scientist, IGFRI, Jhansi) visited United Kingdom for 6 months w e f 7 February 2008 for availing DBT Overseas Associateship Award for 2006-2007. It was financed by Department of Biotechnology.
- Dr S.B.N. Rao (Senior Scientist, NIANP, Bangalore) and Dr A.V. Elangovan (Sr. Scientist, NIANP, Bangalore) visited School of Environmental and Rural Science, University of New England, Armidale, NSW, 2351 Australia for 6 months w e f 14 April 2008. It was financed by DEST, Australia.
- Dr R.R.B. Singh (Senior Scientist, NDRI, Karnal) visited Dublin Institute of Technology, Ireland for availing Erasmus Mundus Scholarship for Research in Food Science, Technology and Nutrition for 3 months w e f 18 February 2008. He visited under Ersmus Mundus Programme.
- Dr Sachinandan De (Senior Scientist, NDRI, Karnal) visited Sweden on deputation for availing DBT Biotechnology Overseas Associateship 2006-2007 for 6 months w e f 1 February, 2008. It was financed by Department of Biotechnology.
- Dr B.M. Naveena (Scientist, NRCM, Hyderabad) visited University of Connecticut, USA for undergoing training in the area of Moss Spectroscopy (Proteomics under DST broad area of Life Science under DST BOYSCAST Fellowship Programme 2007-2008 for 12 months w e f March, 2008. It was financed by Department of Biotechnology.
- Dr Mohan Mandal (Scientist, NRC on Mithun, Jharnapani), visited Michigan State University, USA for availing Biotechnology Overseas Associateship (Long-term) Programme 2006-2007 for 12 months w e f 20 March 2008. It was financed by Department of Biotechnology.
- Dr H.S. Oberoi [Scientist(SS), CIPHET, Ludhiana] visited University of Arkansas, USA for carrying research work on Life Science (Applied) under DBT's Biotechnology Overseas Associateship (Long-Term) Programme 2006-2007 for 12 months w e f from second week of March 2008.
- Dr Arun Kumar (Scientist, Directorate of Seed Research, Mau) visited Oregon State University, USA for undergoing training in the area of Genetic Engineering under DST's BOYSCAST Fellowship Award/Program 2007-08 for 12 months beginning from 1 June 2008. It was financed by Department of Science and Technology.
- Dr K.K. Sharma (Principal Scientist and Network Coordinator IARI, New Delhi) visited California, USA for undergoing training on Pesticide Residue Analysis from 7 to 19 April 2008. It was financed under budget grant of the Department of Agriculture and Co-operation.
- Dr K.P. Ramesha (Sr. Scientist, NRC on Yak, Dirang) visited Harvard University, USA for undergoing training under STIP Programme of Kennedy School under the sponsorship of Indo-US Science and Technology Forum for 11 days w e f 13 April 2008. It was financed under Indo-US Science and Technology Forum.
- Dr Subhojit Dutta (Scientist, IIPR, Kanpur) visited University of California, USA for

undergoing training in the area of Crop Biotechnology under DST's BOYSCAST Fellowship Programme 2007-08 for 3 months beginning tentatively from 31st March 2008. It was financed by Department of Science and Technology.

- Dr Girish Kumar Jha (Senior Scientist, IARI, New Delhi) visited University of Manitoba, Canada for undergoing training in the area of Mathematical Sciences/Artificial Neural Net and Fuzzy Set Theory for 12 months w e f 1 July 2008. It was financed by Department of Science and Technology.
- Dr S.K Srivastava (Sr. Scientist, NRCWA, Bhubaneshwar) visited Swedish International Development Co-operation Agency at Stockholm, Sweden to attend training Programme on Pesticide Risk Reduction from 8 to 30 May 2008 (Phase-I) and 17 to 28 November 2008 (Phase-II). It was financed by Swedish International Development Cooperation Agency and NRC on Women in Agriculture, Bhubaneshwar.
- Dr Reena Arora (Senior Scientist, NBAGR, Karnal) visited Lincoln University, Lincoln, Canterbury 7647, New Zealand undergoing training in the area of Biodiversity and Conservation Biology (Life Science) under DST's BOYSCAST Fellowship Programme 2007-2008 for 3 months w e f 1 June 2008. It was financed by Department of Science and Technology.
- Dr (Mrs.) Th. Premila Devi (Scientist, ICAR Research Complex for NEH Region, Meghalaya) visited University of Saskatchewan, Canada for availing DST's BOYSCAST Fellowship Programme 2007-2008 for 12 months w e f 31 May 2008. It was financed by Department of Science and Technology.
- Dr R.C. Ray (Principal Scientist, Regional Centre of CTCRI, Bhubaneshwar) visited University of Massachusetts, Amherst, M.A.USA for availing the award of Indo-US Professorship in Microbiology for 1 month w e f 7 June 2008. It was financed by IUSSTF.
- Dr M. Sheshu Madhav (Scientist, SS, DRR, Hyderabad) visited at Ohio State University, Columbus, USA for undergoing training in the area of Molecular Biology of Biotic stress in Plants under DST's BOYSCAST Fellowship Programme 2007-08 for 12 months w e f 27 March 2008. It was financed by Department of Science and Technology.
- Dr G. Gopakumar (Principal Scientist) and Dr K Madhu (Senior Scientist), both from CMFRI, Cochin, visited Aquaculture Research Sub-Institute for a North Central, Vietnam to attend training programme/course in Artificial Seed Production of Cobia from 20 May to 20 June 2008.
- Dr T Makesh Kumar (CTCRI, Thiruvananthpuram) visited Dr Stephan Winter, DSMZ, Plant Virus Division c/o BBA Messewag 11/12, 38104 Braunschweighy Germany to attend training of Young Scientist in the Niche area of Biotechnology on "RNAi mediated resistance against cassava mosaic virus present in India" under Department of Biotechnology 2007-2008 for 12 months w e f 5 September 2008. It was financed by Department of Biotechnology.
- Shri D. Pratap (T.O/T-5), Project Directorate on Poultry, Hyderabad) visited University of Peradeiya in Kandy, Sri Lanka for Refresher course on Teaching entrepeneurship to a small-scale farmers from 9 to 20 June 2008. His travel to and fro was financed by Netherland Fellowship Programme other Expenses by PTC+Loading and Boarding by Sponsors NE.
- Dr S.K. Lal (Senior Scientist, IARI, New Delhi) visited Japan for Group Training course in Conservation and Sustainable Use of Plant Genetics Resources from the date of his relieving up to 01 November 2008. It was financed by Japan International Co-operation Agency, JICA, Japan.
- Dr Poonam Jayant Singh (Scientist, SG, NBFGR, Lucknow) visited University of Turin, Italy for 103 days participation in LLM from University of Turin, Italy, w e f 1 September 2008. It was financed by WIPO.
- Mrs Sandhya Sukumaran, (Scientist, Mandapam Regional Centre of CMFRI, Tamil Nadu) visited University of East Anglia, Norwich, England, U.K after permission for pursuing higher studies leading to the award of Ph. D in "Aquatic Ecogenotoxicology" under Ministry of HRD, Government of India Commonwealth Scholarship/Fellowship award 2008 w e f 1 October 2008 to 31 July 2010. It was financed by Commonwealth Scholarship Commission, U.K.
- Dr Mathura Rai (Director, IIVR, Varanasi) visited Michigan State University, USA for attending Indo-US Biotech training programme sponsored by USTDA from 3 to 12 August 2008. It was financed by USTDA.
- Dr J. Satisha (Scientist, SS, NRC for Grapes, Pune) visited University of Missouri, Columbia for availing Post-doctoral position in the Institute of Continental Climate Viticulture and Enology for 12 months w e f August 2008. It was financed by his own pocket.

- Dr A.K. Patra (Principal Scientist, IARI, New Delhi) visited University of Notre Dome Indiana 46556-0767, USA for DBT Biotechnology Overseas Associateship Award on Interactions of nanopasticlas with soil bacteria for 6 months w e f September 2008. It was financed by Department of Biotechnology.
- Dr Amit Kar (Principal Scientist, IARI, New Delhi) visited University of Sussex, UK for availing UGC's sponsored Commonwealth Academic Staff Fellowship, 2008 for 6 months w e f 1 October 2008. It was financed by Commonwealth Secretariat, UK.
- Dr Praveen K. Gupta (Sr. Scientist, IVRI, Izatnagar) visited Institute for Animal Health, Compton, UK for availing UGC's sponsored Commonwealth Academic Staff Fellowship, 2008 for 6 months w e f 1 October 2008. It was financed by Commonwealth Secretariat, U K.
- Dr Y.S. Shivay (Sr. Scientist, IARI, New Delhi) visited Norwegian for availing the Norwegian Government Scholarship as the specialist and visiting scholar for short-term visit to carry out the remaining part of the previous research work data processing and manuscript writing for 1 month w e f 8 September 2008. It was financed by Norwegian Government.
- Dr Jagdish Kumar (Principal Scientist, DWR, Karnal) visited Alexander von Humboldt Foundation, Germany for his renewed research stay in Germany for awarded to him by Alexander vot Humboldt Foundation for 2 months w e f 1 September 2008. It was financed by Alexander von Humboldt Foundation, Germany.
- Dr V. Venkatesan (Scientist, Mandapam Regional Centre of CMFRI) visited Scientific Labs/Institutions in Taiwan to attend National Programme for Training of Scientists and Technologists, Government of India from 1 to 5 September 2008. It was financed by Department of Science and Technology.
- Dr (Mrs.) Josileen (Senior Scientist, CMFRI, Cochin) visited James Cook University, Queenland, Australia for training on Crab larval rearing studies on *Portunus pelagcus* under DBT Overseas Associateship Award for 2007-2008 for 6 months w e f 3 October 2008. It was financed by Department of Biotechnology.
- Dr A. Kumar (Sr. Scientist, IISR, Calicut) visited Wegeningen University, Wegeningen, the Netherlands for training on Molecular identification of cyclic lipopeptide biosthesis in endophytic bacterial strain *Pseudomonas* sp. for 1 year w e f 15 January 2009. It was financed by Department of Biotechnology.
- Dr S.K. Singh (Senior Scientist, IARI, New Delhi) visited University of Florida, USA for Plant Biotechnology (Tropical Fruit Crops) under Department of Biotechnology Overseas Associateship Award 2006-07 for 6 months w e f 30 September 2008. It was financed by Department of Biotechnology.
- Dr Pramod K. Raut (Sr. Scientist, CIRG, Makhdoom) visited Roslin Institute abd R(D)SVS, University of Edinburgh, UK for training on Exploring, modeling and exploting the genetic resistance of goats in response to Gastro-intestinal nematodes with special reference to Haemonchus contortus under DBT Overseas Associates Award for 2007-08 for 6 months tentatively from November 2008. It was financed by Department of Biotechnology.
- Dr V.K. Gupta (Senior Scientist, CIRG, Makhdoom) visited University of Wisconsin–Madison, United States of America for training of Veterinary Microbiology under Department of Biotechnology Overseas Associateship Award-2007-08 for 6 months w e f 1 November 2008. It was financed by Department of Biotechnology.
- Dr Rekha Sharma (Senior Scientist, NBAGR, Karnal) visited University of Illinois, Urbana, USA for availing DBT Overseas Associateship Award (short-term)for 2007-08 for 6 months w e f October 2008. It was financed by Department of Biotechnology.
- Dr R.S. Tanwar (T.O) and Shri K.K. Somayajulu (T.O.), IARI, New Delhi visited Switzerland for participation in the training Bruker 400 MHz Spectrometer of for 5 days Switzerland w e f 29 September 2008. It was financed by Bruker Indian Ltd., Mumbai.
- Dr K.N. Mohnta (Senior Scientist, ICAR Research Complex for Goa, Goa) visited France for training of Assessment of catch up growth of fish after feed depriation and refeeding and associated metabolic changes in nutrient mobilization and gain under DBT Overseas Associateship Award 2007-08 for 6 months tentatively during the February/ March 2009. It was financed by Department of Biotechnology.
- Dr Viswanathan Chinnusamy (Senior Scientist, IARI, New Delhi) visited University of California, Riverside, USA for Post-Doctoral Fellowship/Post-Doctoral Fellow Position in Plant Pathology for 2 years w e f 27 October 2008. It was financed by University of California, Riverside, USA.
- Dr S.K. Das (Senior Scientist, NDRI, Karnal)

visited University of NSW, Randwick NSW 2052, Australia for undergoing Biotechnology Overseas Associateship Award 2007-08 on "Animal Biotechnology" for 6 months w e f December 2008. It was financed by Department of Biotechnology.

- Dr S.D. Sawant (Principal Scientist, NRC Garlic, Pune) visited Washington State University, USA to undertake research work from 11 October to 13 November 2008. It was financed by IAREC except International Air fare that was spent by the Scientist himself.
- Dr J. Poorani (Principal Scientist, PDBC, Bangalore) visited CSAIRO Entomology, Canbera, Australia for study between late October and December 2008. It was financed by CSAIRO.
- Dr Lalit Kumar Tyagi (Scientist, SS, NBFGR, Lucknow) visited Wageningen International, the Netherlands for attending a short-term training on 'Towards Participatory Fisheries Management' under the Netherlands Government Fellowship Programme w e f 20 October to 7 November 2008. It was financed by the Netherlands Government.
- Dr S. Mondal (Scientist, SS, NIANP, Bangalore) visited University of Laval, Quebec, Canada for undergoing Biotechnology Overseas Associateship Award 2007-08 on Small interfering RNA(siRNA) based molecular and cellular mechanisms involved in recognition and establishment of pregnancy for 1 year w e f 28 February 2008. It was financed by Department of Biotechnology.
- Dr A.N. Shylesha (Sr. Scientist, PDBC, Bangalore) visited Israel to attend the workshop and training programme on the production maintenance, release of natural enemies and classical biological control of the eucalyptus gall wasps from 8 to 18 November 2008. It was financed by Indian Paper Manujfactor Association (IPMA).
- Dr Pronab Dhar (Senior Scientist, IVRI, Izatnagar) visited University of Maryland College Park, MD 20742-3711, USA for availing Department of Biotechnology Overseas Associateship Award (short-term) 2007-2008 for 6 months w e f 15 February 2008. It was financed by Department of Biotechnology.
- Dr Mihir Sarkar (Senior Scientist, IVRI, Izatnagar) visited Centre of Life and Food Sciences, Weihenstephan, Technische Universitaet Muenchen, Germany for availing Department of Biotechnology Overseas Associateship Award (short-term) 2007-2008 for 6 months w e f 15 March 2009. It was financed by Department of Biotechnology.
- Dr A.K. Misra (Principal Scientist, IGFRI, Jhansi) visited INRA, Centre Clermont – Theix Unit de Recherche sur Les Herbivores, 63122, Saint-Genes-Chempanelle, France for availing Department of Biotechnology Overseas Associateship Award (short-term) 2007-2008 for 6 months w e f 23 February 2009. It was financed by Department of Biotechnology.

Indian scientists on foreign assignments

- Dr N.V.P.R. Ganga Rao (Senior Scientist, Plant Breeder, D.O.R., Hyderabad), as Scientist (Breeder), visited ICRISAT, Nairobi, Kenya for selection of the 'Scientist (Breeder)' at ICRISAT, Nairobi, Kenya.
- Dr K.P. Singh (Senior Scientist, IVRI, Izatnagar) as Expert Scientist visited Ministry of Agriculture and Fisheries, Sultanate of Oman for selection of the 'Expert Scientist' at M/o. Agriculture and Fisheries, Sultanate of Oman.
- Dr N.P. Singh (Scientist, IARI, New Delhi) as Senior Scientist/Visiting Scientist (Agricultural Economics) visited ICRISAT, Patancheru (Andhra Pradesh), India for Selection of the 'Senior Scientist/Visiting Scientist (Agricultural Economics)' at ICRISAT, Patancheru (Andhra Pradesh).
- Assignment of Dr P S Birthal (Principal Scientist and National Fellow, NCAP) as Principal Scientist (Socio-economics) at International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India for 3 years.
- Dr N. Loganandhan (Scientist, CSWCR and TI, Research Centre, Bellary under CSWCR and TI, DehraDun) as Scientific Officer (ICRISAT-WWF Project) visited ICRISAT-WWF, Patancheru (Andhra Pradesh), India for selection for the 'Scientific Officer (ICRISAT-WWF Project)' at ICRISAT-WWF, Patancheru (Andhra Pradesh), India.
- Assignment of Dr Abhishek Rathore (Scientist, IISS, Bhopal, as Scientist Biometrics) at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (Andhra Pradesh) for 3 years from the date of joining.
- Assignment of Dr N P Singh (Scientist, SS, IARI, Pusa, New Delhi), as Senior Scientist/ Visting Scientist (Agricultural Economics) at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru (Andhra Pradesh) for 3 years w e f 1 July 2008.

ICAR scientists, approved deputation cases

- Deputation of Dr S K Pandey (Director, CPRI, Shimla) in 1 day workshop on Potato and to present paper on Potato Research Priority in the Asia Pacific Region on 6 May 2008 at Bangkok, Thailand.
- Deputation of Dr P K Joshi (Director, NCAP) to Johannesburg, South Africa from 6 to 12 April 2008 for attending 2nd Planery session of IAASTD.
- Participation of Dr B P Singh (Joint Director, CPRI Centre, Modipuram) and Dr Jai Gopal (Principal Scientist, CPRI, Shimla) in 3rd International Conference on Late Blight at Beijing-China from 3 to 6 April 2008.
- Participation by Dr H P Singh (DDG, Hort) in the 1 day workshop on Potato and to present paper on Policies and Strategies conducive to Potato Development on 6 May 2008 at FAO, Bangkok, Thailand.
- Participation of Dr Jai Gopal (Principal Scientist, CPRI, Shimla) in the FAO sponsored meeting in Rome from 23 to 24 April 2008 for the global partnership initiative for plants.
- Consultancy proposal of Dr Rajendra Prasad (National Fellow, IASRI, New Delhi) to International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria for 3 months from 21 April to 20 July 2008.
- Deputation of Dr R S Misra (Principal Scientist, CTCRI, Thiruvananthapuram) to Afghanistan.
- Deputation of Dr (Mrs.) Sindhu Sareen (Karnal) to participate in training course from 12 to 22 May 2008 at Kasetsart University, Bangkok, Thailand.
- Deputation of Dr N Vijayan Nair (Director, Sugarcane Breeding Institute, Coimbatore) to Egypt for 15 days on consultancy for giving technical guidance on sugarcane improvement programme.
- Deputation of Dr S K Kamra (Principal Scientist, CSSRI, Karnal) to visit Mc Gill University, Canada as visiting Scientist.
- Participation of Dr Rajan (Principal Scientist, Plant Quarantine Division) and Dr (Mrs) Kavita Gipta (Senior Scientist, IARI, New Delhi) in the master Class on Plant Biosecurity from 2 to 13 June 2008 in Malaysia.
- Dr G J N Rao (Head, Improvement Division, CRRI, Cuttack) deputation on official field mission of IAEA to China and Yaman to evaluate technical co-operation projects on Sustainable intensification crop production system from 5 to 18 June 2008.
- Deputation of Dr E Vivekanandan (Head, Demersal Fisheries Division, CMFRI, Kochi) for attending a FAO Workshop on Assessment and Bangkok, Thailand from 17 to 19 June 2008.
- Deputation of Dr R K Khetrapal (Head, PQD, NBPGR, IARI, Pusa, New Delhi) for participation as a Plant Pest Risk Analyst for the Project on Strengthening the sanitary and phytosanitary service in Cambodia in two mission for 1 month, the first mission of 1 week, from 7 to 13 July 2008, and final mission of 3 weeks – sometimes later this year.
- Expert Consultation on Agricultural Biotechnology for promoting Food Security in Developing Countries in Malaysia from 20 to 22 August 2008 – Deputation of Project Director, NRC on Plant Biotechnology.
- Consultancy Proposal of Dr (Ms) Neelam Patel (Senior Scientist, WTC, IARI, New Delhi) as consultant pressurized irrigation system software expert for 2 months for onward posting to Ethiopia.
- Nomination of Dr P K Aggarwal (National Professor, IARI) and Dr A K Singh (DDG, NRM) for South Asia Symposium on Climate Change, Dhaka, Bangladesh from 25 to 29 August 2008.
- Participation of Dr Sarvjet Singh (Plant Breeder, Pulses, Department of Plant Breeding and Genetics, PAU, Ludhiana) to FAO/IAEA International Symposium on Induced Mutation in Plants was held at Vienna, Austria from 12 to 15 August 2008.
- Deputation of Dr M C Kharkwal (Principal Scientist, Division of Genetics, IARI, New Delhi) to Vienna, Italy, Czech Republic and Turkey from 12 to 15 August 2008, 18 to 19 August 2008, and 20 to 25 August 2008.
- Deputation of Dr K V Prasad (Senior Scientist, Division of Floriculture and Landscaping, IARI, New Delhi) for attending the International Symposium on Induced Mutations in Plants from 12 to 15 August 2008 to Vienna, Austria.
- Deputation of Dr E Vivekanandan (Head, Demersal Fisheries Division, CMFRI, Cochin) to FAO Regional International Symposium on "Climate Change, Food Security, Sea Level Rise and Environment in South Asia" Dhaka, Bangladesh from 25 to 29 August 2008.
- Deputation of Dr D Rama Rao (Head, ICM, NAARM, Hyderabad) for attending World Conference on Agricultural Information organized by FAO, at Tokyo, Japan from 25 to 27 August 2008.

- Consultancy Proposal of Dr S K Sarkar and Dr P Rautra (Senior Scientist, CIFA) to train and establish a cyrobank facility for Government of Sri Lanka.
- FAO Consultancy in China from 1 to 15 September 2008 for Dr R S Misra (Principal Scientist and Head, Division of Crop Production, CTCRI, Thiruananthapuram).
- Deputation of Dr A K Tiwari (Head, Research Centre, Chandigarh) and Dr Amrish Kumar (Senior Scientist, Headquarters, Dehra Dun of CSWCR & TI to Mongolia under UNDP for conducting training course on Water Harvesting aimed at improving national capacity at technical and extension levels and upgrading knowledge of researchers, water engineers and officials from relevant Government agencies of Mongolia w e f 17 September to 17 October 2008.
- Deputation of Dr Ambekar E Eknath (Director, CIFA, Bhubaneshwar) to attend NACA, IX Technical Advisory Committee Meeting in China w e f 30 October to 1 November 2008.
- Dr T P Trivedi (Project Director, DIPA and ADG, ARIS) and Dr A K Bawa (Principal Scientist, ICAR, Hq) visited Bangkok, Thailand from 19 to 20 April 2008, to attend Technical Workshop on Development and Decentralised Management of ARD Information Resources and APARIS Steering Committee Meeting.
- Deputation of A K Bawa (Principal Scientist) to participate in the Expert Consultation on Climate Change and Agriculture and 10 General Assembly of APAARI, Tsukuba, Japan from 20 to 22 October 2008.
- Appointment of Dr N Loganadhan (Scientist, SS, CSWCR&TI, Research Centre) for the position of 'Visiting Scientist' at ICRISAT-WWF International Project from the date of joining till 31 December 2010.
- Deputation of Dr Masood Ali (Director, IIPR, Kanpur and Co-ordinator), Dr Shiv Kumar (Principal Scientist and Principal Investigator) and Dr B B Singh (Project Co-ordinator, IIPR and Co-Investigator) for visit to Bangladesh, Nepal and Bhutan under MEA sponsored SAARC Project on Shuttle Breeding in Pulses from 10 to 20 October 2008.
- Deputation Proposal of Dr P K Aggarwal (National Professor, Division of Environmental Sciences, IARI, New Delhi) to Japan for attending symposium on Global Climate Change-Imperatives for Asia Pacific from 22 to 23 October 2008.
- Consultancy of Dr G J N Rama Rao (Head, Crop Improvement Division, CRRI, Cuttack) for a National Training Course on Tissue Culture Techniques and their application to be held at the Ministry of Agriculture and Forestry in Freetown, Sierra Leone from 6 to 11 October 2008.
- Deputation of Dr S K Tandon (ADG, Engg) for participation in the Conservation Agriculture Carbon offset Consultation at West Lafayette, Indiana, USA w e f 28 to 30 October 2008.
- Consultancy of Dr Sushil Pandey (Scientist, IARI to FAO, Rome, Italy) as an International Consultant w e f 11 October to 13 December 2008.
- Recommendation of Dr M M Pandey (Director, CIAE, Bhopal) as Expert to the Fourth Session of the Technical Committee of APCAEM at Chiang Rai, Thailand w e f 1 to 5 December 2008.

20

National Agricultural Innovation Project

The National Agricultural Innovation Project (NAIP) has made good progress in approving and grounding 112 subprojects at an total outlay of Rs 658 crore. These subprojects have diverse partnerships with non-conventional partners like ICAR institutions and SAUs, General Universities, IITs, IIMs, CSIR laboratories, other Central and State government departments, private sector, NGOs, to an extent of 40 to 50%.

Seventeen approved subprojects under component-1 (*Strengthening ICAR as Catalyzing Agent of Management of Change*) will contribute to promote knowledge products like digital repository of about 10,000 Ph D theses, accessing titles of more than 1,000 journals, e-course in agriculture, horticulture, veterinary sciences, fisheries and home science, creating of a dynamic ICAR and Institute website, e-publishing of agricultural research journals, establishment of the Central Data Centre and securing NARS intranet, capacity-building in visioning and policy analysis, developing skills of about 3,500 personnel in project-proposal writing and reporting, research prioritization, monitoring and evaluation etc, establishment of Zonal Technology Management and business planning and development units, international training of about 500 scientists in 23 cutting-edge areas of agricultural sciences and training of about 1,000 NARS scientists by about 80 international experts from the Centres of Advanced Studies abroad, implementing on-line financial management system in the NAIP and the ICAR, and the online project management and tracking system under the NAIP.

Under component-2 (*Research on Production to Consumption Systems*), 28 approved subprojects will explore innovations in the utilization of sweet-sorghum for ethanol production, development of food products from millets (sorghum, pearl millet, foxtail and little millet), exploitation of multiple uses of cotton (stalk, cotton fibre for quantity yarn and fabric, oil protein) and of craft and gear for cost-effective and responsible fishing and processing for total utilization of small pelagic and freshwater fishes, clean meat production and utilization, oceanic tuna fisheries, coconut products, seed spices, potato and potato products, utilization of banana pseudostems for fibres and other value-added products, biomass-based decentralized power generation for agro-enterprises, value-chain on seabuckthorn for food, veterinary products, animal feed, natural dyes (indigo, bixa, and marigold), major carps and prawns, agroforestry with improved short-rotation clones (casuarina, eucalyptus and matchwood), clean vegetables, tomato, food products from small millets, murrel seed production, farmed-seafood production using cobia, flowers, novelty pork products and value-added products from *khejri (Prosopis juliflora)*, maize and maize products, coconut fibres and by-products and underutilized fruits.

Under component-3 (*Research on Sustainable Rural Livelihood Security*), 26 approved sub-projects aim at livelihood security by following integrated farming system approach with technological innovations relating to land-and-water management, seed and other input supply, cropping intensity, agro-processing and value-addition and institutional innovations in organizing youth and women self-help groups, producer groups, establishing village knowledge/resource centres, marketing arrangement, processing units, and bringing synergy with ongoing development programmes, capacity-building and entrepreneur-ship development.

Under component-4 (*Basic and Strategic Research in Frontier Areas of Agricultural Sciences*), 31 approved projects will contribute to mitigation strategy to control deadly arsenic problem in food chain, genetic engineering for

fixation of heterosis, genetic solutions for improved cotton boll and fibre development, enhanced yield and quality in buffalo milk, genetic solution for rice-blast management, development of bio-sensor for examination of quality of milk, mango and sesame, genetic enhancement in buffalo, developing wireless sensors for animal management, climate change and soil-organic carbon management, use of nanotechnology for enhancing performance of biodegradable polymers, development of single cell C-4 photosynthetic system in rice, development of decision-support system for insect-pest management in rice and cotton, new strategies for molecular diagnosis of plant viruses, assessment of quality and resilience of soil in different agroecosystems, bio-systematics of three important plant genera, risk assessment and developing insurance products for agriculture, stem cell research in cattle and buffaloes, identification of mammary bio-markers, genetic solutions for enhanced goat-meat production, utilization of bamboo in agricultural applications like rural housing, cattle-shelter, greenhouses, grain-silos, development of herbal acaricides for effective control of ticks, nanotechnology for higher utilization of native phosphorus in arid soils, utilization of rumen microbial diversity on methanogensis and higher use of poor quality feeds and integrating machine vision technology with satellite imagery to promote precision agriculture.

The NAIP is now processing the Concept Notes submitted under the competitive call and plans to complete the process by the end of February 2009. Aftewards, close monitoring and evaluation of all the approved subprojects will be taken up.

National Fund for Basic Strategic Research (NFBSRA)

The 21 projects under the National Fund for Basic and Strategic Research have now started yielding some tangible results in the frontier areas of agricultural sciences. A few salient achievements under the important themes are as follows.

Crop improvement and resistance to biotic and abiotic reverses in plants

- Two somatic embryogenesis receptor kinase (*SERK*) gene homologues have been isolated and cloned in sorghum, and an ovule-specific promoter has been cloned from *Arabidopsis* for sequence information as the first major step towards introducing apomixis in sorghum.
- In *Brassica juncea*, a methyl jasmonate inducible gene *Bjpep1* has been isolated. It is the member of the octadecanoid pathway involved in the first-line of defence of plants against insect pests and other damages
- Protocols based on zinc finger nuclease and homologous recombination for targeted gene integration have been developed. *Cry IF* gene has been integrated at the locus of the *cdn1* gene in cotton and *Cry 1 Aabc* gene at the locus *UGT* gene in rice.
- The occurrence of biovar-2 of *Agrobacterium tumefaciens*, which has potential for use in management of crown gall of stone-fruits, was found for the first time in India.
- For the first time involvement of pathogen-related protein genes in hyper sensitive research-mediated resistance against gall-forming insects in rice was observed.

Animal improvement and management

- A simple and highly sensitive enzyme (EIA) for determination of luteinizing hormone (LH) in goats within 24 hr of fertilization has been optimized and validated.
- Successful cloning and sequencing of *PAG1* (pregnancy associated glycoprotein gene) was achieved. Successful establishment of endometrial cell culture for the first time in buffalo was also achieved as a model to study prostaglandin production in *in-vitro*.
- *Methanomicrobium mobile* has been found the dominant phytotype among the rumen methanogens in buffaloes in India. An archea with 92-94% similarity with *Methanoculleous marisnigri* has also been isolated from buffalo rumen.

Plant biomass for alternate clean energy

Conversion of plant biomass into hydrogen (25%) and CO (24%) and rest into nitrogen has been tested by water-gas shift reactor by first producing CO from the biomass and then using it to produce hydrogen from moisture at 200°-200° C. A new catalyst (based on 1% Pt and CeO2) has been developed for this reaction, which is better than the ones known in the literature. A new method to coat this catalyst on ceramic honey-comb has also been developed, which goes into the reactor to produce hydrogen.

21

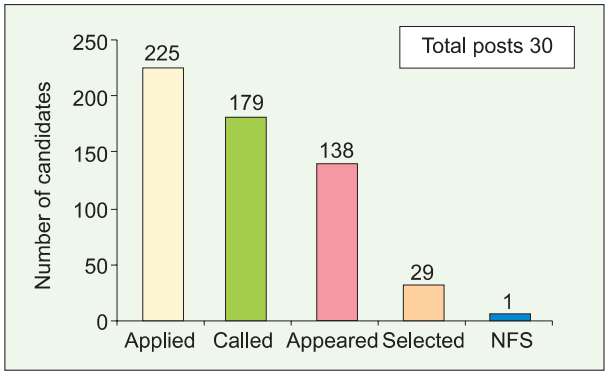
Selection and Assessment of Scientific Resource

The Agricultural Scientists Recruitment Board (ASRB), an independent recruitment body of the ICAR, established a record in direct selections for various positions. Another notable achievement was the conduct of ARS/NET examination in 38 comprehended disciplines for the first time. The results emerging from an analysis of this could be used by the ICAR in personnel policies and reorientation of research and in the education programmes. A beginning has been made by the development of a research project for evolving a recruitment and assessment methodology for diversified agricultural research system. The highlights of the activities made under various mandated programmes of the Board during 2008 are briefly described.

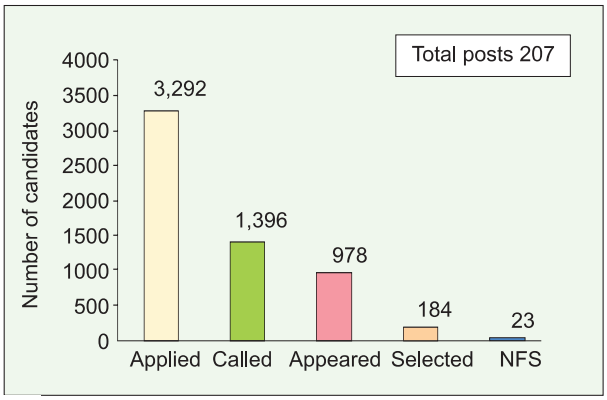
Direct Recruitment to Scientific Positions through Interview

The Board completed recruitment process for 207 posts during the current year. Of these, 16 posts fell in research and management category (RMP), 2 in middle-level management (Project Co-ordinators) and the remaining were those of Training Organizers, Programme Co-ordinators and Senior and Principal Scientists categories. In all, the Board screened more than 3,000 applications and called 1,396 candidates for interview. A total of 978 candidates attended the interview. The Board could make positive recommendations in 184 cases, whereas in the rest of the cases, no suitable candidates were available.

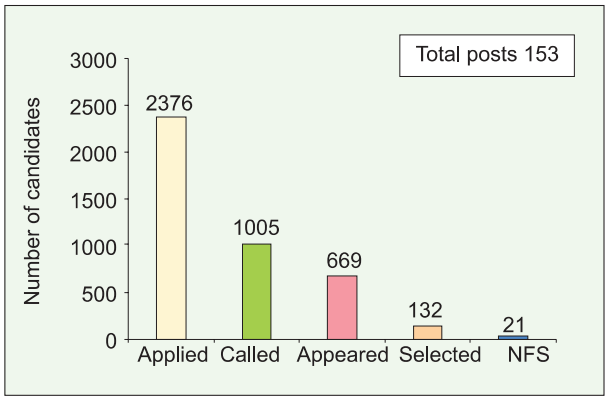
Thus on an average, there were 5 candidates for each position. But the managerial positions attracted a higher number of candidates, the average number for RMP being 8. For the 153 vacancies of Senior Scientists advertised, no suitable candidates were available for 21 vacancies while for rest there were only 4 candidates, on an average for each post.



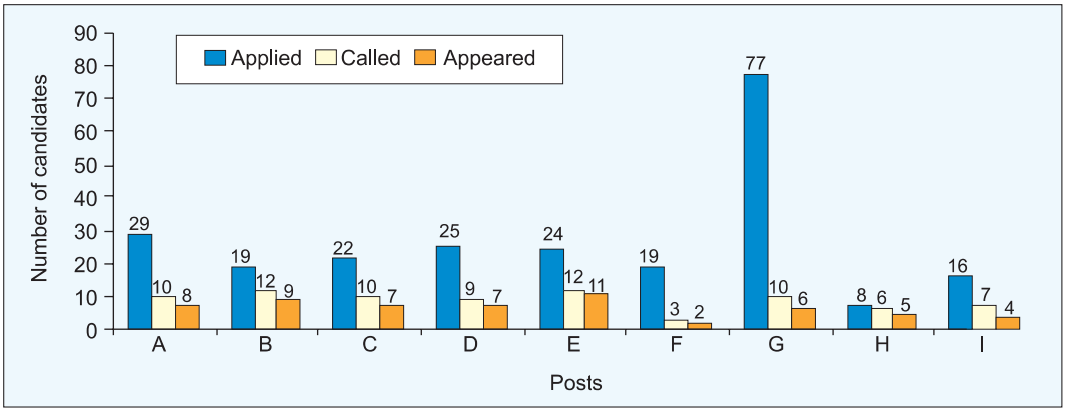
Recruitment detail for positions of Principal Scientists



Details of 207 direct selection posts



Recruitment detail for positions of Senior Scientists



Average number of candidates for different positions. A, Assistant Directors-General; B, Directors of National Institute; C, Directors; D, Joint Directors of National Institute; E, Project Co-ordinators; F, Programme Co-ordinators; G, Training Organizers; H, Principal Scientists; I, Senior Scientists

ARS/NET Examination 2007

The Agricultural Research Service (ARS)/ National Eligibility Test (NET) examination 2007 was conducted by the Board in 40 disciplines on 25 May 2008 at 34 centres in different parts of country. The total number of candidates who applied for the examination was 17,542, and 10,070 (57%) candidates appeared in the examination. Partial list of successful candidates was forwarded to the Council.

Limited Departmental Examination for Section Officers

Limited departmental competitive examination for Section Officers at the ICAR headquarters was held during September 2008. Ten candidates appeared in the examination for 16 posts.

Limited Departmental Audit and Account Examination 2008

Limited departmental competitive examination for Audit and Account personnel was conducted by the Board in November 2008 at 11 centres. A total of 195 candidates were appeared in this test.

Assessment Promotions of Senior Scientists under Career Advancement Scheme

The selection committees for considering the cases of promotion from Senior Scientist to the grade of Principal Scientist were constituted for 207 proposals in 44 disciplines. The Board has completed the process of assessment and the results have been forwarded to the Council.

Right to Information Act -2005

During the year, Board received 29 cases, largely related to the disclosures of marks secured in the scorecard and interviews and the procedures of screening. All the cases were disposed off successfully to the satisfaction of all concerned. There was no appeal with CIC against the ASRB decision.

Reforms

In implementing the reforms made during last 3 years, new experiences have been gained both in respect of direct selections as well as recruitment through interview. The Board remains committed to make further improvements in its guidelines to capture the essence of the diverse ARS system.

(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	Santioned strength
A	Secretary	1
A	Additional Secretary (DARE)/Secretary, ICAR	1
A	Financial Adviser and Additional Secretary	1
A	Director	2
A	Deputy Secretary	1
A	Joint Director	1
A	Senior Principal Private Secretary	1
A	Under Secretary	7
A	Principal Private Secretary	2
B	Assistant Director (Official Language)	1
B	Private Secretary	1
B	Section Officer	4
B	Assistant	4
B	Personal Assistant	4
C	Junior Hindi Translator	1
C	UDC-cum-Cashier	1
C	UDC	2
C	Steno Grade 'D'	5
C	UDC-Hindi Typist	1
C	Staff Car Driver	1
C	LDC	2
D	Daftry	1
D	Peon	5
	Total	50

Names of the Important Functionaries

Sl.No.	Name	Designations
1.	Dr Mangala Rai	Secretary, DARE and DG, ICAR
2.	Mr A K Upadhyay	Additional Secretary, DARE and Secretary, ICAR
3.	Mr Chaman Kumar	Additional Secretary/Financial Adviser, DARE/ICAR
4.	Mr Ajai Kumar	Director
5.	Mr Amar Singh	Director
6.	Mr P R Meena	Joint Director
7.	Mr Ram Avtar	Deputy Secretary
8.	Mr D K Chhatwal	Deputy Secretary
9.	Mr J N Banati	Senior Principal Private Secretary
10.	Mr M S Nayar	Under-Secretary
11.	Mr Rakesh Sharma	Under-Secretary
12.	Mr Roopak Chaudhuri	Under-Secretary
13.	Ms Alka Ahuja	Under-Secretary
14.	Ms Sumita Dasgupta	Under-Secretary
15.	Mr Madan Lal	Under-Secretary
16.	Ms Geeta Nair	Principal Private Secretary
17.	Mr S K Gupta	Principal Private Secretary

APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2007–2008 are Rs 2460.00 crores and Rs 2337.00 crores respectively and BE for 2008–2009 (Plan and Non-Plan) is Rs 2680 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 2007–2008 and BE for 2008–2009 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 2007–2008		Revised Estimates 2007–2008		Budget Estimates 2008–2009	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451' 090 Secretariat	–	165	–	165	–	175
Major Head '2415'	–	–	–	–	–	–
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	–	380	–	380	–	400
(030032) -Other Programmes	950	–	1470	–	1100*	–
(040032) -India's contribution to Asia Pacific Association of Agricultural Institutions	–	5	–	5	–	5
(050032) -India's contribution to NACA	–	12	–	12	–	9
(060032) -India's contribution to CGPRT	–	5	–	5	–	5
(070032) -India's contribution to Seed Seed Testing Association	–	2.25	–	2.25	–	2.25
(080032) -ISHS Belgium	–	0.75	–	0.75	–	0.75

*Includes Rs 10 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	2007–2008 Budget			2007–2008 Revised			2008–2009 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
A. Budget Allocation, net of recoveries										
Revenue		1620.00	840.00	2460.00	1434.00	903.00	2337.00	1760.00	920.00	2680.00
Capital		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1620.00	840.00	2460.00	1434.00	903.00	2337.00	1760.00	920.00	2680.00
1. Secretariat - Economic Service Agricultural Research and Education Payments to ICAR	3451	0.00	1.65	1.65	0.00	1.65	1.65	0.00	1.75	1.75
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	14.00	14.00	0.00	14.00	14.00
2.2 Other Programmes of Crop Husbandry										
2.2.01 Crop Sciences	2415	303.00	202.50	505.50	233.50	217.21	450.71	315.00	220.92	535.92
2.2.02 Horticulture	2415	68.00	73.70	141.70	73.60	86.21	159.81	88.00	87.28	175.28
2.2.03 Agricultural Extension	2415	246.00	0.85	246.85	290.50	1.00	291.50	281.00	1.10	282.10
2.2.04 Agricultural Education	2415	290.00	5.45	295.45	340.60	7.05	347.65	350.00	7.20	357.20
2.2.05 Economics, Statistics and Management	2415	4.00	12.95	16.95	4.00	13.59	17.59	4.00	13.90	17.90
2.2.06 Agricultural Engg.	2415	40.00	24.80	64.80	40.00	29.74	69.74	42.00	30.45	72.45
2.2.07 ICAR Hq Admn., DIPA including ASRB, IPR Management	2415	42.50	202.80	245.30	26.90	229.27	256.17	21.00	235.58	256.58
2.2.08 National Agril. Innovation Project	2415	270.00	0.00	270.00	80.70	0.00	80.70	257.00	0.00	257.00
Total other Programmes of Crop Husbandry		1263.50	523.05	1786.55	1089.80	584.07	1673.87	1358.00	596.43	1954.43
Total Crop Husbandry		1263.50	563.05	1826.55	1089.80	598.07	1687.87	1358.00	610.43	1968.43
3. Soil and Water Conservation										
3.01 Soil and Water Conservation Institutes	2415	3.60	12.00	15.60	3.00	13.21	16.21	4.00	13.46	17.46
3.02 Other NRM Instts. including Agroforestry Research	2415	66.40	72.25	138.65	76.10	81.67	157.77	86.00	82.54	168.54
Total- Soil & Water Conservation		70.00	84.25	154.25	79.10	94.88	173.98	90.00	96.00	186.00
4. Animal Husbandry	2415	78.00	126.60	204.60	70.00	138.79	208.79	80.00	141.05	221.05
5. Fisheries	2415	37.00	60.30	97.30	37.00	65.46	102.46	45.00	66.65	111.65

(Contd . . .)

	Major Head	2007–2008 Budget			2007–2008 Revised			2008–2009 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
6. Loans to ICAR	6402	0.00	0.00	0.00	96.00	0.00	96.00	0.00	0.00	0.00
6.1 Less amount met from social and infrastructure development fund	6402	0.00	0.00	0.00	–96.00	0.00	–96.00	0.00	0.00	0.00
7. Lump-sum provision for Projects/ Schemes for the benefit of North-Eastern Region and Sikkim	2552	162.00	0.00	162.00	143.40	0.00	143.40	176.00	0.00	176.00
Total-Payments to ICAR		1610.50	834.20	2444.70	1419.30	897.20	2316.50	1749.00	914.13	2663.13
8. Contribution to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institutes	2415	9.50	4.15	13.65	14.70	4.15	18.85	11.00	4.12	15.12
Total-Agricultural Research and Education	2415	1620.00	838.35	2458.35	1434.00	901.35	2335.35	1760.00	918.25	2678.25
Grand Total		1620.00	840.00	2460.00	1434.00	903.00	2337.00	1760.00	920.00	2680.00
	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	12415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. Plan Outlay										
1. Agricultural Research Education	12415	1458.00	0.00	1458.00	1290.60	0.00	1290.60	1584.00	0.00	1584.00
2. North-eastern Areas	22552	162.00	0.00	162.00	143.40	0.00	143.40	176.00	0.00	176.00
Total		1620.00	0.00	1620.00	1434.00	0.00	1434.00	1760.00	0.00	1760.00
D. Major Head-wise Totals	Total	1620.00	840.00	2460.00	1434.00	903.00	2337.00	1760.00	920.00	2680.00
	2415	1458.00	838.35	2296.35	1290.60	901.35	2191.95	1584.00	918.25	2502.25
	3451	0.00	1.65	1.65	0.00	1.65	1.65	0.00	1.75	1.75
	2552	162.00	0.00	162.00	143.40	0.00	143.40	176.00	0.00	176.00
New Head on 16.1.08	6402	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(B) INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

The Society shall have the following *Ex-Officio* Members:

(i) *President of the Society*

1. Mr Sharad Pawar
   Minister of Agriculture
   Government of India, Krishi Bhavan
   New Delhi 110 001
2. Mr. Kanti Lal Bhuria
   Minister of State (Agriculture)
   Government of India, Krishi Bhavan
   New Delhi 110 114

(ii) *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. 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 Taslimuddin
   Minister of State for Animal Hisbandry, Dairying and Fisheries Krishi Bhawan, New Delhi 110 114

(v) *Ministers in the States/Incharge of Agriculture/Animal Husbandry/Fisheries*

Andhra Pradesh

9. Mr N Raghuveera Reddy
   Minister of Agriculture, Horticulture and Food
   Government of Andhra Pradesh
   Hyderabad
   (Andhra Pradesh) 500 022
10. Mr Budha Prasad Mandali
    Minister for Animal Husbandry, Fisheries and Dairy Development
    Government of Andhra Pradesh
    Hyderabad (Andhra Pradesh) 500 022

Arunachal Pradesh

11. Mr Tersong Gyurne
    Minister for Agriculture, Animal Husbandry and Horticulture
    Government of Arunachal Pradesh
    Itanagar (Arunachal Pradesh) 791 111
12. Mr Chowna Mein
    Minister of Fisheries
    Government of Arunachal Pradesh
    Itanagar (Arunachal Pradesh) 791 111

Assam

13. Ms Pramila Rani Brahma
    Minister for Agriculture, Government of Assam
    Janta Bhavan,
    Guwahati (Assam) 781 006
14. Mr Khar Singh Engti
    Minister for Veterinary and Animal Husbandry
    Hill Area Development
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006
15. Mr Nurjamal Sarkar
    Minister for Fisheries
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006
16. Minister of Horticulture
    Government of Assam, Janta Bhavan
    Guwahati (Assam) 781 006

Bihar

17. Mr Ram Narayan Mandal
    Minister for Animal Husbandry and Fisheries
    Government of Bihar
    Patna (Bihar) 800 015
18. Mr Nagmani
    Minister for Agriculture and Horticulture
    Government of Bihar
    Patna (Bihar) 800 015

Chhattisgarh

19. Minister for Agriculture, Animal Husbandry & Fisheries
    Government of Chhatisgarh
    Raipur
    (Chhattisgarh)

Delhi

20. Minister for Agriculture Development and Food
    Animal Husbandry & Fisheries
    National Capital Territory of Delhi
    New Delhi 110 012

Goa

21. Mr Antanasio Monserette
    Minister of Agriculture
    Animal Husbandry and Horticulture
    Government of Goa, Panaji (Goa) 403 001
22. Mr Joaquim Braz Alemao
    Minister for Fisheries
    Government of Goa,
    Panaji (Goa) 403 001

Gujarat

23. Mr Dilipnanubhai Sanghani
    Minister for Agriculture, Animal Husbandry and Fisheries
    Government of Gujarat
    Gandhinagar
    (Gujarat) 382 010
24. Minister for Horticulture
    Government of Gujarat
    Gandhinagar
    (Gujarat) 382 010

Haryana

25. Mr Harmohinder Singh Chatha
Minister for Agriculture, Horticulture,
Animal Husbandry and Fisheries
Government of Haryana
Chandigarh (Haryana) 160 001

Himachal Pradesh

26. Mr P K Dhumal
Chief Minister and holding the charge of Agriculture,
Animal husbandry and Fisheries
Government of Himachal Pradesh
Shimla (Himachal Pradesh) 171 001
27. Mr Narendra Bragla
Minister of State for Horticulture
Government of Himachal Pradesh
Shimla (Himachal Pradesh) 171 001

Jammu and Kashmir

28. Minister for Agriculture,
Horticulture and Fisheries
Government of Jammu and Kashmir
Srinagar (Jammu and Kashmir) 190 001
29. Minister of Animal Husbandry
Government of Jammu & Kashmir
Srinagar (Jammu & Kashmir) 190 001
30. Minister of Horticulture
Government of Jammu & Kashmir
Srinagar 190 001

Jharkhand

31. Mr Nalin Soren
Minister of Animal Husbandry, Horticulture and Fisheries
Government of Jharkhand
Ranchi (Jharkhand) 834 002

Karnataka

32. Mr Krishna Palemar
Minister of Fisheries
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001
33. Dv Revu Naik Belamagi
Minister for Animal Husbandry
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001
34. Mr S K Belubbi
Minister for Horticulture
Government of Karnataka
Bangalore 560 001
35. Mr S A Ravindranath
Minister for Agriculture
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001

Kerala

36. Mr Mullakkara Ratnakaran
Minister for Agriculture & Coir including Animal
Husbandry and Horticulture
Government of Kerala
Thriuvananthapuram
(Kerala) 695 001
37. Mr S Sharma
Minister of Fisheries
Government of Kerala
Thiruvananthapuram (Kerala) 695 001

Madhya Pradesh

38. Minister for Agriculture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
39. Minister for Fisheries
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
40. Minister for Animal Husbandry
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
41. Minister for Horticulture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 432 006

Maharashtra

42. Mr Balasaheb Thorat
Minister for Agriculture
Government of Maharashtra
Mumbai (Maharashtra) 400 032
43. Mr Haji Anees Majeed Ahmed
Minister for Fisheries, Animal Husbandry and Dairy
Development
Government of Maharashtra
Mumbai (Maharashtra) 400 032
44. Mr Vinay Vilasrao Kore
Minister for Horticulture and Non-conventional Energy
Government of Maharashtra
Mumbai (Maharashtra) 400 032

Manipur

45. Mr D D Thaissi
Minister of Animal Husbandry
Government of Manipur
Imphal (Manipur) 795 001
46. Mr N Loken Singh
Minister for Agriculture
Government of Manipur
Imphal (Manipur) 795 001
47. Mr T Phungza Thang Tonsingh
Minister for Horticulture
Government of Manipur
Imphal (Manipur) 795 001
48. Md Alauddin Khan
Minister of Fisheries
Government of Manipur
Imphal 795 001

Meghalaya

49. Mr E C Bamon
Minister for Agriculture and Animal Husbandry &
Veterinary
Government of Meghalaya
Meghalaya Secretariat
Shillong (Meghalaya) 793 001
50. Dr A Pariong
Minister for Horticulture
Government of Meghalaya, Meghalaya Secretariat (C)
Shillong (Meghalaya) 793 001

Mizoram

51. Minister for Agriculture and Horticulture
Government of Mizoram
Aizwal (Mizoram) 796 001
52. Minister for Animal Husbandry
Government of Mizoram
Aizwal (Mizoram) 796 001
53. Minister for Fisheries
Government of Mizoram
Aizwal (Mizoram) 796 001

Nagaland

54. Mr Neiphiu Rio
Chief Minister and holding charge of Horticulture and
Fisheries
Government of Nagaland
Kohima (Nagaland) 797 001
55. Mr Chuben Murry
Minister for Agriculture
Government of Nagaland
Kohima (Nagaland) 797 001

56. Mr T R Zeliang
Minister for Animal Husbandry
Government of Nagaland
Kohima (Nagaland) 797 001

Orissa

57. Mr Surinder Nath Nayak
Minister for Agriculture and Horticulture
Government of Orissa
Bhubaneshwar (Orissa) 751 001
58. Mr Golak Bihari Naik
Minister for Fisheries and Animal Resources Development
Government of Orissa
Bhubaneshwar (Orissa) 751 001

Puducherry

59. Mr V Vaithilingam
Chief Minister holding charge of Agriculture, and Horticulture
Government of Puducherry
Pondicherry 605 001
60. Mr T Malladi Krishna Rao
Minister of Fisheries
Government of Pondicherry
Pondicherry 605 001
61. Mr T A Namawwirayom
Minister of Animal Husbandry
Govt. of Puducherry
Puducherry 605 001

Punjab

62. Mr Sucha Singh Lamgha
Minister of Agriculture
Government of Punjab
Chandigarh (Punjab) 160 001
63. Mr G S Ranike
Minister of Animal Husbandry, Fisheries and Dairy Development
Government of Punjab
Chandigarh (Punjab) 160 001
64.
Minister of Horticulture
Government of Punjab
Chandigarh (Punjab) 160 001

Rajasthan

65. Minister of State for Agriculture, Animal Husbandry and Horticulture
Government of Rajasthan
Jaipur (Rajasthan) 302 005

Sikkim

66. Mr Somnath Poudyal
Minister for Agriculture Development and Horticulture
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 101
67. Ms Kalawati Subba
Minister for Animal Husbandry and Fisheries
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 001

Tamil Nadu

68. Mr Veera Pandi S Arumugam
Minister for Agriculture and Horticulture
Government of Tamil Nadu
Chennai, (Tamil Nadu) 600 009
69. Mr K P P Sami
Minister for Fisheries
Government of Tamil Nadu
Chennai (Tamil Nadu) 600 009
70. Mr P N Palanisamy
Minister for Animal Husbandry
Government of Tamil Nadu
Chennai (Tamil Nadu) 600 009

Tripura

71. Mr Aghore Debbarma
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

Uttarakhand

73. Mr Trivendra Singh Rawat
Minister for Agriculture, Fisheries and Animal Husbandry
Government of Uttarakhand
Dehradun (Uttranchal)
Uttarakhand
74. Mr Ajay Tamta
Minister of Horticulture
Government of Uttarakhand
Dehradun

Uttar Pradesh

75. Mr Lakshmi Narayan
Minister for Agriculture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
76. Dr Awadhpal Singh Yadav
Minister for Animal Husbandry
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
77. Mr Narayan Singh
Minister for Horticulture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
78. Mr Dharm Raj Nishad
Minister of Fisheries
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001

West Bengal

79. Mr Naren De
Minister for Agriculture
Government of West Bengal Writers' Building
Kolkata (West Bengal) 700 001
80. Mr Anisur Rahman
Minister for Animal Resources Development
Government of West Bengal
Kolkata, (West Bengal) 700 001
81. Mr Kironmoy Nanda
Minister for Fisheries
Government of West Bengal
Kolkata (West Bengal) 700 001
82. Minister for Horticulture
Government of West Bengal
Writers Building
Kolkata (West Bengal) 700 001

(vi) *Member of Planning Commission, Incharge of Agriculture*

83. 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)*

84. Vacant
85. Mr Sharad Anantrao Joshi 04.07.2010
Member of Parliament (RS)
Angar Mala, Village Ambethan, Taluk khed,
Distt Pune and
12-A Meena Bagh,
New Delhi 110 001

86. Mr Mahdevrao Shivankar — Till the expiry of term in the Lok Sabha
Member of Parliament (LS),
Amgaon, Distt. Gondia 441 902
Maharashtra, and B-603, MS Flats,
BKS Marg, New Delhi 110 001

87. Mr K Manvendra Singh, -do-
Member of Parliament (LS)
Amagarh House, Dampier Nagar, Mathura,
Uttar Pradesh and 20, Willingdon Crescent,
New Delhi 110 001

88. Mr Kishan Singh Sangwan -do
Member of Parliament (LS)
H. No. 563, Ward No. 4, Tehsil Road,
Gohana, Sonepat 131 001 Haryana and
18, Dr Rajendra Prasad Road,
New Delhi 110 001.

89. Mr V K Thummar -do-
Member of Parliament (LS)
Amrut Complex, Station Road,
Amreli 365 601 Gujarat and
7, H C Mathur Lane, New Delhi 110 001

(viii) *Director-General, ICAR*

90. Dr Mangala Rai
Director-General, ICAR
Krishi Bhavan, New Delhi 110 001

(ix) *All Secretaries in the Ministry of Agriculture*

91. Mr T Nanda Kumar
Secretary (Agriculture and Co-operation)
Ministry of Agriculture, Department of Agriculture,
Krishi Bhavan,New Delhi 110 001

92. Ms N Gokulram
Secretary (ADF)
Krishi Bhavan,
New Delhi 110 114

(x) *Secretary, Planning Commission*

93. Mr Sabas Pani
Secretary, Planning Commission
Yojana Bhavan, New Delhi 110 001

(xi) *Secretary, Department of Biotechnology*

94. Mr M K Bhan
Secretary
Department of Biotechnology
CGO Complex, New Delhi 110 003

(xii) Director-General, Council of Scientific and Industrial Research, Anusandhan Bhawan, New Delhi 110 001

95. Prof S K Brahmachari
Director General
Council of Science and Industrial Research
Anusandhan Bhawan, New Delhi 110 001

(xiii) *Chairman, University Grants Commission*

96. Dr S K Thorat
Chairman, University Grants Commission
Bahadur Shah Zafar Marg, New Delhi

(xiv) *Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)*

97. 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

(xv) *Member, Finance (Secretary/Additional Secretary in the Ministry of Finance), Government of India, Alternate Member—Financial Adviser (DARE/ICAR)*

98. Ms Rita Menon
Special Secretary to the Government of India
Ministry of Finance, Department of Expenditure
New Delhi 110 001

(xvi) *Four Vice-Chancellors of the Agricultural Universities nominated by the President*

99. Dr Vijay Mehta — 9.4.2010
Vice-Chancellor
Dr Balasaheb Sawant Konkan
Krishi Vidyapeeth, Dapoli
Ratnagiri, Maharashtra 415 712

100. Dr N N Singh — 09.4.2010
Vice-Chancellor
Birsa Agricultural University
Ranchi 834 006
Jharkhand

101. Dr P Raghava Reddy — 07.02.2011
Vice-Chancellor
Acharya N.G. Ranga Agricultural University
Rajendra Nagar, Hyderabad 500 030
Andhra Pradesh

102. Dr R K Samanta — 29.07.2011
Vice-Chancellor
Bidhan Chandra Krishi Vishwavidyalaya
District Nadia 741 252
West Bengal

(xvii) *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*

103. Dr N B Singh
Agricultural Commissioner — Ex-officio
Department of Agriculture and Co-operation
Krishi Bhavan, New Delhi 110 001

104. Dr M L Choudhary — Ex-officio
Horticultural Commissioner, Department of Agriculture,
Krishi Bhavan, New Delhi 110 001

105. Dr S K Bandyopadhyay
Animal Husbandry
Commissioner
Department of Agriculture, Krishi Bhawan,
New Delhi

106. Mr M K R Nair — Ex-officio
Fisheries Development Commissioner
Department of Agriculture, Krishi Bhavan
New Delhi 110 001

107. 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

(xviii) Fifteen scientists from within and outside the Council, including one from the Indian Council of Medical Research nominated by the President

108. Dr M V Gupta — 9.4.2010
C- 502, Aditya Elite
B.S. Maktha, Somajiguda
H.No. 6-3-1119, Hyderabad 500 016
(Andhra Pradesh)

109 Dr T J Pandian 9.4.2010
Former National Professor
Madurai Kamaraj University
9, Old Natham Road
Madurai- 625 014
(Tamil Nadu)

110 Prof Sudhir K Sapori 9.4.2010
Group Leader
International Centre for Genetic
Engineering and Biotechnology,
Near JNU Campus, Aruna Asaf Ali Road,
New Delhi 110 067

111 Dr N Panda 9.4.2010
Plot No. 62/63, Opp. Unit 8,
Boy's Singh School
P.O. Baramunda,
Bhubaneshwar 751 003 (Orissa)

112. Dr N N Goswami 9.4.2010
JD 20D, Pitampura,
Delhi- 110 088

113. Dr T C Thakur 9.4.2010
National Professor
College of Technology
GB Pant University of
Agriculture & Technology
Pantnagar 263 145
Distt. Udham Singh Nagar (Uttarakhand)

114. Dr Gyanendra Singh 9.4.2010
Vice-Chancellor
Mahatama Gandhi Chitrakoot Gramodaya
Vishwavidyalaya
Chitrakoot Distt. Satna 485 331
(Madhya Pradesh)

115. Dr M Mahadevappa 9.4.2010
Former-Chairman
Agricultural Scientists Recruitment Board
1576, Ist Cross, Chandra Layout
Bangalore 560 040

116. Dr J B Chowdhary 01.07.2010
906, Sumeru Towers
Kaushambi, Ghaziabad

117. Dr C D Mayee 9.4.2010
Chairman
Agricultural Scientists Recruitment Board
New Delhi 110 012

118. Dr Asis Datta 9.4.2010
Former Vice-Chancellor
Jawaharlal Nehru University & Director,
NIPGR
Aruna Asaf Ali Margt, JNU Campus
Post Box No. 10531, New Delhi 110 067

119. Dr K Pradhan 9.4.2010
Former Vice-Chancellor
Orissa University of Agriculture & Technology
H-101, Som Vihar Apartments
R.K. Puram, New Delhi 110 022

120. Dr S S Acharya 9.4.2010
Honorary Professor
Institute of Development Studies
8-B, Jhalana, Institutional Area
Jaipur 302 004 (Rajasthan)

121. Mr J N L Srivastava
Former Secretary
Department of Agriculture and Cooperation
Government of India
Kothi No. 316, Sector 17-A
Gurgaon 122 001 (Haryana)

Representative of ICMR

122. Dr G S Toteja 08.10.2009
Scientist
Division of Reproductive Health and Nutrition
Indian Council of Medical Research
Ansari Nagar, PB 4911, New Delhi 110 029

(xix) *Three representatives of Commerce and Industry nominated by the President*

123. Mr Gokul Patnaik 06.05.2010
Chairman
Global Agri. Systems Pvt. Ltd.
K-13 A, Hauz Khas Enclave, New Delhi 110 016

124. Mr M Manickam 06.05.2010
Vice-Chairman & Managing Director
M/s. Shakti Sugars Limited
180, Race Course Road
Post Box No. 3775
Coimbatore 641 018 and 149 Vasant Enclave
New Delhi 110 057

125. Ms Megha Borase 06.05.2010
President
Flower Growers Association
20/4, Kulkarni Baug Opp. B Y K College
Nasik 422 005 Maharashtra

(xx) *One farmer from each region mentioned in Rule 60(a) and four representatives of rural interest nominated by the President*

126. Prof D P Tripathi 08.06.2011
C-9/9782 Vasant Kunj
New Delhi 110 070

127. Mr Anand Thakur 08.06.2011
At Post Vangaon, Tal. Dhanu
District Thane
Maharashtra

128. Ms Usha Barwale Zehr 08.06.2011
Maharashtra Hybrid Seeds
Company Limited
Post Box No. 78
Jalna 431 203 Maharashtra

129. Mr Sudhir Kumar Bhargava 08.06.2011
Agroman Systems Pvt. Ltd.
25/2, Tardeo AC Market
Tardeo, Mumbai 400 034

130. Ms Rinchin Droma 08.06.2011
Rungkhung P.O. Dirang
West Kameng Dist. 790 101
Arunachal Pradesh

131. Ms Asha Kashyap 08.06.2011
Village - Pawar
Panchayat- Thadi
Post Office - Shoghi
Block-Mashobra, District Shimla 173 219

132. Vacant

133. Vacant

(xxi) *Four representatives of Rural Interest*

134. Mr Sopan Kanchan 08.06.2011
Irrigation Colony
At & Post Office: Uruli Kanchan
District: Pune 412 202

135. Dr Chanda Nimbkar 08.06.2011
Director
Animal Husbandry Division
Nimbkar Agricultural Research Instt.
P.O. Box. 23, Phaltan
Maharashtra 415 523

136. Shri D S Ananth Kumar 08.06.2011
Planter
Sathya Sai Estate, Mahadev Pet,
Madikeri, Coorg District, Karnataka

137. Vacant

(xxi) *Four Directors of the ICAR Research Institutes, nominated by the President*

138. Dr O M Bambawale 9.4.2010
Director
National Centre for Integrated Pest Management
LBS Building Pusa Campus
New Delhi 110 012

139. Dr K A Singh 9.4.2010
Director
Indian Grassland & Fodder Research Institute
Jhansi 238 003 (Uttat Pradesh)

140. Dr B P Singh 31.01.2010
Director
Central Avian Research Institute
Izatnagar 243 122 (Uttar Pradesh)

141. Dr K K Vass 9.4.2010
Director
Central Inland Capture Fisheries
Research Institute, Barrackpore
Kolkata 743 101(West Bengal)

(xxii) *Secretary, Indian Council of Agricultural Research*

142. Mr A K Upadhyay
Member-Secretary, ICAR
Krishi Bhavan, New Delhi 110 014

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

2. Ms Rita Menon
   Special Secretary to the Government of India
   Ministry of Finance, Department of Expenditure
   New Delhi 110 001

Secretary, Planning Commission

3. Mr Subas Pani
   Secretary
   Planning Commission
   Yojna Bhavan, New Delhi 110 001

Secretary, Agriculture

4. Mr T Nanda Kumar
   Secretary (Agriculture and Coop),
   Government of India
   Ministry of Agriculture, Department of
   Agriculture, Krishi Bhavan, New Delhi 110 114

Chairman, University Grants Commission

5. Dr S K Thorat
   Chairman
   University Grants Commission
   Bahadur Shah Zafar Marg, New Delhi 110 002

Secretary, Animal Husbandry and Dairying

6. Mr Pradeep Kumar
   Secretary (ADF)
   Department of Animal Husbandry and Dairying & Fisheries
   Krishi Bhavan, New Delhi 110 114

Secretary, Department of Biotechnology

7. M K Bhan
   Secretary
   Department of Biotechnology
   CGO Complex, New Delhi 110 002

Director-General Council of Scientitic and Industrial Research

8. Prof S K Brahmachari
   Director-General
   Council of Scientist and Industrial Research
   Anusandhan Bhawan, Rafi Marg, 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

9. Mr J N L Srivastava
   Former Secretary, DOAC
   Government of India
   Kothi No. 316, Sector 17 A
   Gurgaon (Haryana) 122 001

Scientists

10. Dr T J Pandian — 09.04.2010
    Former ICAr National Professor
    Kamaraj University
    9, Old Natham Road,
    Madurai (Tamil Nadu) 625 014

11. Dr C D Mayee — 09.04.2010
    Chairman
    Agricultural Scientists Recruitment
    Board, Pusa,
    New Delhi 110 012

12. Dr Asis Datta — 0.9.04.2010
    Former Vice-Chancellor
    Jawaharlal Nehru University & Director,
    NCPGR
    Aruna Asaf Ali Marg
    JNU Campus, POst Boxt No. 10531
    NEW Delhi 110 067

Three Vice-Chancellors (nominated by the President)

13. Dr P Raghava Reddy — 7.02.2011
    Vice-Chancellor
    Acharya N G Ranga Agricultural University
    Hyderabad 500 030

14. Dr R K Samanta — 29.07.2011
    Vice-Chancellor
    Bidhan Chandra Krishi Vishwa Vidyalaya
    Mohanpur
    West Bengal

15. Dr Vijay Mehta — 09.04.2010
    Vice-Chancellor
    Dr Balasaheb Sawant Konkan
    Vidyapeeth, Dapoli
    Maharashtra 415 712

Three Members of Parliament (Two from Lok Sabha and one from Rajya Sabha) nominated by the President

16. Mr Mahdevrao Shivankar — 16.08.2009
    Member of Parliament (Lok Sabha)
    Amgaon, Gundia 441 902 and
    B 603, MS Flats, B K S Marg
    New Delhi 110 001

17. Mr Manvendra Singh — 16.08.2009
    Member of Parliament (Lok Sabha)
    Amgarmala House, Dambiev Nagar
    Mathura and
    20, Willigdon Cresent
    New Delhi 110 001

18. Mr Sharad Anantrao Joshi — 19.06.2009
    Member of Parliament (Rajya Sabha)
    Angarmala, Vill. Ambethom, Taluk Khed,
    Distt. Pune and
    12 A, Meena Bagh, New Delhi 110 001

Three Farmers/Representatives of rural areas nominated by the President

19. Prof. D P Tripathi — 08.06.2011
    C-9/9782 Vasant Kunj
    New Delhi 110 070

20. Dr Chandra Nimbkar — 08.06.2011
    Director
    Animal Husbandry Division
    Nimbkar Agricultural Research Institute
    P O Box 23, Phaltan
    Maharashtra 415 523

21. Mr Sudhir Kumar Bhargava — 08.06.2011
    Director
    Agroman Systems Pvt Ltd.
    25/2, Tardeo A C Market
    Tardeo, Mumbai 400 034
    Maharashtra

Three Directors of Research Institutes of the Council nominated by the President

22. Dr O M Bambawale — 09.04.2010
    Director
    National Centre for Integrated Pest Management
    LBS Building, Pusa Campus
    New Delhi 110 012
23. Dr B P Singh — 31.01.2010
    Director
    Central Avian Research Institute
    Izatnagar 243 122
    Uttar Pradesh
24. Dr K K Vass — 09.04.2010
    Director
    Central Inland Capture Fisheries
    Research Institute, Barrackpore
    Kolkata 743 101 (West Bengal)

Member-Secretary

25. Mr A K Upadhyay
    Additional Secretary (DARE) and Secretary
    Indian Council of Agricultural Research
    Krishi Bhawan
    New Delhi 110 001

APPENDIX 3

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. **Mr A K Upadhyay**
   Secretary, ICAR and
   Additional Secretary to Government of India
   Department of Agricultural Research and Education

Deputy Directors-General

1. Dr Puranjan Das (Agricultural Extension) up to 31.12.08
2. Dr A K Singh (Natural Resource Management)
3. Dr S Ayyappan (Fisheries)
4. Dr Nawab Ali (Agricultural Engineering) up to 31.12.08
5. Dr S P Tiwari (Education)
6. Dr H P Singh (Horticulture)
7. Dr P L Gautam (Crop Sciences) up to 31.12.08
8. Dr K M Bujarbaruah (Animal Sciences)

Assistant Directors-General

Crop Science

1. Dr K C Jain (Commercial Crops)
2. Dr S N Shukla (Food and Fodder Crops)
3. Dr T P Rajendran (Plant Protection)
4. Dr N D Jambhale (Seeds)
5. Dr V D Patil (OP)

Horticulture

1. Dr S N Pandey (Horticulture-I) up to 31.10.08
2. Dr U C Srivastava (Horticulture-II)

Natural Resource Management

1. Dr P D Sharma (Soils)
2. Dr A K Gogoi (Agronomy)

Engineering

1. Dr P Chandra (Process Engineering)
2. Dr S K Tandon (Engineering)

Animal Sciences

1. Dr Lal Krishna (Animal Health)
2. Dr T J Rasool (AP&B)
3. Dr O P Dhanda (ANP)

Fisheries

1. Dr V V Sugunan (Inland Fisheries)

Education

1. Dr G C Tiwari (EPD)
2. Dr R K Mittal (EQR)

Extension

1. Dr A K Mehta (Agril. Extn.)
2. Dr Ram Chand (KVK)

ARIS

1. Dr T P Trivedi

Others

1. Dr J P Mishra (ESM & Co-ordinator)
2. Dr K S Khokhar (PIM)
3. Dr S Mauria (IPR & Policy)

Principal Scientists

Crop Science

1. Dr A K Sharma (Food Crops)
2. Dr C P Singh (Seeds)
3. Dr Sudhir Kochhar (PB)
4. Dr Sanjeev Saxena
5. Dr G N Mishra

Natural Resource Management

1. Dr D K Paul (IWM)
2. Dr P P Biswas (Soil)

Education

1. Dr S D Sharma (HRD)

Fisheries

1. Dr Anil Aggarwal (Marine Fisheries)
2. Dr Usha Moza

Animal Sciences

1. Dr Ranjan Gupta
2. Dr Vineet Bhasin

ARIS Unit

1. Dr D K Aggarwal

Extension

1. Dr A M Narula

Engineering

Nil

Others

1. Dr A K Bawa (DG Section)
2. Dr D B S Sehra (ES&M)
3. Dr Ravindra Kumar (Awards)

National Agricultural Innovation Project

1. Dr Mruthyunjaya, National Director
2. Dr J P Mittal, National Coordinator
3. Dr A P Srivastava, National Coordinator
4. Dr N T Yaduraju, National Coordinator
5. Dr A Bandhopadhyay, National Coordinator

Administration

Directors

1. Mr K K Bajpai, Director (P)

2. Mr Devendra Kumar, Director (F)
3. Mr H C Joshi, Director (OL)
4. Mr V P Kothiyal, Director (Works)

Deputy Secretaries

1. Mr J Ravi
2. Mr B N Rao
3. Mr Sanjay Gupta
4. Mr H L Meena
5. Mr A C Ghosh
6. Ms Shashi Prabha Razdan
7. Mr S N Mitra

Others

1. Mr B N P Pathak, Legal Advisior

Agricultural Scientists' Recruitment Board

1. Dr C D Mayee, Chairman
2. Dr N K Tyagi, Member
3. Dr M J Modayil, Member
4. Mr N S Randhawa, Secretary
5. Mr Vikram Singh, Controller of Examination

Directorate of Information and Publications of Agriculture

1. Dr T P Trivedi, Project Director
2. Dr R P Sharma, Editor (English) and Unit Incharge
3. Mr V K Bharti, Chief Production Officer
4. Mr Kuldeep Sharma, Editor (Hindi) and Unit Incharge
5. Mr Hans Raj, Information System Officer
6. Mr S K Joshi, Business Manager
7. Dr B N Chattopadhya
8. Dr P Vishaki, Librarian, Krishi Bhavan
9. Mr Anil Sharma, Public Relations Officer

APPENDIX 4

ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr S A Patil
   Indian Agricultural Research Institute
   New Delhi 110 012
2. Dr S P S Ahlawat
   Indian Veterinary Research Institute
   Izatnagar (Uttar Pradesh) 243 122
3. Dr A K Srivastava
   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
5. Dr S M Ilyas
   National Academy of Agricultural Research and Management, Rajendranagar
   (Andhra Pradesh) 500 030

Agricultural Sciences

6. Dr R C Srivastava
   Central Agricultural Research Institute
   Andaman and Nicobar Group of Islands
   P B 181 Port Blair
   (Andamans & Nicobar Islands) 744 101
7. Dr K P R Vittal
   Central Arid Zone Research Institute
   Jodhpur (Rajasthan) 342 003
8. Dr M M Pandey
   Central Institute of Agricultural Engineering
   Berasia Road, Nabi Bagh,
   Bhopal (Madhya Prdesh) 462 038
9. Dr T A More
   Central Institute of Arid Horticulture
   Bikaner (Rajasthan) 334 006
10. Dr K R Kranti
    Central Institute for Cotton Research
    ICAR Housing Complex, Central Bazar Road
    Bajaj Nagar,Nagpur (Maharashtra) 440 010
11. Dr B M C Reddy up to 31.12.08
    Central Institute for Sub-tropical Horticulture
    Rehmankhera, PO Kakori
    Lucknow (Uttar Pradesh) 227 107
12. Dr Nazeer Ahmed
    Central Institute of Temperate Horticulture
    Old Air Field
    Rangreth (Jammu and Kashmir) 190 007
13. Dr R T Patil
    Central Institute of Post-Harvest Engineering and Technology, Ludhiana (Punjab) 141 004
14. Dr S Sreenivasan
    Central Institute for Research on Cotton Technology
    PB 16640, Adenwala Road, Matunga
    Mumbai (Maharashtra) 400 019
15. Dr George V Thomas
    Central Plantation Crops Research Institute
    Kasaragod (Kerala) 671 124
16. Dr S K Pandey
    Central Potato Research Institute
    Shimla (Himachal Pradesh) 171 001
17. Dr B Venkateswarlu
    Central Research Institute for Dryland Agriculture
    Santoshnagar, P O Saidabad
    Hyderabad (Andhra Pradesh) 500 059
18. Dr B S Mahapatra
    Central Research Institute for Jute and Allied Fibres
    Barrackpore, Distt 24 Paraganas
    (West Bengal) 700 120
19. Dr T K Adhya
    Central Rice Research Institute
    Cuttack (Orissa) 753 006
20. Dr Gurbachan Singh
    Central Soil Salinity Research Institute
    Zarifa Farm, Kachwa Road
    Karnal (Haryana) 132 001
21. Dr V N Sharda
    Central Soil and Water Conservation Research and Training Institute, 218 Kaulagarh Road
    Dehradun (Uttaranchal) 248 195
22. Dr V Krishnamurthy
    Central Tobacco Research Institute
    Rajahmundry (Andhra Pradesh) 533 105
23. Dr S K Naskar
    Central Tuber Crops Research Institute, PB 3502
    Sreekariyam, Thiruvananthapuram (Kerala) 695 017
24. Dr V S Korikanthimath
    ICAR Research Complex for Goa,
    Ela, Old Goa (Goa) 403 402
25. Dr M A Khan
    ICAR Research Complex for Eastern Region
    Walmi Complex, Phulwari Sharif
    Patna (Bihar) 801 505
26. Dr S V Ngachan
    ICAR Research Complex for North-Eastern Hills Region
    Umiam (Meghalaya) 793 103
27. Dr V K Bhatia
    Indian Agricultural Statistics Research Institute
    Library Avenue, Pusa Campus
    New Delhi 110 012

28. Dr K A Singh
Indian Grassland and Fodder Research Institute
Pahuj Dam, Gwalior-Jhansi Road
Jhansi (Uttar Pradesh) 284 003
29. Dr Meenakshi Srinivas
Indian Institute of Horticultural Research
P.O. Hassaraghatta Lake
Bangalore (Karnataka) 560 089
30. Dr Masood Ali
Indian Institute of Pulses Research
Kanpur (Uttar Pradesh) 208 024
31. Dr A Subba Rao
Indian Institute of Soil Science
Nabi Bagh, Bhopal (Madhya Pradesh) 462 038
32. Dr V A Parthasarathy
Indian Institute of Spices Research
P B 1701, P O Marikunnu
Kozhikode (Kerala) 673 012
33. Dr R L Yadav
Indian Institute of Sugarcane Research
P O Dilkusha
Lucknow (Uttar Pradesh) 226 002
34. Dr Bangali Baboo
Indian Institute of Natural Resins and Gums
Namkum, Ranchi (Jharkhand) 834 010
35. Dr Mathura Rai
Indian Institute of Vegetable Research
P.B. 01, P.O. Jakhini
Shahanshapur, Varanasi (Uttar Pradesh) 221 305
36. Dr S K Bhattacharyya
National Institute of Research on Jute and
Allied Fibre Technology
12 Reagent Park
Calcutta (West Bengal) 700 040
37. Dr N Vijayan Nair
Sugarcane Breeding Institute
Coimbatore (Tamil Nadu) 641 007
38. Dr H S Gupta
Vivekananda Parvatiya Krishi Anusandhan Sansthan
Almora (Uttar Pradesh) 263 601

Animal Sciences and Fisheries

39. Dr B P Singh
Central Avian Research Institute
Izatnagar (Uttar Pradesh) 243 122
40. Dr R K Sethi
Central Institute for Research on Buffaloes
Sirsa Road, Hisar (Haryana) 125 001
41. Dr M C Sharma
Central Institute for Research on Goats
Makhdoom, Mathura, (Uttar Pradesh) 281 122
42. Dr K K Vass
Central Inland Capture Fisheries Research Institute
Barrackpore (West Bengal) 743 101
43. Dr A G Ponniah
Central Institute of Brackishwater Aquaculture
75 Santhome High Road
R A Puram, Chennai (Tamil Nadu) 600 028
44. Dr B Meena Kumari
Central Institute of Fisheries Technology
Willingdon Island, P O Matsyapuri
Cochin (Kerala) 682 029
45. Dr A E Eknath
Central Institute of Freshwater Aquaculture
Kausalyaganga, Bhubaneshwar (Orissa) 751 002
46. Dr G Syda Rao
Central Marine Fisheries Research Institute
P B 1603, Tatapuram, Kochi (Kerala) 682 018
47. Dr S A Karim
Central Sheep and Wool Research Institute
Avikanagar, District Tonk
Via Jaipur (Rajasthan) 304 501
48. Dr K T Sampath
National Institute of Animal Nutrition and Physiology
Adugodi, Bangalore (Karnataka) 560 030

APPENDIX 5

NATIONAL BUREAUX AND THEIR DIRECTORS

Agricultural Sciences

1. Prof D K Arora
National Bureau of Agriculturally Important
Micro-organisms
PB No. 6, Kusmaur
Mau Nath Bhanjan
Uttar Pradesh 275 101
2. Dr S K Sharma
National Bureau of Plant Genetic Resources
FCI Building, Pusa, New Delhi 110 012
3. Dr Dipak Sarkar
National Bureau of Soil Survey and
Land Use Planning
P B 426, Shankar Nagar, Amravati Road
Nagpur (Maharashtra) 440 010

Animal Sciences

4. Dr P K Joshi
National Bureau of Animal Genetic Resources
PB 129, Karnal (Haryana) 132 001
5. 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

APPENDIX 6

PROJECT DIRECTORATES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr R J Rabindra
   Project Directorate of Biological Control
   Bellary Road, P.B. 2491
   HA Farm Post, Hebbal
   Bangalore (Karnataka) 560 024
2. Dr M S Gill
   Directorate of Cropping Systems Research
   Modipuram
   Meerut (Uttar Pradesh) 250 110
3. Dr Sain Dass
   Project Directorate of Maize Research
   Cummings Laboratory
   Indian Agricultural Research Institute,
   Pusa
   New Delhi 110 012
4. Dr D M Hegde
   Directorate of Oilseeds Research
   Hyderabad (Andhra Pradesh) 500 030
5. Dr B C Viraktamath
   Directorate of Rice Research
   Hyderabad (Andhra Pradesh) 500 030
6. Dr A B Mandal
   Directorate of Seed Research
   Kusmaur, Mau Nath Bhanjan
   (Uttar Pradesh) 275 101
7. Dr T P Trivedi
   Directorate of Information and Publications of Agriculture
   KABI, Pusa,
   New Delhi 110 012
8. Dr Jag Shoran
   Directorate of Wheat Research
   P B 158, Kunjpura Road, Karnal (Haryana) 132 001

Animal Sciences

9. Dr A K Misra
   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
    Project Directorate on Animal Disease Monitoring and Surveillance
    Hebbal, Bangalore (Karnataka) 560 024
12. Dr B Pattanaik
    Project Directorate on Foot and Mouth Diseases
    IVRI Campus, Mukteshwar
    Kumaon (Uttaranchal) 263 138

APPENDIX 7

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 M M Mustaffa
   National Research Centre for Banana
   Thogamalai Main Road, Thayanur Post
   Thiruchirapalli (Tamil Nadu) 620 102
3. Dr M Gopalakrishna Bhat
   National Research Centre for Cashew
   Kamminje, Puttur (Karnataka) 574 202
4. Dr V J Shivankar
   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 J B Mishra
   National Research Centre for Groundnut
   Ivnagar Road, Timbawadi
   PB 5, Junagadh
   (Gujarat) 362 001
7. Dr O M Bambawale
   National Research Centre for Integrated Pest Management
   Lal Bahadur Shastri Building
   IARI, Hillside Road,
   Pusa
   New Delhi 110 012
8. Dr K K Kumar
   National Research Centre for Litchi
   Manchi House
   Muzaffarpur (Bihar) 842 002
9. Dr Satyabrata Maiti
   National Research Centre for Medicinal and Aromatic Plants
   Boriavi Seed Farm,Boriavi
   Anand (Gujarat) 387 310
10. Dr R P Tiwari up to 31.12.08
    National Research Centre for Mushroom
    Chambaghat,
    Solan (Himachal Pradesh) 173 213
11. Dr M Kochu Babu
    National Research Centre for Oilpalm
    Pedavegi (Andhra Pradesh) 534 450
12. Dr K E Lawande
    National Research Centre for Onion and Garlic
    Rajguru Nagar
    Pune, (Maharashtra) 410 505
13. Dr R P Medhi
    National Research Centre for Orchids
    Pakyang (Sikkim) 737 106
14. Dr P Ananda Kumar
    National Research Centre for Plant Biotechnology
    Indian Agricultural Research Institute
    Pusa, New Delhi 110 012
15. Dr Vilas T Jadhav
    National Research Centre on Pomegranate
    C/o Centre on Rabi Sorghum
    NH 9 Bye Pass
    Shelgi, Solapur (Maharashtra) 413 006

16. Dr Arvind Kumar
National Research Centre for Rapeseed and Mustard
P B 41, Bharatpur
(Rajasthan) 321 303

17. Dr M M Anwar
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 up to 31.12.08
National Research Centre for Soybean
Bhawerkua Farm, Khandwa Road,
Indore (Madhya Pradesh) 452 017

20. Dr Ashwani Kumar
Water Technology Centre for Eastern Region
Chandrasekharpur,
Bhubaneshwar (Orissa) 751 023

21. Dr J G Varshney
National Research Centre for Weed Science
Maharajpur, Adhartal
Jabalpur (Madhya Pradesh) 482 004

Animal Sciences and Fisheries

22. Dr K M L Pathak
National Research Centre on Camel
Jorbeer, PB 07
Bikaner (Rajasthan) 334 001

23. Dr A K Gupta
National Research Centre for Equines
Sirsa Road, Hisar (Haryana) 125 001

24. Dr N Kondaiah
National Research Centre on Meat and
Meat Products
CRIDA Campus, Santosnagar
Hyderabad (Andhra Pradesh) 500 059

25. Dr Chandan Rajkhowa
National Research Centre for Mithun
ICAR Research Complex
Jharnapani, Medziphema (Nagaland) 797 106

26. Dr Anuprata Das
National Research Centre for Pigs
Panjabari Road, 6th Mile, Guwahati (Assam) 785 037

27. Dr Mohan Bhattacharya
National Research Centre on Yak
West Kemeng, Dirang (Arunachal Pradesh) 790 101

28. Dr P C Mahanta
Directorate of Cold Water Fisheries Research
Nainital (Uttarakhand) 263 136

General

29. Dr P K Joshi
National Centre for Agricultural Economics and
Policy Research
Library Avenue, Pusa, New Delhi 110 012

30. Dr (Ms) Krishna Srinath
National Research Centre for Women in Agriculture
1199, Jagamara
Bhubaneshwar (Orissa) 751 030

APPENDIX 8

A. ALL-INDIA CO-ORDINATED RESEARCH PROJECTS AND PROJECT/NETWORK CO-ORDINATORS

Crop Sciences

1. Dr B Mallik
Network Co-ordinator (Acarology)
UAS
GKVK, Hebbal, Bangalore (Karnataka) 560 065

2. Dr D Kumar
Project Coordinator (Arid Legumes)
CAZRI
Jodhpur (Rajasthan) 342 003

3. Dr D M Hegde
Project Co-ordinator (Castor)
Directorate of Oilseeds Research
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030

4. Dr N Gopala Krishan
Project Co-ordinator (Cotton)
CICR Research Station, PO Lawley Road,
Coimbatore
(Tamil Nadu) 641 003

5. Dr N P Singh
Project Co-ordinator (Chickpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024

6. 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

7. Dr J B Misra
Project Coordinator (Groundnut)
NRC on Groundnut
Junagarh
(Gujarat) 362 001

8. Dr R K Lakra
Project Co-ordinator (Honeybees and Pollinators)
Division of Entomology
CCS Haryana Agricultural University
Hisar (Haryana) 125 004

9. M K Sinha
Network Co-ordinator (Jute and Allied fibres)
Central Research Institute for Jute and Allied Fibres
Barrackpore (West Bengal) 700 120

10. Dr R L Srivastava
Project Co-ordinator (Linseed)
CSA University of Agriculture and Technology
Kanpur
(Uttar Pradesh) 208 002

11. Dr Sain Dass
Project Co-ordinator (Maize)
Directorate of Maize Research
New Delhi 110 012

12. Dr B B Singh
Project Co-ordinator (MULLARP)
Indian Institute of Pulses Research
Kalyanpur, Kanpur
(Uttar Pradesh) 208 024

13. Dr R K Jain
Project Co-ordinator (Nematodes)
Division of Nematology
Indian Agricultural Research Institute, Pusa
New Delhi 110 012

14. Dr V Vasudeva Rao
Project Co-ordinator (Ornithology)
ANGRAU, Rajendranagar
Hyderabad (Andhra Pradesh) 500 030

15. Dr I S Khairwal
Network Co-ordinator (Pearl Millet)
Agricultural Research Station, RAU, Mandore
Jodhpur (Rajasthan) 342 304
16. Dr K K Sharma
Network Coordinator (Pesticide Residues)
Division of Agricultural Chemicals, LBS Building
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
17. Dr N D Majumdar
Project Co-ordinator (Pigeonpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
18. Dr D M Hegde
Project Coordinator (Safflower and Sunflower)
Directorate of Oilseeds Research
Hyderabad, Andhra Pradesh 500 030
19. Dr S S Duhoon
Project Co-ordinator (Sesame and Niger)
JNKVV, Jabalpur (Madhya Pradesh) 482 004
20. Dr S Seetharama
Project Co-ordinator (Sorghum)
National Research Centre for Sorghum
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
21. Dr K T Krishne Gowda
Project Co-ordinator (Small Millets)
University of Agricultural Sciences
GKVK Campus, Bangalore (Karnataka) 560 065
22. Dr G S Chauhan
Project Co-ordinator (Soybean)
NRC on Soybean
Indore (MP) 452 017
23. Dr O K Sinha
Project Co-ordinator (Sugarcane)
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002
24. Dr B C Viraktamath
Project Coordinator (Rice)
Directorate of Rice Research
Hyderabad, Andhra Pradesh 500 030
25. Dr Arvind Kumar
Project Co-ordinator (Rapeseed Mustard)
NRCRM, Sewar
Bharatpur (Rajasthan) 321 303
26. Dr R S Tripathi
Project Co-ordinator (Rodent Control)
CAZRI, Jodhpur (Rajasthan) 342 003
27. Dr V Krishnamurthy
Project Co-ordinator (Tobacco)
CTRI, Rajamundry (Andhra Pradesh) 533 105
28. Dr R P Dua
Network Co-ordinator (Under-utilized crops)
NBPGR, Pusa, New Delhi 110 012
29. Dr Jag Shoran
Project Co-ordinator (Wheat and Barley)
Directorate of Wheat Research
Karnal (Haryana) 132 001
30. Dr Y S Mathur
Network Co-ordinator (White Grubs and other soil anthropods)
Agricultural Research Station, RAO
Jaipur (Rajasthan) 302 018

Horticulture

31. Dr T A More
Project Coordinator (Arid Fruits)
Centeral Institute of Arid Horticulture
Bikaner (Rajasthan) 334 006
32. Dr Satyabrata Maiti
Project Co-ordinator (Betelvine and Medicinal and Aromatic Plants)
NRC on Medicinal and Aromatic Plants
Anand (Gujarat) 387 310
33. Dr Gopala Krishna Bhat
Project Co-ordinator (Cashew)
National Research Centre for Cashew
Puttur
(Karnataka) 574 202
34. Dr A S Sidhu
Project Co-ordinator (Floriculture)
Division of Floriculture and Landscaping
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
35. Dr R P Tiwari
Project Coordinator (Mushrooms)
National Centre for Mushroom Research and Training
Chambaghat, Solan (Himachal Pradesh) 173 213
36. Dr S Arulraj
Project Co-ordinator (Palms)
Central Plantation Crops Research Institute
Kasaragod (Kerala) 671 124
37. Dr P S Naik
Project Co-ordinator (Potato)
Central Potato Research Institute
Shimla (Himachal Pradesh) 171 001
38. Dr A K Misra
Project Co-ordinator (Subtropical Fruits)
Central Institute for Subtropical Horticulture
Rahmankhera, Lucknow (Uttar Pradesh) 227 107
39. Dr M Anandraj
Project Co-ordinator (Spices)
Indian Institute of Spices Research
PB 170, Marikunnu, Calicut (Kerala) 673 012
40. Dr V Krishnamurthy
Project Co-ordinator (Tobacco)
Central Tobacco Research Institute
Rajamundry
Andhra Pradesh 533 105
41. Dr Meenakshi Srinivas
Project Co-ordinator (Tropical Fruits)
Indian Institute of Horticultural Research
Hessarghatta Lake Post
Bangalore (Karnataka) 560 089
42. Dr M S Palaniswami
Project Co-ordinator (Tuber Crops), Regional Station of the Central Tuber Crops Research Institute
Thiruvananthapuram (Kerala) 695 017
43. Dr Mathura Rai
Project Co-ordinator (Vegetables)
Indian Institute of Vegetable Research
Varanasi (Uttar Pradesh) 221 005

Natural Resource Management

44. Dr G G S N Rao
Project Co-ordinator (Agricultural Meteorology)
CRIDA Campus
Santoshnagar
Hyderabad (Andhra Pradesh) 500 059
45. Dr D L N Rao
Network Co-ordinator (Bio-fertilizers)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
46. Dr S K Dhyani
Project Co-ordinator (Agroforestry)
National Research Centre on Agroforestry
Jhansi
(Uttar Pradesh) 284 003
47. Dr M S Gill
Project Co-ordinator (Cropping Systems Research)
Project Directorate of Cropping Systems Research
Modipuram, Meerut (Uttar Pradesh) 250 110
48. Dr P K Mishra
Project Co-ordinator (Dryland Agriculture)
CRIDA Campus, Santoshnagar
Hyderabad
(Andhra Pradesh) 500 059

49. Dr Muneshwar Singh
Project Co-ordinator (Long-term Fertilizer Experiments)
Indian Institute of Soil Science
Bhopal
(Madhya Pradesh) 462 038
50. Dr S K Gupta
Project Co-ordinator (Management of Salt-affected Soils and Saline Water in Agriculture)
Central Soil Salinity Research Institute
Karnal
(Haryana) 132 001
51. Dr Mahavir 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
52. Dr Ashwani Kumar
Project Co-ordinator (Optimization of Ground Water Utilization)
Khurda, Bhubaneshwar
(Orissa) 751 023
53. Dr Y Muralidharudu
Project Co-ordinator (Soil Test and Crop Response)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
54. Dr Ashwani Kumar
Project Co-ordinator (Water Management)
WTC for Eastern Region
Bhubaneshwar (Orissa) 751 023
55. Dr J G Vashney
Project Co-ordinator (Weed Control)
National Research Centre for Weed Science
Adhartal
Jabalpur (Madhya Pradesh) 482 004

Engineering and Technology

56. Dr P R Bhatnagar
Project Co-ordinator (Application of Plastic in Agriculture)
Central Institute of Post-harvest Technology
Ludhiana (Punjab) 141 004
57. Dr L P Gite
Project Co-ordinator (Ergonomics and Safety in Agriculture)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
58. Dr Surendra Singh
Project Co-ordinator (Farm Implements and Machinery)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
59. Dr S K Nanda
Project Co-ordinator (Post-Harvest Technology)
Central Institute of Post-Harvest Technology
Ludhiana (Punjab) 141 004
60. Dr M Shyam
Project Co-ordinator (Renewable Sources of Energy for and Agriculture and Agro-based Industries)
Central Institute of Agricultural Engineering
Bhopal
(Madhya Pradesh) 462 038
61. Dr S K Rautaray
Project Co-ordinator (Utilization of Animal Energy with Enhanced System Efficiency)
Central Institute of Agricultural Engineering
(Madhya Pradesh) 462 038

Animal Sciences

62. Dr K Prabhudas
Project Co-ordinator (ADMAS)
Project Directorate on Animal Disease Monitoring and Surveillance
Hebbal, Bangalore (Karnataka) 560 024
63. Dr R S Chauhan
Network Co-ordinator (Blue tongue)
IVRI
Izatnagar (Uttar Pradesh) 243 122
64. Dr R K Sethi
Network Co-ordinator (Buffalo improvement)
CIRB
Hisar (Haryana) 125 001
65. Dr A K Misra
Project Co-ordinator (Cattle)
Project Directorate on Cattle
Meerut (Uttar Pradesh) 250 002
66. Dr K T Sampath
Project Co-ordinator (Feed Resources and Nutrient Utilization)
NIANP
Audugodi, Bangalore (Karnataka) 560 030
67. Dr B Pattnaik
Project Co-ordinator (FMD)
Project Directorate on Foot and Mouth Diseases
IVRI Campus
Mukteshwar (Uttar Pradesh) 263 138
68. Dr M C Sharma
Project Co-ordinator (Goats)
Central Institute for Research on Goat
Mathura (Uttar Pradesh) 281 122
69. Dr R S Chauhan
Network Co-ordinator (Haemmrrhagic Septicaemia)
IVRI, Izatnagar 243 122
70. Dr J K Malik
Network Co-ordinator (Gastro-intestinal parasitism)
IVRI, Izatnagar (Uttar Pradesh) 243 122
71. Dr Anuprata Das
Project Co-ordinator (Pigs)
NRC on Pigs
Guwahati (Asom) 781 037
72. Dr R P Sharma
Project Co-ordinator (Poultry)
AICRP on Poultry Breeding
Project Directorate on Poultry
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030
73. Dr B K Joshi
Network Co-ordinator (Animal Genetic Resources)
NBAGR
Karnal (Haryana) 132 001
74. Dr G R Patil
Network Co-ordinator (Process Upgradation of indigenous milk)
NDRI, Karnal (Haryana) 132 001
75. Dr A L Arora
Network Co-ordinator (Sheep Breeding)
CSWRI
Avikanagar (Rajasthan) 304 501

Education

76. Dr Krishna Srinath (Home Science)
NRC for Women
Bhubaneshwar (Orissa) 751 001

APPENDIX 9

AGRICULTURAL UNIVERSITIES AND THEIR VICE-CHANCELLORS

1. Dr P Raghava Reddy
   Acharya N G Ranga Agricultural University
   Rajendranagar,
   Hyderabad (Andhra Pradesh) 500 030
2. Dr M C Varshneya
   Anand Agricultural University
   Anand (Gujarat) 388 110
3. Dr B C Bhowmick
   Assam Agricultural University, Jorhat
   (Assam) 785 013
4. Dr R K Samanta
   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 V P Kanaujia
   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 Tej Partap
   Ch Sarwan Kumar Krishi Vishwavidyalaya
   Palampur (Himachal Pradesh) 176 062
9. Dr Vijay Mehta
   Dr Balaesahib Sawant Konkan Krishi Vidyapeeth
   Dapoli (Maharashtra) 415 712
10. Dr V M Mayande
    Dr Panjabrao Deshmukh Krishi Vidyapeeth
    Akola (Maharashtra) 444 104
11. Dr K R Dhiman
    Dr Yashwant Singh Parmar University of Horticulture and Forestry
    Nauni, Distt Solan (Himachal Pradesh) 173 230
12. Dr B S Bisht
    Govind Ballabh Pant University of Agriculture and Technology
    Pantnagar (Uttaranchal) 263 145
13. Dr V K Taneja
    Guru Angad Dev Veterinary and Animal Sciences University
    PAU Campus, Ludhiana, Punjab 141 004
14. Mr Serjius Minj
    Indira Gandhi Krishi Vishwavidyalaya
    Raipur (Chhatisgarh) 492 012
15. Mr Deepak Kumar Panwar
    Horticulture University
    Tadepalligudam (West Godavari)
    Andhra Pradesh
16. Dr Gautam Kalloo
    Jawaharlal Nehru Krishi Vishwa Vidyalaya
    Jabalpur, (Madhya Pradesh) 482 004
17. Dr B K Kikani
    Junagarh Agricultural University
    Junagarh (Gujarat) 362 001
18. Dr Suresh S Honnappagol
    Karnataka Veterinary, Animal and Fisheries Sciences University
    Bidar (Karnataka) 585 401
19. Dr K R Viswambharan
    Kerala Agricultural University
    Vellanikara, Distt Trichur (Kerala) 680 656
20. Dr Arun S Ninawe
    Maharashtra Animal Sciences and Fisheries University
    Nagpur (Maharashtra) 440 006
21. Dr R B Deshmukh
    Mahatma Phule Krishi Vidyapeeth
    Rahuri (Maharashtra) 413 722
22. Dr S S Kadam
    Marathwada Agricultural University
    Parbhani
    (Maharashtra) 431 402
23. Dr Basant Ram
    Narendra Dev University of Agriculture and Technology
    Faizabad (Uttar Pradesh) 224 229
24. Dr R P S Ahlawat
    Navsari Agricultural University
    Navsari (Gujarat) 396 450
25. Dr D P Ray
    Orissa University of Agriculture and Technology
    Bhubaneshwar (Orissa) 751 003
26. Dr Manjit Singh Kang
    Punjab Agricultural University
    Ludhiana (Punjab) 141 004
27. Dr Pratap Narain
    Maharana Pratap University of Agriculture and Technology
    Udaipur (Rajasthan) 313 001
28. Dr Pranab Narain
    Rajasthan Agriculture University
    Bikaner (Rajasthan) 334 006
29. Dr M L Chaudhary
    Rajendra Agricultural University
    Samastipur, Pusa (Bihar) 848 125
30. Dr R C Maheshwari
    SD Agricultural University
    Dantiwada (Gujarat) 385 506
31. Dr M P Yadav
    Sardar Ballabh Bhai Patel University of Agriculture and Technology
    Modipuram, Meerut (Uttar Pradesh) 250 110
32. Dr Anwar Alam
    Sher-E-Kashmir University of Agricultural Sciences and Technology
    Srinagar (Jammu and Kashmir) 191 121
33. Dr B Mishra
    Sher-e-Kashmir University of Agricultural Sciences and Technology
    45-B, Gandhinagar, PB 37
    Jammu (Jammu and Kashmir) 180 012
34. Dr DVG Krishna Mohan
    Sri Venkateswara Veterinary University
    Tirupati (Andhra Pradesh) 517 502
35. Dr C Ramasamy
    Tamil Nadu Agricultural University
    Coimbatore (Tamil Nadu) 641 003
36. Dr P Thangaraju
    Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu) 600 051
37. Dr P G Chengappa
    University of Agricultural Sciences, GKVK
    Bangalore (Karnataka) 560 065
38. Dr J H Kulkarni
    University of Agricultural Sciences
    Dharwad (Karnataka) 580 005
39. Dr M L Madan
    UP Deen Dayal Upadhyaya Veterinary and Animal Science University
    Mathura (Uttar Pradesh) 281 001
40. Dr Asit Kumar Das
    Uttar Banga Krishi Vishwavidyalaya
    Pundibari, Cooch, Bihar (West Bengal) 736 165

41. Dr C S Chakrabarti
West Bengal University of Animal and Fishery Sciences, 68KB Sarani
Kolkata (West Bengal) 700 037

Central Agricultural University

1. Dr S N Puri
Central Agricultural University
Imphal (Manipur) 795 004

Central Universities

1. Dr P K Abdul Azis
Aligarh Muslim University
Aligarh (Uttar Pradesh) 202 002
2. Professor D P Singh
Banaras Hindu University
Varanasi (Uttar Pradesh) 221 005
3. Professor Rajat Kumar Roy
Upacharya, Visva Bharati
Sriniketan (West Bengal) 731 236
4. Prof K Kannan
School of Agricultural Sciences and Rural Development
Nagaland University
Medziphema (Nagaland) 797 106

Deemed-to-be Universities

1. Dr S A Patil
Indian Agricultural Research Institute
Pusa,
New Delhi 110 012
2. Dr S P S Ahlawat
Indian Veterinary Research Institute
Izatnagar
(Uttar Pradesh) 243 122
3. Dr A K Srivastava
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 10

Total number of employees in the ICAR and its research institutes and number of Scheduled Castes, Scheduled Tribes and Other Backward Classes

	Total posts sanctioned	Total employees in position	Total SC among them	Per cent to total employees	Total ST among them	Per cent to total employees	Total OBC among them	Per cent to total employees
1. Scientific Post								
Scientist	3,881	3,258	432	13.2	96	2.9	352	10.8
Senior Scientist	1,651	510	62	12.1	7	1.3	54	10.5
Prinicipal Scientist	749	263	45	17.1	5	2.0	18	6.8
RMP Scientist	147	134	3	2.2	2	1.5	7	5.2
Total	**6,428**	**4,165**	**542**	**13.1**	**110**	**2.6**	**431**	**10.3**
2. Technical Posts								
Category I	4,950	3,311	599	18.0	290	8.7	275	8.3
Category II	2,798	2,567	489	19.0	168	6.5	292	11.3
Category III	668	600	129	21.5	42	7.0	90	15.0
Total	**8,460**	**6,478**	**1,217**	**18.7**	**500**	**7.7**	**657**	**10.0**
3. Administration Posts								
(a) Directors/Dy.Secretaries Under Secretaries/ Sr. Admn. Officers/ Sr. Accounts Officers/ Admn. Officer/ F&AO/Legal, PA to Chairman, ASRB etc.	181	160	22	13.75	11	6.87	7	4.4
(b) Asstt. Fin. & Accounts Officer/Accounts Officer Section Officer/Hindi Officer/Desk Officer/ Protocol Officer	645	574	88	15.33	38	6.22	28	4.87
(c) Assistants, UDC/PA AD (OL)/PS/ SO/DO/JA/	4,199	3,706	680	18.34	294	7.93	359	9.68
Total	**5,025**	**4,440**	**790**	**17.79**	**343**	**7.73**	**384**	**8.65**
4. Supporting Staff								
Grade I	3,299	2,567	696	27.11	179	6.97	508	19.78
Grade II	4,025	3,063	864	28.20	217	7.08	180	5.87
Grade III	1,925	1,773	526	29.66	141	7.95	90	5.07
Grade IV	966	889	247	27.78	104	11.69	46	5.17
Total	**10,215**	**8,292**	**2,333**	**28.13**	**641**	**7.73**	**824**	**9.93**
5. Safiwala	113	136	88				01	
Auxillary post dying cadre	18	13	03					

APPENDIX 11

AWARDS

AWARD	AWARDEES
Sardar Patel Outstanding Institution Award (2007)	*ICAR Institutes* (i) Central Marine Fisheries Research Institute, Kochi, Kerala (ii) Vivekananda Parvatiya Krishi Anusandhan Shala, Almora, Uttarakhand *State Agricultural Universities* (i) Acharya N G Ranga Agricultural University, Hyderabad, Andhra Pradesh
Jawaharlal Nehru Award for Outstanding Post-graduate Agricultural Research (2007)	*Crop Sciences and Crop Improvement* (i) Dr Sanjay B Patil, UAS, Dharwad, Karnataka (ii) Dr R Narasimman, Perunthalaivar Kamaraj KVK, Karumbapet, Puducherry *Biotechnology* (i) Dr P Azhahianambi, IVRI, Izatnagar, Uttar Pradesh (ii) Dr V Girijashankar, JNTU, Hyderabad, Andhra Pradesh *Plant Protection including Microbiology* (i) Dr P N Sivalingam, IARI, New Delhi (ii) Dr K S Shankarappa, UAS, Bangalore, Karnataka *Soil Science, Natural Resource Management and Agronomy* (i) Dr C Sudhalakshmi, TNAU, Coimbatore, Tamil Nadu (ii) Dr S Sangeetha Mohanty, IARI, New Delhi *Horticulture* (i) Dr E Srinavasa Rao, IIHR, Bangalore, Karnataka (ii) Dr Resmi Paul, KAU, Thrissur, Kerala *Engineering and Technology* (i) Dr Kundan Kumar Jain, JNKVV, Jabalpur, Madhya Pradesh (ii) Dr Narendra Kumar Gontia, JAU, Junagarh, Gujarat *Animal Production and Veterinary Sciences* (i) Dr Samit Kumar Nandi, WBUA&FS, Kolkata, West Bengal (ii) Dr Richard Churchil, IVRI, Izatnagar, Uttar Pradesh (iii) Dr Suresh Kumar, TNVASU, Chennai, Tamil Nadu *Fisheries* (i) Dr P S Asha, CMFRI, Tuticorin, Tamil Nadu *Social Sciences including Home Science, Extension and Economics* (i) Dr Malay Naskar, University of Calcutta, West Bengal (ii) Dr S Gurunathan, TNAU, Coimbatore, Tamil Nadu
N.G. Ranga Farmer Award for Diversified Agriculture (2007)	(i) Mr Gangaraju Venkata Ramaraju, Siddiraju Kandrika Village, Railway Kodur Mandal, Kadapa Dist. Andhra Pradesh
Panjabrao Deshmukh Women Agricultural Scientist Award (2007)	*Crop Physiology* (i) Dr C Vijayalakshmi, TNAU, Coimbatore, Tamil Nadu *Crop Production* (ii) Dr S Vennila, CICR, Nagpur, Maharashtra
Vasantrao Naik Award for Research Applications in Dryland Agriculture (2007)	(i) Dr N Sahoo and Associates Drs S K Jena, P Nanda, Madhumita Das, P S Brahmanand, R K Mohanty, W T C for Easter Region, Bhubaneshwar, Orissa
Chaudhary Devi Lal Outstanding AICRP Award (2007)	(i) AICRP on Tubercrops Improvement, Thiruvananthapuram, Kerala

Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research & Development (2007)	(i) Dr Mahendra Madhup *Sharad Krishi* (Hindi), Jaipur, Rajasthan
ICAR Awards for outstanding Interdisciplinary Team Research in Agriculture and Allied Sciences for the Biennium (2005–06)	*Crop Improvement* (i) Dr S K Garg and team, NCIPM, New Delhi (ii) Dr H S Gupta, VPKAS, Almora, Uttarakhand *Natural Resource Management* (i) Dr Tapas Bhattacharya and team, NBSSLUP, Nagpur, Maharashtra *Horticulture* (i) Dr George V Thomas and team, CPCRI, Kasargod, Kerala *Engineering* (i) Dr Sanjeev Kumar Tyagi and team, CIPHET, Ludhiana, Punjab *Animal Production and Health* (i) Dr R K Singh and team, IVRI, Nainital Mukteswar, Uttarakhand (ii) Dr Raj Narayan and team, CARI, Izatnagar Uttar Pradesh *Social Sciences and Home Science* (i) Dr K Abraham and team, CALPI, New Delhi *Fisheries* (i) Dr J R Jena and team, CIFA, Bhubaneshwar, Orissa
Jagjivan Ram Kisan Puraskar (2007)	*Crop Production* (i) Mr Mekala Lakshmi Narayana, Guntur, Andhra Pradesh *Livestock, Poultry, Fish Farming* (i) Mr Dada Sadhu Boadke, Solapur District, Maharashtra
Fakhruddin Ali Ahmed Award for outstanding Agricultural Research in Tribal Areas for Biennium (2006-07)	*Agricultural Sciences* (i) Dr Chandra Bhushan Pandey, Dr S Ghoshal Choudhuri and Dr Maharani Din, CARI, Port Blair, Andaman and Nicobar Islands *Animal Sciences* (i) Dr Mohan Mondal and Dr Chandan Rajkhowa, NRC on Mithun, Medziphema, Nagaland
Bharat Ratna Dr C Subramaniam Award for Outstanding Teachers for the Biennium (2006-07)	*Crop Sciences* (i) Dr K Vanangamudi, TNAU, Coimbatore, Tamil Nadu (ii) Dr Prem Dureja, IARI, New Delhi *Resource Sciences* (i) Dr B R Yadav, WTC, IARI, New Delhi *Engineering and Food Technology* (i) Dr Satish Kulkarni, NDRI, Bangalore, Karnataka *Veterinary and Animal Sciences* (i) Dr V H Rao, S V Veterinary University, Tirupati, Andhra Pradesh (ii) Dr Veer Singh, SDAU, Baneskantha, Gujarat *Social Sciences* (i) Dr S K Tewari, GBPUAT, Pantnagar, Uttarakhand
Dr Rajendra Prasad Award for 2005-06	*Crop Sciences* (i) Dr Prem Kishore, IARI, New Delhi *Soil and Agronomy* (i) Dr V N Sharda, CSWCR&TI, Dehradun, Uttarakhand (ii) Dr G P Juyal, CSWCRTI, Dehradun (iii) Dr Alok Kumar Sikka, National Rainfed Authority, New Delhi *Horticulture* (i) Dr R C Maheshwari, Hindustan Science and Technology College, Farah, Mathura, Uttar Pradesh *Animal Health* (i) Dr Ramesh Somvanshi, IVRI, Izatnagar, Uttar Pradesh *Animal Production* (i) Dr S C Dubey, High Security Animal Diseases Laboratory, Anandnagar, Bhopal, Madhya Pradesh (ii) Dr A K Shinde, CSWRI, Avikanagar, Rajasthan (iii) Dr V N Singh, M P Livestock and Poultry Cooperative, Bhopal, Madhya Pradesh

APPENDIX 12

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Summary of Audit Observations
(C&AG Report no. CA 3 of 2008)

Non-implementation of Dairy Project

Indian Council of Agricultural Research sanctioned a pilot project Rs 4.90 crore to National Dairy Research Institute for establishment of 6 dairy centres and for providing scientific and technical support to farmers for production of quality milk and agricultural products. However, the objectives of the project could not be achieved due to inadequate monitoring and poor implementation.

(Paragraph 9.1.)

Irregular payment of Island Special Allowance

Failure of Central Agricultural Research Institute, Port Blair to follow the instructions of Ministry of Finance issued in May 2002 to regulate payment of Island Special Allowance resulted in payment of Rs.67.23 lakh from October 2001 to March 2007.

(Paragraph 9.2)

Irregular payment of AMC charges

Indian Council of Agricultural Research paid Rs 25.04 lakh towards annual maintenance contract of UPS systems procured under a World Bank assisted project, which was required to be paid by respective institutions to whom UPS systems were supplied. The amount was yet to be recovered from the respective institutions/ organization.

(Paragraph 9.3)

Activities of Central Sheep and Wool Research Institute

Central Sheet and Wool Research Institute did not take up any collaborative, sponsored and consultancy projects and also did not develop transferable technologies finding acceptance with farmers. It failed to achieve the envisaged objectives fully, in 6 of the 7 in-house projects test checked. It also failed to put machinery in use resulting in low output. It also failed to modernize its machinery, despite grants being given for modernization by Indian Council of Agricultural Research.

(Paragraph 9.4)

Non-operationalization of Quarantine Building

Project Directorate of Biological Control entrusted the work relating to the construction of quarantine building to Central Public Works Department. However, lack of proper planning and inability to rectify deficiencies in the quarantine building resulted in non-operationalisation of the building even after a lapse of more than 8 years and after incurring Rs 1.65 crore.

(Paragraph 9.5)

Council's response

Action Taken Notes in respect of paras at Sl No. 1, 3 & 4 have already been furnished to Audit. In respect of paras at Sl No. 2 & 5, the Action Taken Notes shall be furnished to Audit shortly.

Acronyms

AAU	:	Assam Agricultural University
AI	:	Artificial Insemination
AICRP	:	All-India Co-ordinated Research Project
AINP	:	All-India Network Project
AKI	:	Agricultural Knowledge Initiative
ANGRAU	:	Acharya NG Ranga Agricultural University
ARIC	:	Agricultural Research Information Centre
ARIS	:	Agricultural Research Information System
ARS	:	Agricultural Research Service
ASRB	:	Agricultural Scientists Recruitment Board
AU	:	Agricultural University
AUTM	:	Association of Universities for Technology Management
BBF	:	Broad Bed and Furrow
BE	:	Budget Estimate
BHU	:	Banaras Hindu University
BPD	:	Business Planning Development
BTV	:	Bluetongue Virus
CAU	:	Central Agricultural University
CAZRI	:	Central Arid Zone Research Institute
CCSHAU	:	Chaudhary Charan Singh Haryana Agricultural University
CGIAR	:	Consultative Group on International Agricultural Research
CIAE	:	Central Institute of Agricultural Engineering
CIBA	:	Central Institute of Brackishwater Aquaculture
CICR	:	Central Institute for Cotton Research
CIFA	:	Central Institute of Freshwater Aquaculture
CIFE	:	Central Institute of Fisheries Education
CIFRI	:	Central Inland Fisheries Research Institute
CIMMYT	:	Centro International de Mejormento de Maize Trigo
CIPHET	:	Central Institute of Post-harvest Engineering and Technology
CIRCOT	:	Central Institute for Research on Cotton Technology
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
CTCRI	:	Central Tuber Crops Research Institute
CTMC	:	Central Technology Management Committee
CTRI	:	Central Tobacco Research Institute
CU	:	Central University
DARE	:	Department of Agricultural Research and Education
DAS	:	Days After Sowing
DBT	:	Department of Biotechnology
DDG	:	Deputy Director-General
DG	:	Director-General
DIPA	:	Directorate of Information and Publications of Agriculture
DM	:	Dry Matter
DU	:	Deemed-to-be University
DWR	:	Directorate of Wheat Research
EC	:	Electrical Conductivity
EIA	:	Enzyme Immuno Assay
ELISA	:	Enzyme-linked Immunosorbent Assay
EPN	:	Entomopathogenic Nematode
ETL	:	Economic Threshold Level
FAO	:	Food and Agriculture Organization
FMD	:	Foot-and-mouth Disease
FSH	:	Follicle-stimulating Hormone
FYM	:	Farmyard Manure
GBPUAT	:	Govind Ballabh Pant University of Agriculture and Technology
GCMS	:	Gas Chromatography Mass Spectrometry
GH	:	Growth Hormone
GIS	:	Geographical Information System
GKVK	:	Gandhi Krishi Vignana Kendra
GPA	:	Global Plan of Action
GPS	:	Global Positioning System
GRD	:	General Recommended Dose
HAPA	:	Hybridization-supplemented Apomixis Components Partitioning Approach
HDPE	:	High Density Polyethylene
HF	:	Holstein-Friesian
HPTLC	:	High Performance Thin Layer Chromatography
HRD	:	Human Resource Development
HTMA	:	Hair Tissue Mineral Analysis
IARI	:	Indian Agricultural Research Institute
IASRI	:	Indian Agricultural Statistics Research Institute
ICAR	:	Indian Council of Agricultural Research
ICARDA	:	International Centre for Agricultural Research in Dry Areas
ICRISAT	:	International Crops Research Institute for Semi-Arid Tropics
ICT	:	Information and Communication Technologies
IFS	:	Integrated Farming System
IGFRI	:	Indian Grassland and Fodder Research Institute
IGKVV	:	Indira Gandhi Krishi Vishwa Vidyalaya
IIHR	:	Indian Institute of Horticultural Research
IINRG	:	Indian Institute of Natural Resins and Gums
IISR	:	Indian Institute of Sugarcane Research
InsCot	:	Information System on Cotton Cultivars
IPGRI	:	International Plant Genetic Resources Institute
IPM	:	Integrated Pest Management
IPR	:	Intellectual Property Right
IRRI	:	International Rice Research Institute
ITMUs	:	Institute Technology Management Units
IVDMD	:	*In-vitro* Dry Matter Digestibility
IVF	:	*In-vitro* Fertilization
IVRI	:	Indian Veterinary Research Institute
JAU	:	Junagarh Agricultural University
JNKVV	:	Jawaharlal Nehru Krishi Vishwa Vidyalaya

JRF	:	Junior Research Fellowship
KF	:	Karan Fries
KS	:	Karan Swiss
KVK	:	Krishi Vigyan Kendra
LDPE	:	Low Density Polyethylene
LE	:	Larval Equivalent
MAP	:	Modified Atmosphere Packaging
MAS	:	Molecular Marker-assisted Selection
MNFB	:	Multi-nutrient Feed Block
MoU	:	Memorandum of Understanding
MPAUT	:	Maharana Pratap University of Agriculture and Technology
MR	:	Moderately Resistant
MW	:	Molecular Weight
NA	:	Nutrient Agar
NAARM	:	National Academy of Agricultural Research and Management
NADRES	:	National Animal Disease Referral Expert System
NAIP	:	National Agricultural Innovation Project
NARC	:	Nepal Agricultural Research Council
NARD	:	National Agricultural Research Database
NARS	:	National Agricultural Research System
NBAGR	:	National Bureau of Animal Genetic Resources
NBAIM	:	National Bureau of Agriculturally Important Microorganisms
NBFGR	:	National Bureau of Fish Genetic Resources
NBPGR	:	National Bureau of Plant Genetic Resources
NCAP	:	National Centre for Agricultural Economics and Policy Planning
NDRI	:	National Dairy Research Institute
NET	:	National Eligibility Test
NGOs	:	Non-Government Organizations
NHCP	:	National Herbarium of Cultivated Plants
NIANP	:	National Institute of Animal Nutrition and Physiology
NIRJAFT	:	National Institute of Research on Jute and Allied Fibre Technology
NISAGENET	:	National Information System on Agricultural Education Network
NISM	:	National Information Sharing Mechanism
NRC	:	National Research Centre
NRCWA	:	National Research Centre for Women in Agriculture
NSKE	:	Neem Seed Kernel Extract
NTS	:	National Talent Scholarship
O&M	:	Organization and Management
OBCs	:	Other Backward Classes
OL	:	Other Languages
OMP	:	Outer Membrane Protein
OUAT	:	Orissa University of Agriculture and Technology
PAGE	:	Polyacrylamide Gel Electrophoresis
PAU	:	Punjab Agricultural University
PCR	:	Polymerase Chain Reaction
PCR-DGGE	:	Polymerase Chain Reaction Denaturing Gradient Gel Electrophoresis
PCT	:	Patent Cooperation Treaty
PD_ADMAS	:	Project Directorate on Animal Disease Monitoring and Surveillance
PE	:	Pan Evaporation
PG	:	Post-graduate
PPVFR	:	Protection of Plant Varieties and Farmers' Right
PSB	:	Phosphate Solubilizing Bacteria
PTO	:	Power Take Off
PVP	:	Polyvinyl Pyrrolidone
QTL	:	Quantitative Trait Loci
RAPD	:	Random Amplified Polymorphic DNA
RAU	:	Rajendra Agricultural University/ Rajasthan Agriculture University
RDF	:	Recommended Dose of Fertilizer
RDN	:	Rumen Degradable Nitrogen
RE	:	Revised Estimate
RFLP	:	Restricted Fragment Length Polymorphism
RH	:	Relative Humidity
RTV	:	Rice Tungro Virus
SAC	:	Space Application Centre
SAUs	:	State Agricultural Universities
SBI	:	Sugarcane Breeding Institute
SC	:	Scheduled Caste
SCC	:	Somatic Cell Count
SHGs	:	Self-help Groups
SLTL	:	Soil Loss Tolerance Limit
SNP	:	Single Nucleotide Polymorphism
SOC	:	Soil Organic Carbon
SRF	:	Senior Research Fellowship
SRI	:	System of Rice Intensification
SSD	:	Super Saturated Designs
SSNM	:	Site-specific Nutrient Management
SSP	:	Single Superphosphate
SSRs	:	Simple Sequence Repeats
ST	:	Scheduled Tribe
STMS	:	Sequence Tagged Micro Satellite
SVVU	:	Sri Venkateswara Veterinary University
TAI	:	Timed Artificial Insemination
TANUVAS	:	Tamil Nadu University of Veterinary and Animal Sciences
TCAI	:	Transcervical Artificial Insemination
TCP	:	Total Crude Protein
TDN	:	Total Digestible Nutrient
TLCV	:	Tomato Leaf Curl Virus
TNAU	:	Tamil Nadu Agricultural University
TSS	:	Total Soluble Solids/Sugars
TVCSC	:	Teaching Veterinary Clinical Service Complex
UAS	:	University of Agricultural Sciences
UG	:	Under-graduate
UGC	:	University Grants Commission
UNCTAD	:	United Nations Conference on Trade and Development
USLE	:	Universal Soil Loss Equation
UTM	:	Uterine Milk Protein
VAM	:	Vesicular-arbuscular Mycorrhiza
VPKAS	:	Vivekananda Parvatiya Krishi Anusandhan Sansthan
WBNV	:	Watermelon Bud Necrosis Virus
WP	:	Wettable Powder
ZECC	:	Zero Energy Cool Chamber
ZTMCs	:	Zonal Technology Management Centres

Index

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