1. Overview

The year 2006–07 augured well for Indian agriculture and the country recorded an all-time high production of foodgrains, sugarcane and cotton. The horticulture, livestock and fisheries sector also showed an impressive performance. The *kharif* production for 2007-08 is presently estimated to be 112.24 million tonnes.

The Planning Commission has approved a total plan outlay for the 11th Five-Year Plan of DARE/ ICAR at Rs 12,023 crore which is more than the double of the 10th Plan outlay of Rs 5,368 crore. The enhanced outlay would help boost institutional capacity, both in terms of human and infrastructural resources, to generate cutting-edge technologies.

The slowdown in the rate of growth in agriculture sector is a national concern and technological backstopping is an imperative to increase the velocity of agricultural growth. Recent initiatives have started paying dividends with agricultural growth of about 4 per cent. The Indian Council of Agricultural Research (ICAR) has documented *State-specific Technological Interventions* to address the location-specific technology dissemination which is being widely used.

The project on quality seed production in agricultural crops and fisheries has paid rich dividends, as the production of quality seed, saplings and fingerlings has more than doubled within a short span of an year of its launch. In the ongoing year, there is every indication that it would be further doubled in most of the cases. Virtually, this has triggered further growth.

Water for use in agriculture is rapidly becoming a critical limiting factor. Realizing the need to address this vital component of sustainable agriculture, a special corpus fund amounting to Rs 96 crore has been earmarked to impart training and conduct demonstrations for trainers and farmers in 32 institutions on water management. Climate change in the form of rising temperature, altered water cycles, melting of glaciers in the Himalayas, etc. now poses a threat to the sustainability of agriculture. A National Conference on climate change was organized to deliberate upon the probable scenario, and research strategies for adaptation and mitigation were drawn. Many of them are already put to implementation.

An annual financial support of Rs 388 crore was given to Agricultural Universities for modernization and strengthening of academic facilities and updating infrastructure and faculty improvement. This one-year support is more than the financial support provided in the entire IXth Five-Year Plan period. For strengthening the human resource development programme in the North-east region of the country, a new College of Post-graduate studies was established during the year at Barapani in Meghalaya and another on Post-harvest Management was made operational in Sikkim under the Central Agricultural University.

During the year, seven patents were granted, and 53 patent and 272 Plant Variety Protection applications were filed. An overview of the important activities, research achievements and new initiatives taken during the period under report is presented here.

Soil and water productivity

Soil resource maps were digitized and developed for Karnataka and Andhra Pradesh. A rapid biological field kit was developed to assess decomposability of farm-waste during composting. System of Rice Intensification was demonstrated for enhancing land, water and crop productivity and saving labour input. For reclamation of saline sodic soils, a horizontal flushing technique to reduce the gypsum requirement substantially has been proposed. Integrated farming systems combining agriculture, livestock, fisheries and

aquaculture, and a host of agri-enterprises with enhanced productivity, profitability and livelihoods were demonstrated. A highly remunerative cropping system involving plantation of drumstick with greengram-fennel was suggested in place of tobacco monocropping for the reclaimed Mahi ravines.

Genetic resources

Collection and conservation of plants, animal and fish genetic resources is one of the important activities for their improvement. A total of 22,003 cultivated and wild germplasm were collected from 21 states. About 25,000 accessions were characterized and evaluated, and over 16,800 plant genetic resources conserved in the National Gene Bank. Besides, salvaged 96.64% of the infected/ infested exotic accessions were processed for quarantine clearance. More than 365 exotic germplasm of *Gossypium hirsutum* could be acquired from the USA, China, Pakistan and Iran. Germplasm (49), possessing unique traits, were registered which included cereals, millets, pulses, oilseeds, fibre crops and forages, vegetables, tubers, ornamentals, medicinal and aromatic plants. In important fruit crops, 190 accessions enriched the genetic resources. More than 650 genotypes strains of different fruits grown in arid regions were collected. In vegetables 2,000 germplasm lines were also collected from different parts of country.

In case of freshwater and marine fish species, 1,200 tissue accessions and 550 DNA sequences were added to the NBFGR repository. DNA repository of sheep breeds Ganjam, Kendrapara, Deccani, Nellore, Nali, Magra, Chokla, Garole, Patanwari, Marwari, Kheri, Malpura, Muzaffarnagri, Jaisalmeri and Sonadi was established. The cDNA of uterine milk protein and genome sequence (>4 kb) of *ghrelin* gene of buffalo was cloned and characterized.

Nearly 3.2 lakh insects and mites were collected through field surveys in 27 states/union territories in 165 districts and over 2,500 cultures of isolated filamentous fungi, bacteria, actinomycetes and yeasts from soil, plants and insects were maintained in repository. Twenty different groups of *Bacillus* in Indo-Gangetic plains, based on 16S rDNA-RFLP analysis, could be identified.

Crop improvement

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

The significant achievements in crop improvement research include: development of marker-assisted selection based Improved Pusa Basmati 1, having all the qualities of basmati rice and also resistance to bacterial blight; Indira Sona (hybrid of rice) with good grain and cooking quality for irrigated condition of Chhattisgarh; maize cultivar Vivek 27 for Bihar, West Bengal, Orissa, Jharkhand, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu, and Vivek 25 for Himachal Pradesh, Uttarakhand, Jammu and Kashmir and North-eastern region; Guinea-grass JHGG 04-1 for semi-arid condition; CMS-based pigeonpea hybrid GTH 1 for Gujarat; sunflower hybrid (DRSH 1) for *rabi*-summer; soybean variety Pratap Soya 2 for all the north-eastern states and Karnataka, Tamil Nadu and parts of Maharashtra and TAMS 98-21 for Vidharbha region of Maharashtra; high-yielding white-seeded sesame variety TKG 306 for Madhya Pradesh; linseed varieties, Kartika and RLU 6 for Chhattisgarh and Rajasthan respectively; six sugarcane varieties having higher yield and better-quality characters for commercial cultivation; and mesta variety Madhuri for roselle-growing tract. Some of these are value-added varieties.

Thar Sevika ber with early maturity and high yield with excellent fruits; CISH-G 1, a red colour guava selection promising for long shelf-life; Goma Ashwarya, a prolific bearer aonla maturing earlier than NA 7; and MP/98-71 and Kufri Himsona processing potato suitable for French fries are the improved horticultural varieties/hybrids showing higher productivity.

Kashi Unnati and Kashi Kanchan, photo-insensitive cowpea varieties, highly tolerant to golden mosaic virus and *Pseudocercospora cruenta* disease are suitable for growing in both spring-summer and rainy seasons. Onion variety Bhima Raj is suitable for *kharif* seasons in Maharashtra, Karnataka, Gujarat and for *rabi* season in Rajasthan, Gujarat, Haryana and Delhi. Black pepper hybrids IISR Garmunda and IISR Malabar and turmeric varieties LAP Supreme and IISR Kedaram were released for commercial cultivation.

A new genetic linkage map of sorghum and quality trait loci (QTLs) for shoot fly and terminal drought resistance was developed. Cytoplasmic male sterlity (CMS) system was developed in safflower. Indigenously synthesized genes *Cry 1F* and Cry *1Aa3* could be transferred in *desi* cotton and American cotton varieties.

Identification of pomelo with thin rind and pink pulp; cloning of anti-microbial peptide gene and formation of transformants in Ney Poovan and Rasthali banana; transformation of tomato plants with *DREB-1* gene for tolerance to moisture stress; development of breeding line for bacterial resistance in pomegranate; revelation of a transgenic watermelon with complete resistance to WBNV; evolvement of heat-tolerant lines in tomato, capsicum, peas and French bean; and

identification of donor sources of resistance to leaf curl virus in chilli (GKC 29, BS 35 and EC 49763) are new research innovations.

Livestock improvement

Six pure lines of White Leghorn were improved through intra-population selection. In S-23 generation, fertility and hatching ability could be improved and remained above 95% in both the lines. The phenotypic response to egg production up to 64 weeks of age was 3.2 and 6.8 eggs/ generation in IWN and IWP, and the corresponding genetic response was 8.3 and 4.7 eggs/generation, respectively, over last 5 generations. Naked Neck and Dwarf were used for improvement of gene lines for utilization in tropical poultry production. Biotechnological interventions were used for faster multiplication of superior germplasm of buffalo.

Transferrin partial complementary DNAs were cloned from the liver of 5 species in 4 genera of Indian carps and a phylogenetic tree of amino acid sequences of transferring cDNAs from carps was also drawn. In rohu *(Labeo rohita)* early maturity and breeding was achieved and it will help improve the pond fish productivity. Riverine catfish, *Pangasius pangasius* could breed in captivity, thereby indicating possibility of its artificial propagation and mass-scale seed production.

Crop management

Annada, Naveen and IR 64 rice varieties and Rajlaxmi and KRH 2 hybrids were found suitable for direct-seeded aerobic condition in coastal Orissa. The increase in soil organic carbon was about 0.1% after two years with full residue incorporation of rice or both rice and wheat. In sugarcane ratoon crop paired row planting system significantly reduced the gaps, produced the highest number of millable canes and cane yield over conventional planting in sub-tropical region of the country. Four plant health clinics were established for knowledge support and demonstration of IPM strategies. Pest Management Information System (PMIS) was evolved for cotton, brinjal and okra and decision making software (Pesticide Advisor) with information on available pesticides was developed. Bumble bees was found good pollinators of crops in temperate conditions and the research on their artificial rearing is in progress.

Global positioning system and geographical information system based information on bird-roosting sites vis-à-vis proximity to preferred food and feeding activity of birds to demonstrate correlation with cropping patterns and preparation of wooden nest boxes that are readily acceptable for breeding common myna and spotted owlet, are some of the important findings.

A meadow orchard system was developed for guava, accommodating 5,000 plants/ha for high yield. Rice-potato-okra or rice-potato-jute or French bean was found most remunerative cropping sequence for potato. Varieties of tomato, peas, okra, muskmelon and bean were standardized for polyhouse cultivation. Raised-bed planting of onion with drip irrigation was developed. Neem oil along with *Trichoderma harzianum* and *Pseudomonas fluorescens* proved effective in managing the anthracrose and greenaria leaf spot in grape. Walnut selections propagated vegetatively were found promising for earliness and nut quality. A package was developed for management of oily leaf spot disease/bacteria leaf spot disease of pomegranate.

Development of leaf-borer management technology in litchi; mass multiplication technique for biogents *Paecilomyces lilacinus, Pseudomonas fluorescens* and *T. harzianum*; revelation of osmo-air drying technology for bitter gourd, cauliflower and okra; standardization of dehydration process for rose, chrysanthemum, gomphrena and helichrysum; and effectiveness of cauliflower leaf waste in reducing snail population in elephant-foot yam are the developed technologies suitable for commercialization.

More than 61,000 tonnes quality seed was produced including 5,291 tonnes breeder seed of centrally released varieties and 2,520 tonnes of state released varieties of cereal, forage, oilseed, pulse and fibre crops. In addition, 52,000 tonnes seed was produced in horticultural crops including medicinal and aromatic plants. About 22.5 million saplings of horticultural crops and 2,800 packets of mushroom spawn were prepared.

Livestock management

District-wise database on feed and animal resources was developed for six agro-ecosystems of the country, to plan for filling the gap between demand and supply of feed and fodder. Cost-effective, locally available, feed resources were utilized in formulation of complete feed block for yak. A low-cost animal feed mixer for mixing heterogenous feed ingredients was designed and developed. Rapid and sensitive techniques were developed for assessing the Imidacloprid residue in water and soil samples to estimate the pollution in fodder farms that may harm the animals. In buffaloes, supplementation of bypass protein rich in limiting amino acids (lysine and methiomine) improved their milk production. Digestibility of nutrients and performance of birds improved after supplementation of deoiled rice bran-based diets with xylanase. Transcervical artificial insemination technique using frozen-thawed semen was

standardized in sheep for effective artificial insemination. As the semen collection is very difficult in mithuns, its effective method was standardized. Cumulative toxicity due to high concentration of cadmium caused infertility in buffaloes. An indigenous medicine, M-cure, was developed and evaluated for treatment of skin disease (sarcopticosis) in camel. A safe inactivated pentavalent vaccine was developed against bluetongue in sheep, and its has passed the safety test.

The total marine fish catch registered an increase of about 4.1 lakh tonnes compared to the previous year. Shrimp, produced using organic inputs, maintained a higher growth rate and health status than other shrimp. Culture practice was developed for the banana shrimp, *Fenneropenaeus merguiensis*, which has high potential as an alternative to tiger shrimp during winter in Gujarat.

Post-harvest management and value-addition

In a significant development, nanotechnology using nanoparticles of zinc oxide and silver oxide for coating has been successfully used to impart anti-microbial treatment to paper and fabric. This will help in retaining the quality of printed paper for a longer period and also in the manufacture of medical and healthcare textiles. New avenues for the development of smart textiles, have been opened. In another development, organically grown cotton has been processed to obtain "green" towels. Jute-synthetic fibre blends have been successfully prepared for diverse applications such as apparel and geo-textiles. Water- and termite-resistant jute-fibre glass reinforced shellac sheets have been developed for partition walls and window panels.

Community-level evaporatively cooled storage (ECS) structures could be an important link in the cool chain development for horticultural produce. The ECS structure enhanced the shelf-life of potato, knnnow and tomato significantly.

A low-cost technology for preparing extruded products from sorghum and legumes has been developed. Several value-added products from horticultural, livestock and fishery produce have been developed. These include jelly, leather, powder and toffee from aonla, Srikand from jackfruit, coated trout fillets, curried products from freshwater fish, canned trout, prawn soup powder, smoked fish, tuna *biryani*, and ready-to-serve mahaseer curry.

Technologies for long shelf-life of paneer, gulab-jamun mix and palada paysam mix were transferred to industry. A simple and rapid test was developed for detection of adulteration of ghee with vegetable oils and fats. Efforts have been made to develop rapid diagnostic kits to test for adulteration in ghee and milk; and probiotic yogurt has been developed as a functional food.

Agricultural engineering and energy management

The notable developments are zero-till drill with rotary slit opener, 7-row seed-cum-fertilizer attachment for rotavator, multipurpose implement for sugarcane, inclined plate planter with raised bed forming attachment for intercrop, turmeric harvester, banana shredder and banana clump remover as tractor-operated machineries. A self-propelled fodder harvester has been developed. Other implements and machineries developed are: barrow-type seed-cum-fertilizer spreader, single/two-row inclined plate planter for cotton, power-tiller-operated earthing-cum-fertilizer applicator for sugarcane, bullock-drawn sprayer for soybean, power-operated maize dehusker-cum-sheller, multiplier onion peeler, curry leaf stripper and tree climber. Sugarcane harvesting knife has been ergonomically designed for better performance. A feeding attachment for power-operated chaff cutter has been designed and tested to minimize accidents.

To facilitate the partial removal of water from the digested slurry from biogas plants, a rotating cylinder-type machine has been developed and demonstrated. Durable improved biomass cook stoves for agro-industrial and community applications were fabricated and demonstrated. A solar concentrator has been developed, which improved the performance of solar photovoltaic power-generation system.

Agricultural human resource development

Twenty-eight Niche Areas of Excellence were supported in different agricultural universities for building excellence in specific strategic areas in education and research. More than 180 Experiential Learning Units have been established in 43 Universities for providing skill-oriented hands-on training to the students.

A total of 1,332 students were admitted on UG Programmes in 45 Universities and 1,552 candidates in PG programmes in 51 Universities through Common Entrance Tests. Junior Research Fellowship was provided to 470 students in agricultural universities. National Talent Scholarship was given to over 1,000 students who got the admission in UG programmes. Scholarships and fellowships were also provided to meritorious and economically handicapped students.

The NAARM, Hyderabad, conducted 62 need-based programmes that benefited capacity building of 1,547 participants in different areas. Competence and research capability of 448 faculty members

was improved through Centres of Advanced Studies by organizing 68 trainings. Additional 400 scientists were trained in emerging subjects areas through 91 summer/winter schools.

Fourteen agricultural universities have been accredited for enhancing quality and relevance of education. A National Core Group, appointed by the ICAR, has initiated the revision of Post-graduate and Doctoral course curricula and syllabi. Under Indo-US Knowledge Initiative, 13 Borlaug Fellows were selected to get trained in the USA.

Information, communication technology and publicity services

Information, communication technology and publicity services have been reorganized under the Directorate of Information and Publications of Agriculture for better delivery system and marketing the technologies/products developed by the ICAR. New initiatives were started for transformation of information services by launching the scrolling on-line news, digitization of printed literature, single window of *ICAR News* by combining English, Hindi and ARIS News for various stakeholders.

Information services were brought under single umbrella and process is on to introduce/provide on-line library services in computerized mode. Initiatives have also been put in place to upscale internet connectivity by increasing bandwidth, dedicated lines and reduction in subscription charges. Video conferencing and IP Telephony has been started. The ICAR participated in 10 national and international exhibitions. Some of the regular publications are available in a public domain on ICAR Webpage (www.icar.org.in).

Technology assessment, refinement and transfer

A total of 1,058 technologies in various crops, livestock and fisheries were taken up for on-farm trials with its network of 558 Krishi Vigyan Kendras. The Krishi Vigyan Kendras conducted 18,306 demonstrations on oilseeds spread over 6,284 ha, and 13,042 demonstrations on pulses in 4,286 ha, showing 34.8 and 37.6% more yield than farmers' practice respectively. Besides, 6,206 demonstrations were conducted on cotton, covering an area of 4,281 ha, benefiting 2,495 and 2,450 farmers directly from demonstrations on production technology and farm implements, respectively, in 1,012 and 2,344 ha. The KVK also conducted 31,248 demonstrations, covering 10,149 ha on other crops, besides 2,838 on dairy, piggery, rabbit rearing, sheep, goat etc.

A total 39,912 training programmes were organized on various technologies, benefiting 10.94 lakh farmers and farmwomen. Skill-oriented trainings were imparted in different areas of agriculture, benefiting 1.52 lakh rural youth. More than 3,370 training programmes were organized for 80,416 extension personnel to upgrade their knowledge and skills in frontier areas of agriculture technology. Besides, 5,265 sponsored training programmes were conducted for 1.52 lakh participants from government and non-government organizations. Seed/planting material—111,164 q seed (value Rs 84,852,506) of cereals, oilseeds, pulses, and vegetables; 91.29 lakh saplings/seedlings of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species; 8.94 lakh kg bio-products; 40.08 lakh fingerlings and other livestock/poultry strains were produced for availability to farmers. And 1.11 lakh samples of soil, water, plants, and manures were analysed during the year.

National Agricultural Innovation Project (NAIP)

The Council had launched NAIP in 2006 with an overall objective to facilitate the accelerated and sustainable transformation of Indian agriculture in support of poverty alleviation and income generation through collaborative development, and application of agricultural innovations by the public organizations in partnership with farmers' groups, the private sector and other stakeholders. The research funding is made on competitive basis. In the competitive grant scheme 992 Concept Notes were submitted for funding under NAIP components on production to consumption system research, sustainable livelihood security and basic and strategic research in agriculture. And 37 were recommended for full proposal development and 17 have been approved. Second call for competitive projects under NAIP has been made, and review of the Concept Notes by expert committees is in progress.

Twenty-one projects have been approved under National Fund for Basic Strategic Research (NFBSR) of the ICAR and 14 are in implementation. These projects are multi-institutional, multidisciplinary, diverse, novel and in advanced areas of molecular and genetic bases of crop plants, responses to biotic and abiotic stresses, physiology, rumen microbial manipulation to enhance feed efficiency in cattle, hybrid development in plant, etc. These projects are expected to generate new knowledge and solve outstanding scientific problems, and will also be directly applicable in the near future for technology development to tackle challenges in agriculture.

Organization and management

Perspective Plan-Vision 2025 documents of 94 ICAR Institutes have been published. Fifteen

Research Institutes/Centres of the ICAR have been notified in the Gazzette of the Government of India, raising total number of notified Institutions to 104 under rule 10 (4) of the Official Language Rule 1976. The Budget Estimate (BE) and Revised Estimate (RE) of the DARE and ICAR (Plan, Non-Plan) for 2006-07 were Rs 2,160 crore and Rs 2,276 crore, respectively, and BE for 2007-08 (Plan and Non-Plan) is Rs 2,460 crore. In recognition and to encourage professional excellence, the ICAR gave 54 awards under 12 different categories to honour institutions, scientists and their associates, farmers and journalist. Besides, *Rajbhasha* Award was also given.

Partnership and linkages

An MoU was signed between the ICAR, and College of Agriculture and Life Sciences, Cornell University, USA. Work Plans were also signed with University of Western Australia, Australia and the Ministry of Agriculture and Food Industry, Socialist Republic of Vietnam. Two projects, viz. Atmospheric Brown Cloud, and Multi-trophic Interactions in the Rhizosphere and Management of Nematode Pests and Diseases, were approved for implementation. India–US Joint Workshop on 'Curriculum Development' under the Agricultural Knowledge Initiative (AKI) was organized at New Delhi.

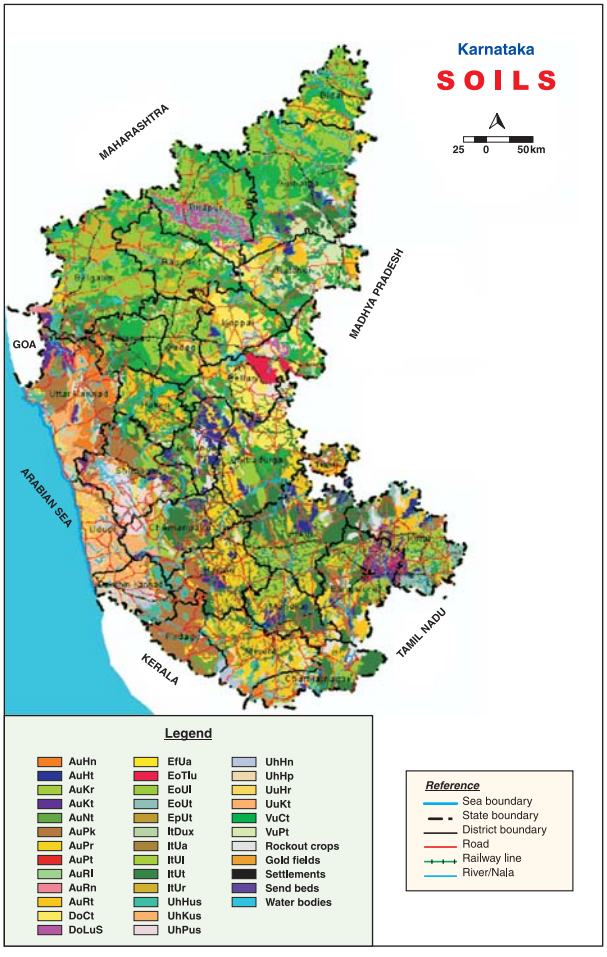
The XI Plan envisages an inclusive agricultural growth where key elements could be enhancement of resource-use efficiency, farm productivity and profitability. Keeping this in view, our priority areas would be eco-region specific technology generation and extension in continuation; systems perspective in research and education; enhancement of water productivity and nutrient-use efficiency; climate change and management of stresses; land-use systems for multi-functional agriculture; diagnostics, vaccines and delivery systems; value-added product development, food safety and quality assurance; biosensors, biofuels, biomolecules, biofortification, biosafety, biosecurity, bioremediation, and biofertlization; IT-based decision support systems for technology transfer; human resource development in niche areas; and enabling mechanisms for enhancing R&D productivity. This calls for significant new initiatives in research and development and enhanced investments for technology generation relevant to different regions/situations. In the national efforts to accelerate much-needed growth in farming sector, as in the past, the Council would continue to remain a committed partner.

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

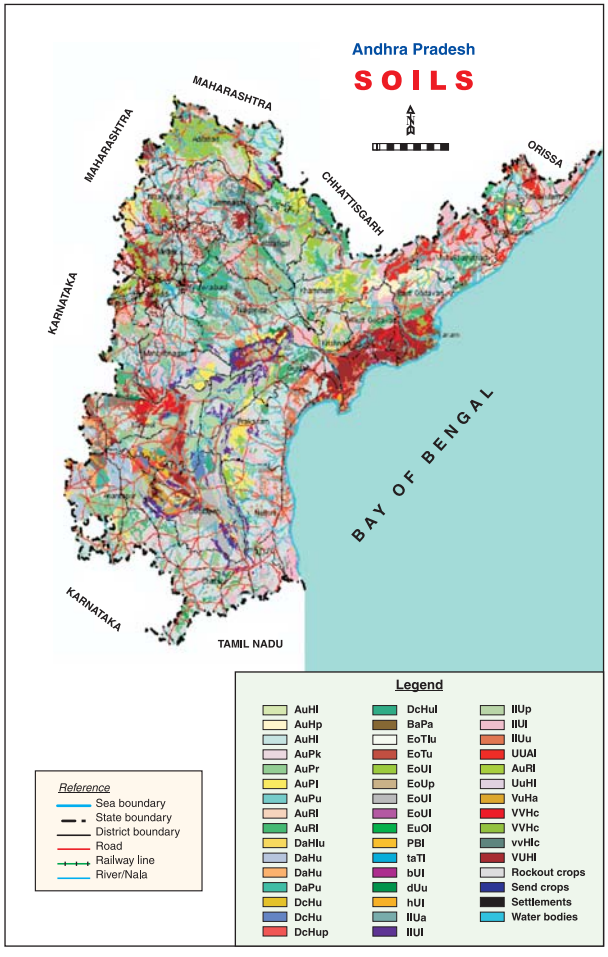
2. Soil and Water Productivity

Soil resource inventory

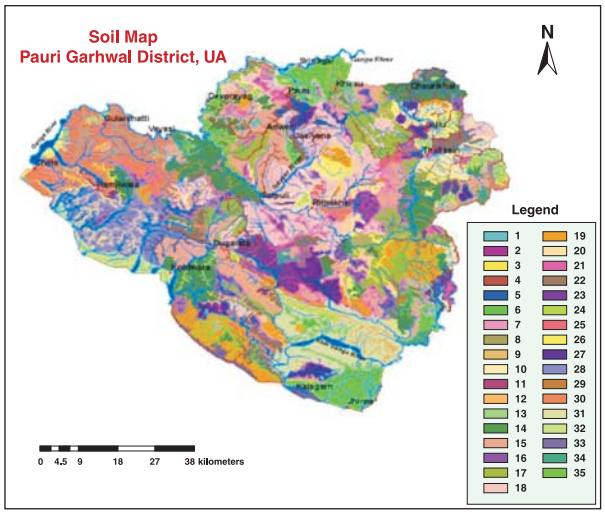
Digitization of soil database: Soil information of the states on 1 : 500,000 was digitized on toposheet basis (1 : 250,000 scale) to create parity in soil resource database. The toposheets were scanned, geo-referenced and edge-matched in ArcInfo GIS software. The soil boundaries and associated layers were digitized in shape format to build topology. The values of soil parameters were assigned to the soil polygons. The databases on site and physical and chemical parameters were created in MS-Access. From the soil coverage and attribute database, thematic maps for Karnataka and Andhra Pradesh states were generated in ArcMap and SPANS/Agroma GIS softwares respectively.



Digitized soil map of Karnataka



Digitized soil map of Andhra Pradesh



Digitized soil map of Pauri Garhwal district of Uttarakhand for perspective land-use planning

Similarly, soil map of Pauri Garhwal district (1: 50,000 scale) of Uttarakhand containing 25 soil series and 35 soil mapping units has been digitized for perspective land-use planning. The database would be used for generation of thematic maps like slope, erosion, surface texture, stoniness, soil reaction, organic carbon status, soil depth and textural class etc.

Block level land resource inventory and GIS database for farm planning: Soil survey and mapping in all the 48 villages of Sivaganga block, Tamil Nadu, revealed existence of about 18 soil series. About 62% of the area is moderately good (Class III lands) for cultivation. Good (Class II), fairly good (Class IV) and lands unfit for cultivation occur in a limited area. About 60% of the area has severe limitations for irrigation due to factors such as soil, drainage and to some extent topography. The land resources are moderately suitable for cultivation of cereal, oilseed, pulse and tree crops.

Assessment of ravinous land in Bundi district: Detailed physiographic distribution of different landforms was delineated for Bundi district of eastern Rajasthan from satellite data of IRS–ID of 2003 on 1: 50,000 scale. Variability in soils was mapped through geo-statistical model in GIS environment and extent, and distribution of ravine land in the district were estimated. In eastern Rajasthan upland, severely eroded ravinous land is 27,770 ha (5.4%) and in Vindhyan landform ravinous land constitutes 69,017 ha (13.3%). Ravines are predominantly occurring in Indergarh, Keshoraipatan, Bundi and Nenwa tehsils.

In 1972, the ravinous land in Bundi district was assessed as 86,000 ha (16.6%). Thus with a span of 30 years, there has been increase in ravine land by 11,000 ha to 97,000 ha which constitutes 18.7% area of the district.

Crop diversification to improve productivity and profitability of reclaimed ravines – Vasad (Gujarat): Plantation of drumstick as pure block plantation with greengram–fennel intercropping was found more remunerative than the prevalent tobacco monocropping system in reclaimed Mahi ravines. The highest net returns of Rs 36,260/ha was obtained from pure drumstick and Rs 27,758/ ha from greengram–fennel compared to Rs 9,518/ ha from tobacco. Crop diversification also reduced irrigation water requirement by 70–75% in the region. Productivity of these marginal rainfed ravine lands can also be enhanced by cultivating improved sorghum (SSG 59-3) with either sub-soiler or contour furrow land treatment.

Drumstick plantation as pure block with greengram-fennel intercropping is more beneficial than tobacco monocropping in reclaimed Mahi ravines

Evaluating land management practices in watershed: Five watersheds were selected in Agro-ecological sub-region 7.2 in Telangana region of Andhra Pradesh, to assess the impact of land management practices in watersheds. The average yields of crops were substantially higher in treated micro-watershed (3.62 tonnes/ha) than untreated micro-watershed (1.72 tonnes/ha). Average net income accrued by farmers in the treated micro-watershed was Rs 13.19/caput/day with a maximum of Rs 44.35/caput/day. In the untreated micro-watershed, average net income was Rs 4.31/caput/ day with a maximum of Rs 13.34/caput/day.

Soil fertility and nutrient management

Soil carbon stock (SOC): The soils of the hot region contain less organic carbon due to unfavourable climatic conditions. The total mass of organic carbon stored in the upper 30 cm and 150 cm of the soils in India is 9.5 and 29.5 Pg respectively. The SOC stock of Indian soils is 10–12% of the tropical regions and about 3% of the total carbon mass of the world. Thus, the

share of India in overall SOC stock of the world is not substantial, although it covers 11.9% of the total geographical area of the world.

Methodology for preparing district soil fertility maps using GIS and GPS tools: The digital soil fertility map with tehsil boundaries of Hoshangabad district on the scale 1: 50,000 was prepared by digitization and mosaicing (merging of digitized boundary) of toposheets. Geo-referenced soil samples were collected and assigned the point values of N, P and K based on laboratory analyses.

Site-specific nutrient management (SSNM) in rice–wheat cropping system: The SSNM experiments with rice–wheat system were conducted at 10 locations under All-India Co-ordinated Research Project on Cropping Systems. Both crops received recommended doses of N, P and K while rice received S and micronutrients in addition. The average annual grain yields under SSNM were 15-17 tonnes/ha compared to 13.3 tonnes/ha under farmers' practices.

Balanced fertilization in cotton: Balanced fertilization for cotton comprising N, P, K + Zn + B as foliar spray twice resulted in 13 to 41% more yield over farmers' practice under on-farm demonstration in Balwada village of Khargoan district, Madhya Pradesh.

A field kit method for assessing decomposability of farm-waste during composting: A new rapid biological method has been developed to assess decomposability of farm-waste during composting. Method is based on conversion of 2, 3, 5-tetrazoliumchloride to triphenyl formazan by micro-organisms growing on farm-waste. Growth of micro-organisms is rapid on easily decomposable farm-waste leading to higher conversion of 2, 3, 5-tetrazoliumchloride to triphenyl formazan, imparting residues dark red colour. The intensity of the red colour and the time taken for its development indicate compostability. Decomposability of 11 farm-wastes was assessed using this method and these were classified into 3 categories as easily decomposable, moderately decomposable and slowly decomposable.

Screening for micro-organisms tolerant to salt and temperature: Out of the total 55 strains collected, 10 *Bacillus* and 12 *Pseudomonas* strains were evaluated for thermo- and osmo-tolerance. *Pseudomonas* strains P1, P4, P6 and P7 could grow up to 7% NaCl (1.2 M) and temperatures up to 50°C, while *Bacillus* strain B2 could grow up to 11% NaCl (2 M) and strains B4, B6 and B7 up to 50°C.

Water management

Assessment of water utilization in lift irrigation schemes (LIS): Two schemes, namely 'Amarachinta' in Mahabubnagar and 'Kanuparthy' in Prakasam district of Andhra Pradesh were selected for evaluation having command area of 1,943 ha and 1,984 ha respectively. The depth of water-table in Amarachinta LIS rose from 13.30 to 9.78 m below ground level during pre-monsoon and 8.55 to 5.01 m during post-monsoon over a span of just 5 years, indicating chances of waterlogging and salinity in near future. An increase in command area from 1,182 to 1,567 ha as well as per cent water utilization (50 to 81) was noticed with transfer of management of LIS from state authority to water user's society. In case of Amarachinta LIS, the field water-use efficiency was found to be 3.85 and 5.11 kg/ha-mm during monsoon and post-monsoon season, respectively, whereas the crop water-use efficiency was found to be 12.48 and 9.40 kg/ha-mm for monsoon and post-monsoon season respectively. On the other hand in case of Kanuparthy LIS, these values

Predicting changes in SOC stock due to climate change

The SOC stocks for the year 2020, 2050 and 2080 were predicted for different locations of India. The data on SOC stock (Mg/ha) of 1980 was considered as the base year. The maximum increase in organic stock predicted to be in eastern Maharashtra and parts of Chhattisgarh containing Agro-ecological Region No.10, 11 and 12 preferably due to increase in predicted rainfall.

The maximum decrease in SOC stock is predicted for southern Kerala and southern Tamil Nadu containing Agro-ecological region No. 8, 18 and 19. The soils of these Regions have comparatively high SOC stock and the decrease in SOC can perhaps be because of rise in temperature.

Rainfall-runoff-groundwater dynamics in semi-arid region–A case study

The study was taken up in Kurmapally watershed with an area 107 km² falling in Nalgonda and Mahabubnagar districts of semi-arid region in Andhra Pradesh. The topography is undulating and is underlined by crystalline rocks. Its average annual rainfall is 575 mm and is erratic both temporally and spatially.

Seasonal variability (estimated for 4 years from 2003-07) between the availability and utilization pattern in the watershed indicated higher groundwater utilization compared to the groundwater recharge potential resulting in more withdrawal from deeper aquifers. The potential recharge is almost equivalent to utilization only in one (2005–2006) out of 4 years of study period that received rainfall of 1,141 mm. This calls for attention of farmers and decision makers for judicious use of available groundwater for sustainability and discouragement of water loving crops.

Adoption of tank-cum-well system increased the cropping intensity within 4 years in a tribal village of Keonjhar district of Orissa. A tank with rice in its command (*left*); an open well with rice in its command (*right*)

were found comparatively low (field water-use efficiency 1.86 and 2.43 kg/ha-mm and crop water-use efficiency 14.8 kg/ha-mm).

System of rice intensification—an alternative for enhancing land and water productivity: The System of Rice Intensification (SRI) has received considerable attention globally, particularly owing to its potential for yield improvement and water saving. In Bhubaneshwar area, SRI with spacing of 20 cm × 20 cm gave highest grain yield up to 6 tonnes/ha which was 36–49% higher than conventional transplanted crop.

In SRI, only 1,571 litres water was required to produce 1 kg seed, but with conventional method 2,801 litres water was needed for 1 kg seed production. The SRI method also showed reduction in labour inputs by 14% than the conventional transplanting method for various cultural practices.

Rainwater harvesting to increase cropping intensity: A tank-cum-well system was developed for micro-level water harvesting in the plateau region of eastern India in a tribal village of Keonjhar district of Orissa. Through this technology tanks and wells were constructed in a series along the drainage line of a watershed to harvest rainwater in high rainfall areas. The adoption of technology resulted in increase in cropping intensity by 100-180% within 4 years of intervention. Due to the intervention, farmers shifted from direct sown rice to transplanted rice. Availability of irrigation water, application of fertilizer and use of high-yielding varieties resulted in increase in crop productivity from 1.2 to 3.1 tonnes/ha. The total investment on tank-cum-well system (Rs 25,000–30,000) can be recovered within 3–4 years. The technology is suitable for plateau areas with slope of 2 to 5%.

Effective utilization of gypsum for reclamation of sodic soils with high salts: The recommended practice of addition of gypsum @ 50% gypsum requirement followed by vertical leaching is not suited to heavy textured (silt + clay > 60%) sodic soils, especially those containing high levels of soluble sodium carbonate. Field studies showed that two horizontal flushings to remove soluble salts, each followed by addition of gypsum @ 25% gypsum requirement could considerably enhance the effectiveness of applied gypsum and thus can be recommended for reclamation of saline sodic soils with high concentration of soluble salts (EC > 15 dS/m).

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3. Farming Systems

Integrated farming systems

Integrated farming systems for marginal and small farmers: An integrated farming system (IFS) model for marginal and small farmers of western Uttar Pradesh was developed for an average farm family of 7 members. The IFS model, besides producing all the required domestic food and feed items including cereals, pulses, oilseeds, vegetables, fruits, meat and milk etc. for daily consumption, also produced green and dry fodders for their animals in sufficient quantities and generated an additional revenue of Rs 130,622/year to meet the other liabilities. The system besides being profitable in term of net return of Rs 75,211/ha/year, also generated 347 additional man-days as compared to crops alone (182 man-days/year), offering increased employment opportunities to the rural youth. Not only this, all the farm-wastes, crop residues, animal urine and dung etc. were properly collected, composted and recycled in production process of different enterprises, viz preparation of vermicompost (3.2 tonnes FYM), fish meal and fruits and crop production etc.

Rainwater harvesting and multiple water use: A rainwater harvesting tank was constructed on the mid-land of the plateau region lined by LDPE film. Multi-tier horticulture system comprising litchi as main crop, guava as filler crop was planted in the command area with vegetables (including pea, French bean, cucumber and tomato) on about 1,000 m^2 area as per water availability. With the supplementary irrigation from the harvested rainwater, rice and cowpea were sown in an area of 1,210 m^2 and 456 m^2 respectively. On bunds, bottle gourd, pointed gourd, and maize cobs were grown. In all, the total income from vegetables, rice and fish was Rs 18,690 in the very first year.

Multiple-enterprise agriculture for livelihood security in reclaimed sodic lands: The traditional rice–wheat cropping system gives income to farmers only twice at the harvest time, though regular income is needed throughout the year. A multi-enterprise farming system model is being developed to increase water productivity, farmers' income and year-round employment generation relevant for small land-holding farmers. The model involves components of crops, fisheries, animal husbandry, horticulture, vegetables, bee keeping, *gobar* gas plant, solar heating system etc. for a 2 ha reclaimed sodic soils area. The initial first year

Multiple uses of harvested rainwater in Jharkhand

Multiple enterprise agriculture-based integrated farming system

results indicated that rice–wheat rotation provides an annual return of Rs 39,400/ha, vegetable (bottle gourd–cauliflower)-based crop rotation Rs 80,000/ha, and the forage-based crop rotations like maize– maize–berseem and sorghum–berseem/ oat Rs 59,000 and Rs 40,000/ha respectively. About Rs 35,000 were earned in 3 months through the sale of milk from 4 buffaloes. The vegetables cultivated on the dikes of fish pond are generating weekly income of Rs 200–300. Sale of fish from 0.2 ha fish pond generated a revenue of Rs 15,000. The cowdung was utilized in the *gobar* gas plant to generate cooking gas to meet energy requirement of 6–8 people. After generating energy, the cow-dung slurry was poured into fishpond as fish feed.

Enhancing productivity of waterlogged area through optimizing micro-water resources design and integrated farming system: Micro-level water resources design was optimized in waterlogged area using water balance simulation model. The design dimension of on-farm ponds were decided from field level water balance. As a part of reclamation, an integrated farming system was developed with integration of bio-drainage and cultivation of water-loving co-existing crops.

The waterlogged wasteland was converted into alternate elevated platforms on which bio-drainage vegetation of *Acacia* and *Casuarina* was planted at 2 m × 2 m spacing with an objective to lower the rising water-table. In the 2nd year of planting the water-table was below 2.75 m under bio-drainage vegetation, while in other experimental plots it was within 0.75 m during summer. Intercrops like pineapple, arrowroot, turmeric have also been successfully raised inside bio-drainage vegetation.

Crop diversification

Alternate cropping systems to rice–wheat system for different agro-climatic zones of northern India

- In mid-high altitude intermediate zone of Jammu and Kashmir a system involving rice–potato–wheat was found to be more efficient in terms of production (13.9 tonnes/ha/year), giving about 51% higher yield than the existing rice–wheat system. But in economic terms, rice–wheat–sorghum+cowpea (fodder) was better than other systems and gave highest profitability of Rs 121/ha/day, resulting in relative gain of 38% higher over the existing rice–wheat system.
- In terms of wheat-equivalent yields, rice–potato–sunflower (18.30 tonnes/ha/annum) and rice–potato–wheat (15.50 tonnes/ha/annum) and sugarcane–ratoon–wheat (14.40 tonnes/ha/annum) have emerged as potential alternatives to existing rice–wheat system (9.00 tonnes/ha) under north-western plain region.
- In central plain zone of Punjab, system involving rice–potato–groundnut was identified to be more productive with highest productivity of 54.5 kg grain/ha/day and profitability of Rs 96/ha/day. This system was more productive with relative production efficiency of 82% and relative economic efficiency of 191% than rice–wheat system.
- In *bhabar* and *tarai* zone of Uttarakhand, rice–vegetable pea–rice system was more productive (14.0 tonnes/ha/year) with highest productivity (38.4 kg rice- equivalent yield/ ha/day) and profitability of Rs 112/ha/day.
- In central plain zone of Uttar Pradesh, maize–potato–wheat was more productive (15.8 tonnes/ha/year) with highest productivity of 43.2 kg grain/ha/day. But, in terms of economics, maize–pea–sunflower was found to be more economical which gave highest profitability of Rs 78/ha/day. It was 114% higher than the existing rice–wheat system.
- In Vindhayan plain zone of Uttar Pradesh, rice–potato–greengram system was more productive (14.3 tonnes/ha/year) with highest productivity (39.2 kg grain/ha/day) and profitability (Rs 58.2/ha/day). This system was superior to the tune of 69% in terms of relative production efficiency and 80% in terms of relative economic efficiency compared to the existing rice–wheat system.
- In south alluvial zone of Bihar, rice–potato–onion was found better with highest system yield of 18.1 tonnes/ha/year in terms of rice-equivalent yield, productivity of 49.7 kg/ day/year and relative production efficiency of 135% compared to existing rice–wheat system. But in terms of economics, rice–berseem–maize+cowpea (fodder) system was more remunerative which gave highest net return of Rs 45,624/ha/year, profitability of Rs 125/ha/day and relative economic efficiency of Rs 224% compared to existing rice–wheat system.
- In plain zone of Chhattisgarh, rice–tomato system was superior to existing rice–wheat system which gave highest yield (15.2 tonnes/ ha/year) with productivity of 41.6 kg/ha/day and profitability of Rs 168/ha/day.
- In Keymore plateau and Satpura hill zone of Madhya Pradesh, system involving black-gram–potato+wheat was better for production (11.8 tonnes/ha/year) and productivity (32.3 kg rice grain-equivalent/ha/day).
- In Vindhyan plateau zone of Madhya Pradesh, soybean–wheat system was found better in terms of rice-equivalent yield (7.1 tonnes/ ha/year), productivity (19.6 kg grain/ha/day) and profitability (Rs 62/ha/day).

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4. Genetic Resources

CROPS

Germplasm augmentation, conservation and use: Explored and collected 2,203 cultivated and wild germplasm from 21 states of the country, and added 1,021 specimens (herbaria, seeds and other economic products) to the National Herbarium of Cultivated Plants at the NBPGR, New Delhi. Germplasm conserved for long-term has increased in the National Gene Bank; ***orthodox seed samples***- 16,299 accessions, ***non-orthodox cryopreserved samples*** - 455, and ***in-vitro tissue cultures*** - 57. Germplasm exchange included import of international nursery trial entries and transgenics. Promising germplasm introductions include rust and powdery mildew resistant *Triticum aestivum* (EC 592591) from China; anthracnose and bacterial wilt resistant *Cicer arietinum* (EC 589469), and *Lycopersicon esculentum* (EC 589472-84) with multiple resistance from Taiwan; lodging resistant upright bushy type *Phaseolus vulgaris* (EC 589468) with mid-season maturity, resistance to viruses and tolerance to rust; powdery mildew resistant *Cucumis melo* (EC 589374), and high-yielding *Perilla frutescens* (EC 592842-59) with high-oil content from the USA. Introduced transgenics include drought-tolerant *Gossypium* (EC 589424-27), containing *rolB* gene of *Agrobacterium rhizogenes*, and glyphosate herbicide and lepidopteran pest infestation tolerant cotton from China and the USA (EC 589428-34), containing *CP4 EPSPS*, *cry 1 Ac* and *cry 2 Ab* genes. Characterized and evaluated 25,181 germplasm accessions that are maintained at the NBPGR. Conducted 190 experiments including germplasm evaluation (63), breeding trials (87), agronomic (32) and quality traits (8) in different agroclimatic zones. Supplied 49,184 germplasm samples for research use and crop improvement in the country.

Maize accessions collected from Nagaland

A total of 29 germplasm accessions of mango were collected, added to the field gene bank and maintained. In clonal selection, a total of seven clones, viz. two of Alphonso and five of Bangalora, were collected. Among the collections, Dudhiya Malda gave the highest yield followed by Dholikothi Maldah. The maximum fruit yield (125.75 kg/tree) was obtained from Bangalore Goa followed by Zafrani Gola. The evaluation of seedling germplasm revealed that the maximum number of fruits and yield were recorded in Peddapur 16. Collection No.7/80 was the highest yielder followed by collection No. 10/80. Clone Rati Banganpalli was found promising for cluster-bearing habit; Early Baneshan for early maturity; Pedda Baneshan and Allahabad Baneshan for bigger sized fruits. Bangalora clones Salem and Javori, recorded bigger sized fruits weighing 300–500 g and export quality. Mallika recorded maximum fruit yield, average fruit weight, high TSS, and low acidity. In guava, morphological characterization was carried out for 12 genotypes following IPGRI now descriptors. Out of 18 accessions tested, 10 were able to withstand salinity up to 6.0 dS/m with minimum damage to plant growth. In

Monitoring Global Plan of Action (GPA)

The FAO-funded Project *Establishment of Information Sharing Mechanisms for Monitoring the Implementation of GPA* has yielded two publications, including Indian experience of National Information Sharing Mechanisms (NISM). This experience of a large and elaborate National Agricultural Research System (NARS) has set exemplary tone for developing NISM by other countries.

banana, eight accessions were added in field gene bank. RAPD analysis corroborated genetic variability discovered by isozyme analysis between *Fusarium* wilt resistant Silk banana cultivar and Martman and other susceptible members of the group. Manjeri Nendran-II banana continued to be superior for yield and tolerance to Sigatoka leaf spot. Among the already identified Kanthali clones at Mohanpur, clone-I and clone-II have been observed to be more potential.

The citrus genetic resources are being maintained and evaluated for a set of descriptors at different centres. A total of 19 accessions were added to citrus germplasam collection. Acid lime selections, viz. RHR-L 122 and RHR-L 124, confirmed their superiority for yield, summer cropping and tolerance to canker. Kagzi lime clone, PDKV lime, was found promising for yield and has been released. Mandarin orange selection 5 outyielded at Akola, while Khasi mandarin selection CRS 4 consistently recorded high yield at Tinsukia. In litchi, 52 accessions were maintained in the field gene bank. Longan (*Dimocarpus longan*), a related species of litchi, maturing in August, was found to be promising. In sapota, seven accessions were added to the germplasm collection. In pomegranate, 119 germplasm accessions were collected. Four accessions of jackfruit were added to the genetic resources. The jackfruit accession NJ 1 was found superior for growth parameters.

In arid zone fruits, a total of 311 genotypes/ strains of *Ziziphus*, 154 of pomegranate, 48 of date palm, 50 of aonla, 18 of bael, 65 of *Cordia*, 9 of *khejri* and 2 of mulberry collected from different parts of the country were maintained in the national germplasm repository. At Godhra, 1,882 germplasm/strains of different arid fruits and vegetable crops were maintained.

In vegetable crops, a total of 6,000 germplasm accessions have been maintained. This includes 1,200 in tomato, 600 in brinjal, 307 in chilli and sweet pepper, 760 in okra, 95 in cauliflower, 425 in pea, 181 in cowpea, 115 in dolichos, 275 in French bean and 2,042 in cucurbits. During the reported period, 2,000 germplasm lines in different vegetables were collected. The promising lines identified for different traits were F7028 for high lycopene, F6061 for high carotenoid, H 88-78-4 for resistance to TyLCV in tomato; SA 90 for high carotenoid in pumpkin; VR 315 for resistance to YVMV in okra and BS 35 for resistance to leaf curl virus in chilli. A total of 4,350 accessions of different tuber crops have been collected and being maintained.

Plant quarantine: Out of 30,739 exotic germplasm processed for quarantine clearance, 17.71% were found infested/infected with insects and mites, nematodes, fungi, bacteria or viruses; 96.64% of the infected/infested accessions have been salvaged. Important interceptions include **insects**- *Bruchophagus roddi, Bruchus dentipes, B. lentis, B. rufimanus, Rhizopertha dominica, Sitophilus oryzae, S. zeamais, Sitotroga cerealella, Tribolium castaneum*; **mites** - *Oligonychus* sp.; **nematodes** - *Aphelenchoides besseyi, Helicotylenchus pseudorobustus, Pratylenchus penetrans* and *Xiphinema diversicaudatum*; **fungi and bacteria** - *Alternaria brassicae, A. helianthi, A. padwickii, Botrytis cinerea, Colletotrichum capsici, C. dematium, Cercospora kikuchii, Diplodia maydis, Drechslera maydis, D. oryzae, Fusarium moniliforme, F. oxysporum, F. solani, Peronospora manshurica, Pseudomonas syringae, Puccinia helianthi, Rhizoctonia solani, Sclerotium oryzae* and *Xanthomonas campestris* pv. *campestris*; **viruses** - Alfalfa mosaic virus, bean common mosaic virus, broad bean stain virus, cucumber mosaic virus, grape wine fan leaf virus, pea seed-borne mosaic virus and tomato black ring virus.

DNA fingerprinting: Okra species *Abelmoschus moschatus, A. ficulneus* and *A. esculentus* have been found closely related, and *A. tuberculatus*, a distant relative, when analysed by sequencing Internal Transcribed Spacers (*ITS-1, ITS-2*) from nrDNA and three intergenic spacers (*trnC-trnD, trnE-trnF* and *trnH-psbA*) from cpDNA.

Genetic diversity analysis: Forty-five rice landraces from Kerala and adjacent regions have been characterized using 25 STMS markers and

Pongamia pinnata (VNK-P 113), unique accession with high seeds/pod from Vizianagaram district, Andhra Pradesh

Indigenous *Bacillus thuringiensis* strains isolated

Bacillus thuringiensis isolates (PDBC-BT1 and PDBC-BNG-BT1) have shown 100% mortality of *Plutella xylostella* and *Helicoverpa armigera* larvae. PDBC-BTI also gave 100% mortality of first instar larvae of *Chilo partellus* and *Sesamia inferens*.

clustered into groups based on the geographical locations. Seventeen of the 179 alleles detected (9.49%) were unique to specific landraces. The results indicate substantial exchange of pollen between populations, and moderate genetic differentiation among sub-populations.

AGRICULTURALLY IMPORTANT MICROORGANISMS

Germplasm augmentation, conservation and use: Filamentous fungi, bacteria, actinomycetes and yeasts cultures 2,517 from soil, plants and insects have been isolated and maintained in the NBAIM repository. Gene sequences of partial ITS-1 region, complete 5.8S rDNA and partial ITS-2 region have been submitted to GenBank. Two species-specific primers and an oligo-nucleotide probe from conserved sequence of ITS region have been designed for identification of *Macrophomina phaseolina*. Growth of soil-borne pathogenic fungi *in vitro* could be suppressed using strains belonging to *Pseudomonas fluorescens, P.aeuriginosa, Bacillus subtilis, B. brevis, Fusarium oxysporum, Hypocrella discoidea, Metarrhizium anisopliae, Trichoderma harzianum, T. koningii* and *Verticillium lecanii*. Diagnostic probes have been developed for *Fusarium udum;* following a simple procedure based on the sequencing of only a small fragment of 16S rRNA for identification of *Bacillus* genus, and also for species-level identification.

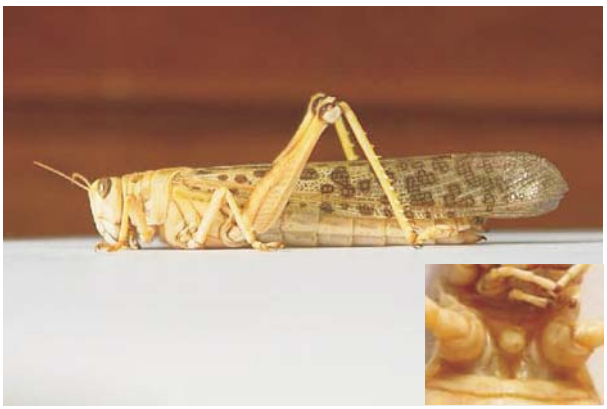
Twenty different groups of *Bacillus* in Indo-Gangetic plains have been identified based on 16S rDNA-RFLP analysis. More than 200 isolates of actinomycetes have been isolated; six isolates belonging to *Streptomyces* species were good producers of protease. Temperature tolerant cellulase and xylanase producing bacteria have been identified which appeared promising for biomass degradation. And bacterial inoculants that can alleviate harmful effects of salinity and improve growth of wheat in salt-affected soil have been developed. These are capable of producing IAA and solublize phosphorus at a salt concentration of 8%.

PESTS AND NATURAL ENEMIES

Biosystematics: Agriculturally Important Insect Biodiversity (AIIB) was explored through field surveys in 27 states/union territories in 165 districts which led to maintenance of 319,877 insects and mites. Among the insects collected Hymenoptera, Coleoptera, Diptera, Hemiptera, Lepidoptera and Coleoptera were most abundant. More than 65 crops in their various stages of growth from sowing to post-harvesting stages were covered. Towards the objective of identification and morphological characterization, 14 different insects/mite groups were focussed upon and 15,830 species were studied. The detailed studies were focussed on 225 species of pests, and their defenders, namely parasitoids and predators. Nineteen diagnostic keys for identification of taxa at various levels, namely families, genera and species, have been developed, of which most significant are families of Lepidoptera and Hymenoptera, genera and species of leafhoppers, plant-hoppers and fruit flies. Detailed taxonomic studies have led to description of a new species of *Trichogrammatoidea*. The faunistics, diversity and taxonomy of different insect groups, viz. Hymenoptera, Hemiptera and Coleoptera have been published.

There was an epidemic of an invasive pest, gall wasp in eucalyptus that is used commercially for production of pulp and other raw materials for paper industry in different parts of India. This

Symptoms of damage of *Leptocybe invasa*

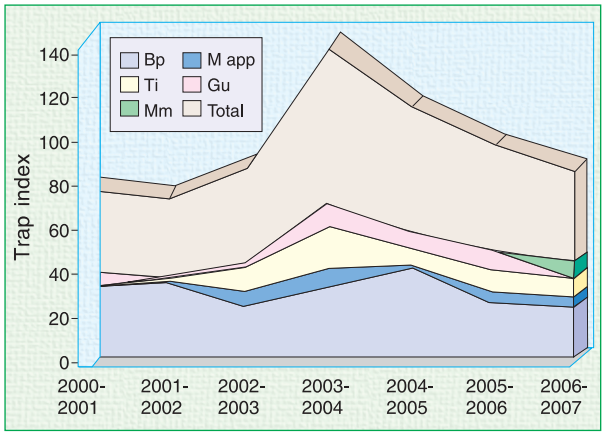


Schistocerca gregaria; with prosternal tubercle (*inset*)

invasive pest on eucalyptus nurseries and plantations in Andhra Pradesh, Karnataka and Tamil Nadu, Delhi, Uttar Pradesh, Haryana, Rajasthan and Madhya Pradesh has been identified as *Leptocybe invasa* (Eulophidae: Hymenoptera) details of its ecology and bionomics have been worked out. Due to the outbreak of desert locust, *Schistocerca gregaria* in six villages of Jalore district of western Rajasthan and adjoining localities in Gujarat during *kharif* 81 hectares and 129 farmers had been affected in villages Partappur, Paladsar, Luniasar, Barsam and Mekhpura in Sanchore tehsil and Vanse in Bilmal tehsil. The technical support provided by the project aided diagnostics of locust, paved way for clearing confusion regarding its similarity with migratory locust, *Locusta migratoria migratorioides*, which occurred in epidemic in Leh of Ladakh in Jammu and Kashmir in 2006–07.

Molecular characterization of parasitoids and predators: The ITS-2 region of DNA of *Trichogramma chilonis* (DQ 220703), *T. brassicae* (DQ314611), *T. mwanzai* (DQ381279), *T. evanescens* (DQ381280), *Trichogramma brasiliense* (DQ381281), *T. dendrolimi* (DQ344045), *T. embryophagum* (DQ344044), *T. japonicum* (DQ 471294) and *T. pretiosum* (DQ 525178) have been sequenced and deposited with Genbank.

Rodent diversity: In rice-rice-pulses cropping system in coastal Andhra Pradesh only *Bandicota bengalensis* (> 80%) and *Mus booduga* were found. In lower Brahmaputra zone in Asom, four species *B. bengalensis* (49%), *R. nitidus* (27%), *R. sikkimensis* (17%) and *M. booduga* (7%) occurred. In Karnataka, *B. bengalensis, Millardia meltada, M. booduga* and *Tatera indica* were found in rice-ragi-soybean, sugarcane fields in varying proportions with predominance of lesser bandicoots. Seven species (3 rats, 1 gerbil and 3 mouse species) *Bandicota bengalensis, Tatera indica, Mus musculus, Golunda ellioti, M. meltada, M. booduga* and *Millardia platythrix* were reported in Punjab.



Year-wise abundance of different rodent species in crop fields in Punjab

In Asom, *Rattus rattus* (32%), *B. bengalensis* (29%), *M. musculus* (21%), *R. sikkimensis* (4.5%) and *R. norvegicus* (12.8%) were reported inhabiting in urban stores and *R. rattus* (41%), *B. bengalensis* (25%), *M. musculus* (25%) and *R. sikkimensis* (9%) in rural storage. Commensalization of a field rodent *Tatera indica* was seen in grain mandis situated in outstations of Jodhpur town. In Punjab, similarly *Rattus rattus* was trapped from inside the stores and *Bandicota bengalensis* from outside in the vicinity of stores. Studies of recently introduced *Bandicota bengalensis* in Jodhpur revealed very heavy infestation of bandicoots in the city area. Their population remained almost constant throughout the year. Maximum body weight of bandicoots was recorded in January, followed by March.

ANIMALS

Phenotypic characterization

Red Sindhi cattle: Red Sindhi cattle coat is red but under body parts are whitish/gray colour. Body is large, compact and straight. The average body length, height at wither, heart girth, paunch girth, face length, face width, horn length, ear length, tail length without switch and teat length

Red Sindhi cattle needs immediate attention for conservation

were recorded. Body weights of calves at 3, 6 and 12 months of age and of adult animals were 41, 58 and 110, 450 kg in males; and 40, 55.0, 95 and 320 kg in females respectively. The average age at first fertile service, age at first calving, lactation milk yield, lactation length, gestation period, dry period, service period and inter-calving period were 1,215±53 and 1,577±56 days, 1,532±88 kg, 291±5, 291±3, 195±14, 192±14 and 485±13 days respectively. The population status indicated that the breed is threatened in the country and needs immediate attention for conservation.

Krishna Valley cattle: The breed is distributed around Krishna River in Karnataka state, hence named as Krishna Valley. The animals are of

medium size. The coat colour varies from grey to white with darker shades. The average measurements of body length, height at wither, chest girth, paunch girth, face length, ear length, horn length, horn circumference, tail length are 129, 119, 157.62, 153.12, 46.87, 19.75, 21.87, 20.87, 73.25 cm, respectively, in bulls and 106.25, 110.5, 155.5, 163.25, 41.25, 22, 36, 18, 67.25 cm in females. The breed is utilized for draught purpose. The average daily milk yield ranges from 3 to 5 kg. Age at first calving is 3–4 years and inter-calving period varied from 1.5 to 2 years.

Madras Red sheep: Madras Red sheep is distributed in Chennai, Kancheepuram, Tiruvellore, Villupuram, Vellore, Cuddalore and Thiruvannamalai districts of Tamil Nadu. They are of medium size, well built with a broad and deep chest and straight top line. Average adult body weight is 31.8±1.05 kg in rams and 24.5±0.35 kg in ewes. The skin is fine and soft with short hair. The coat colour is light to dark red/brown/tan. Age at first breeding is about 12 months in rams with an average breeding life of about 4 years. Lambing season is October-January. Age at first lambing ranges between 18 and 24 months. An ewe produces about 5–7 lambs in its lifetime.

Madras Red sheep—age at first lambing is between 18 and 24 months; ewe produces 5–7 lambs in its lifetime

Tiruchy Black sheep: Tiruchy Black sheep are found in the native habitat in Pannagaram, Nallampalli, Dharmapuri, Palakodu, Kairimangalam, Krishnagiri of Dharmapuri district of Tamil Nadu. The animals are medium to small in size. Average body weight is 35.5±0.9 kg in rams and 29.6±0.3 kg in ewes. Body is completely black. Fleece is extremely coarse, hairy and open. Age at first breeding is 12–18 months in rams with a breeding life of 4–5 years. In ewes age at first lambing is 12–18 months. Lambing per cent is 70–80 with a lambing interval of about 10–12 months. An ewe produces 5 to 6 lambs in its lifetime.

Tiruchy Black sheep—average body weight in rams 35–37 kg and in ewes 29–30 kg

Magra sheep: Magra sheep prevails in Bikaner district of Rajasthan. The animals are medium to large in size. Face is white with brown circular patches around the eyes, which is a characteristic of this breed and hence also named as *Rata Chakria/chakria*. Age at first breeding in males is 18–24 months. In ewes, age at first lambing is 18–24 months. The average body weight at birth, 3, 6, and 12 months of age are 2.2, 15.9, 21.5 and 29.1 kg in males, and 2.4, 14.7, 19.4 and 25.6 kg in females respectively. The breed is known for lustrous and carpet quality wool production. Animals are shorn thrice a year in March, July and November. Average greasy wool production is 1.5 to 2.5 kg/annum in three clips.

Magra sheep—known for lustsrous, carpet quality wool; average greasy wool production is 1.5 – 2.0 kg/annum

Gohilwadi goat: Gohilwadi breed of goat has derived its name from Gohilwad, which was a part of the Kathiawar region. The animals are spread mainly in Junagadh, Amreli and Bhavnagar districts. The Gohilwadi goats are of medium to large size having the average measurements of 81.04, 79.78, 79.23 and 82.70 cm for height at withers, body length, heart girth and paunch girth respectively. The coat colour is uniformly black

Gohilwadi goat—milk yield of 3 litres/day was recorded in some elite goats

covered with long coarse hair. Face is proportionate to the body measuring 20.93 cm. Both sexes have wattles. Some of the elite milch goats yield about 3.0 litres milk per day.

Daothigir chicken: The Daothigir chicken is found in districts of Kokrajhar, Chirang, Udalguri and Baska of Assam. Plumage color is mostly black interspersed with white feathers. Comb is red, single, erect and large in size. Average weight of cock is 1.79±0.13 kg and that of hen 1.63±0.13 kg. The annual egg production ranges from 60 to 70. Average egg weight is 44.42±1.35 g.

Tellichery chicken: Tellichery birds are found mainly in Calicut district but are also available in surrounding areas in Kannur and Malappuram districts of Kerala, and adjoining Mahe of Pondicherry. Plumage color is black with shining bluish tinge on hackle, back and tail feathers. Comb is red, single and large in size. Average weight of cock is 1.62±0.16 kg and of hen 1.24±0.10 kg. Eggs are tinted and their annual production ranges from 60 to 80; and average egg weight is 40.02±0.94 g.

Genetic characterization

Cattle: Within breed diversity was estimated for Dangi cattle of Maharashtra. The comparison of allelic diversity and heterozygosity values of Dangi cattle with Tharparkar, Rathi, Gir, Kankrej, Mewati, Nagori, Rathi, Khillar provided the relative genetic variability that existed in these Indian cattle breeds. The average inbreeding coefficient (F_{IS}) in Dangi cattle was 0.102 while this was lowest in Kankrej cattle which did not show any heterozygote deficiency. The interbreed differentiation —F_{ST} — between Dangi and other cattle populations reflected moderate level of genetic divergence between different pairs of cattle breeds; maximum divergence of Dangi cattle is with Tharparkar and minimum with Kankrej cattle. The mean differentiation value indicated that majority of the breed differences corresponded to differentiation among individuals.

The comparative microsatellite analysis of cattle breeds Ponwar, Gangatiri, Kherigarh and Kenkatha, and Siri cattle were completed. The genetic relationship tree based on genetic distances showed that 4 breeds of Uttar Pradesh are divided into 2 branches where Ponwar and Kherigarh clustered together and were clearly differentiated from Gangatiri and Kenkatha that formed the second branch. The pattern of population differentiation revealed the comparative close relationship of Ponwar and Kherigarh breeds and of Gangatiri and Kenkatha breeds. The breeding tract of Ponwar and Kherigarh are adjacent to each other, whereas that of Gangatiri and Kenkatha are distant from these two and also from each other.

Buffalo: *Karyotypic feature of Chilika buffalo.* Distinctive karyotypic features of swamp and river buffaloes were exploited to explicitly ascertain whether Chilika buffaloes belong to the riverine or swamp category. The chromosomal constitution and karyotypic characteristics of Chilika buffaloes investigated were identical to those of typical riverine type buffaloes standardized internationally (CSKBB 1994). Cytogenetic analyses thus confirm the riverine status of Chilika buffaloes of Orissa. This assumes special significance in the light of general belief and swamp type behaviour of Chilika buffaloes and the fact that another type of buffaloes (Paralakhemundi buffaloes) found in the vicinity of breeding tract of Chilika in the same state of Orissa has been cytogenetically authenticated to be swamp type.

Molecular characterization of buffaloes. Full length cDNA of serum lysozyme gene of riverine buffalo was cloned and characterized. DRB3 exon 2 was found highly polymorphic in Umblacherry cattle. Based on sequencing results, the *Rsa* I-*v* seems to be a new genotype.Single strand conformation polymorphisms (SSCP) in two different fragments of serum lysozyme gene were identified in Murrah, Surti, Mehsana and Bhadawari buffaloes. cDNA encoding entire coding sequences of Toll-like receptor, MIP1-alpha and TNF-a were cloned and characterized in buffalo. Significant association of ITGB2/*Msp*I genotypes with the per cent neutrophil and lymphocyte was observed in buffalo. cDNA of uterine milk protein (UTMP) and genomic sequence (>4 kb) of ghrelin gene of buffalo was cloned and characterized.

Buffalo phenotype and milk yield correlationship. Specific breed characters of Murrah, viz. coat colour, type of head and face, tail and tail switch, etc. showed significant relationship with milk production. Buffaloes of docile temperament, having fine skin, more capacious udder and cylindrical teats produced more milk. However, type of horns was not associated with milk production.

Identification of molecular markers associated with production and reproduction performance for early germplasm selection. For characterization of buffalo growth hormone (GH) gene, DNA prepared from low and high producing buffalo subgroups and progeny tested sires, revealed a >760 bp size amplicon, whose Msp restriction patterns showed more number of restriction sites than cattle GH gene.

Goats: *Changthangi goat.* The estimates of effective number of alleles and gene diversity revealed substantial genetic variation at 25 loci. The average observed and expected heterozygosity values were 0.599 and 0.740 respectively. The mean polymorphic information content (PIC) value further reflected high level of polymorphism across the loci. The analysis of data showed a normal L-shaped distribution representing likelihood that Changthangi population has not experienced a recent reduction of their effective population size.

Sheep: *Jalauni sheep.* The genetic variability was examined at 25 microsatellite loci covering 19 chromosomes. Allele frequencies loci ranged from 0.022 to 0.863. A total of 148 alleles were identified with an allele diversity of 5.92. The effective allele number (3.71) was lower than the allele diversity. The mean observed heterozygosity (0.589) and gene diversity (0.681) estimates elucidated substantial genetic diversity within Jalauni breed. The breed exhibited high genetic polymorphism.The typical L-like distribution implied the absence a recent genetic bottleneck in this indigenous breed of sheep.

Chhotanagpuri sheep. Genetic diversity in Chhotanagpuri sheep was estimated in terms of allele frequency, observed number of alleles, effective number of alleles, observed heterozygosity, expected heterozygosity and within breed heterozygosity deficit. Distinct alleles (141) were detected across the analyzed microsatellite loci. A normal L-shaped curve suggested that the population has not experienced a genetic bottleneck. Within population inbreeding estimate (F_{IS}) ranged from 0.01 (CSSM31) to 0.68 (OaeAE129) with an average positive value of 0.24.

Mithun: *Nagami.* The genetic characterization was carried out using 28 cattle primers. The number of alleles observed varied from 3 to 9 with a mean of 5.11± 1.57, whereas average effective number ranged from 1.317 to 4.842. The overall mean of Shannon index and PIC values were 1.020 ± 0.407 and 0.482 ± 0.186 respectively. Nagami mithun population showed heterozygotic deficiency at 12 of the 25 loci but has not suffered with the population bottleneck in the recent past. Decreasing heterozygosity suggests that immediate attention is required to increase the outbred population.

Yak: *Paternally inherited species specific ssp1-PCR-RFLP assay for hybridization analysis in yak-cattle hybrid populations.* Species hybridization between yak and cattle is commonly practised in yak tracts in India to utilize hybrid vigour. Hybrid females are sterile while males including backcross males are sterile. F_1 hybrid females (Dzomo) are backcrossed to bulls from either of the parental species. Using backcrossing, a number of generations (up to F_5/F_6) of hybrids is produced. It is difficult to identify the sire in F_2 and a further generation as mating generally takes place while they are in herds in vast grazing land. SRY gene is the only single copy Y-chromosomal gene without a X-chromosomal homologue. A simple reliable Ssp1-PCR-RFLP assay to identify male mediated introgression based on mutation in SRY gene was developed for identification of paternal origin of hybrids between yak and cattle. This assay could be used to identify the paternal species in yak and cattle hybrids of different filial generations.

Association of polymorphism of defensin genes with milk somatic cell count in yaks and zebu cattle. Defensins have antimicrobial role in various tissues including mammary gland. Defensin/*Taq1* PCR-RFLP studies showed polymorphic patterns in yaks, and their hybrids, cattle, mithun. The defensin genotypes have significant effect on somatic cell count (SCC) in hill cattle and yaks. B_2 type individuals either in homozygous or in heterozygous conditions had lower somatic cell count. Defensin genotypes showed an effect on SCC in milk of yak and cattle.

Poultry: *Molecular characterization of layer and broiler germplasm.* Six different genetic groups of a diallel cross of chicken were analyzed with five microsatellite markers, viz. MCW007, ADL020, ADL023, ADL102 and ADL176. ADL176 was the highest polymorphic marker, depicting the availability of six alleles in the crossbred populations. Genotypic proportion was found distributed from low to moderate and the allelic frequency of all microsatellites, except ADL176, varied. In ADL176, some alleles were rare with the existence of only 3 to 4% in the population. These alleles may be in the path of extinction from the population and are mostly present in heterozygotic condition.

The genotypes of MCW007, ADL 176, and ADL020 microsatellite were found associated with body weight. The ADL023 microsatellite was associated with egg production. Microsatellites MCW007, ADL020, ADL023 and ADL176 were found associated with age at sexual maturity.

Identification of genetic polymorphism in genes regulating appetite in chicken. Genes — ghrelin and melanocortin-4 receptor — controlling appetite and energy balance in poultry were studied to

identify the single nucleotide polymorphism (SNP). Dahlem Red birds and control broilers (CB) populations were screened for polymorphism. Different alleles A, B and C were identified in CB line and alleles A and B were seen in NB lines with varying allele frequencies. The 336 bp fragment in MC4R gene was amplified in chicken, duck, emu, ostrich, quail and turkey, sequenced, and compared. The sequences have been submitted to the NCBI gene bank. In the coding region, there were 2–5 substitutions across the species.

Genetic characterization of native ducks. Indian Runner Native duck was characterized using RAPD-PCR technique and also 14 microsatellite loci. The RAPD-PCR analysis resolved 66.67% polymorphic bands.

Conservation: During the period, *in-situ* conservation units for Beetal goat; Surti goat; and Kilakarsel sheep, and *ex-situ* conservation units for Krishna Valley cattle and Jaffarabadi buffalo; Kherigarh and Ponwar cattle were continued.

DNA repository of Ganjam, Kendrapara, Deccani, Nellore, Nali, Magra, Chokla, Garole, Patanwari, Marwari, Kheri, Malpura, Muzaffarnagri, Jaisalmeri and Sonadi has been created. *FecB* gene in Garole, Garole × Malpura, and backcross progeny, Ganjam, Kendrapara and Deccani sheep has been identified. In genetic improvement for resistance to *Haemonchus contortus* in sheep, preliminary study revealed that mortality rate was 6.06 in R-line while in S-line it was 12.90%.

Genetic diversity and population structure of Jamunapari goats. Allelic richness, gene diversity, linkage disequilibrium, effective population size were analysed, and bottleneck analysis was carried out. Despite the smallest population size, the amount of variability both in terms of allelic richness and gene diversity observed in Jamunapari goats is higher. No recent bottleneck was observed in the population. There was no sign of recent reductions in N_e in Jamunapari population. The base line information on genetic diversity, bottleneck analysis and mismatch analysis was obtained to assist the conservation decision management of the breed.

Marwari breed conservation at farmer's door. The Marwari breed of equines is threatened due to non-availability of true-to-breed stallions and indiscriminate breeding practices. To conserve the true-to-breed Marwari germplasm, the population in the field was characterized phenotypically and genotypically. The semen was collected and cryopreserved from selected stallions at farmers' door using mobile semen laboratory, first ever thought activity in the country and probably globally in any other domestic livestock. This semen was used for artificial insemination (AI) of 10 Marwari mares at the centre to produce superior offspring.

Marwari—artificial insemination was carried out in Marwari mares to produce superior offsprings

FISH

Development of a resource mapping population and a new set of microsatellite markers in rohu: A backcross family with about 50 individuals was generated by crossing *Labeo rohita* female with *L. calbasu* male. Microsatellites (40) were charaterized from rohu genome, and PCR amplification of these microsatellite loci in kalbasu showed more than 15 loci to be cross amplifying. This indicated that about 80% of the rohu markers can be mapped using the current inter-species mapping panel.

Molecular characterization of backcross population of Indian major carps (*Labeo rohita* and *Catla catla*): Random RAPD primers (10 mer oligonucleotides) from 3 complete sets, viz. OPA, OPG and OPQ series, and some other arbitrary primers tested already like OPC-13, OPE-7, OPF-14, OPK-02, OPK-12, OPK-17, OPY-20 were used, mounting to a total of 19 primers. Out of them, 11 primers (OPA-02, OPA-04. OPA-05, OPA-07, OPC-13, OPG-02, OPG-03, OPG-18, OPK-12, OPK-17 and OPY-20) were found satisfactory with respect to amplification and band clarity. Analysis of 314 bands from four combinations of template DNA samples having catla, rohu, F_1 hybrids, B_1 backcross, B_1R backcross and BC_1F_2 backcross in a formatted loading of progeny's DNA along with parental DNA side by side showed quite a good number of catla type bands, rohu type bands as well as few typical bands. Parentage catla bands showed the sharing of 20–100% in various progenies, whereas rohu bands showed 40–100% in various progenies.

Genomic library of *Pangasius pangasius:* Microsatellite enriched genomic library was constructed for the riverine catfishes, *Pangasius pangasius* to identify sequences containing microsatellite repeat regions. Of the 28 sequences found to contain microsatellite repeats, primers were designed for these loci and tested for amplification of microsatellite loci. The 15 pairs of primers gave amplified products with 42 individuals collected from rivers, Brahmaputra and Mahanadi. This genotyping provided 9 polymorphic loci while four were monomorphic. These microsatellite markers are useful for population genetic structuring in *P. pangasius*.

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5. Crop Improvement

IMPROVEMENT

Rice: Five varieties and one hybrid, at the regional/ central level and thirteen varieties and two hybrids at the state level have been released for different states of the country.

Released rice varieties and hybrids

Variety/Hybrid	Grain type	Farming system	Resistance to pests/ diseases	State/region of adaptation
JKRH 401 (Hybrid)	Long Bold	Irrigated, transplanted	Leaf blight, Bacterial blight, Rice tungro disease, White backed plant hopper, Sheath rot, Brown spot, Sheath blight, Neck blast	West Bengal, Bihar and Orissa
Abhishek	Short Bold	Irrigated	Bacterial blight, Shoot borer, Gall midge, Leaf folder, Sheath rot, Sheath blight	Uttar Pradesh, Bihar, Jharkhand and Asom
Shusk Samrat	Long Bold	Rainfed, upland (direct seeded)	Leaf blight, Shoot borer, Brown spot, Sheath rot, Gall midge, Sheath blight	Uttar Pradesh, Orissa and Bihar
Virender	Short Bold	Rainfed, upland (direct seeded)	Leaf blight; SB; Brown plant hopper and White backed plant hopper, Gall midge, Sheath rot, Brown spot	Orissa and Gujarat
VL Dhan 86	Short Bold	Irrigated, transplanted	Leaf blight and Neck blast, Sheath blight, Brown plant hopper, Leaf folder	Uttarakhand and Himachal Pradesh

Rice variety VL Dhan 86, suitable for Uttarakhand and Himachal Pradesh, possesses resistance to diseases and insects

Released rice varieties and hybrids

Variety/Hybrid	Grain type	Farming system	Resistance to pests/ diseases	State/region of adaptation
Bhuthnath	Long Slender	Waterlogged, coastal saline areas	MR– Leaf blight, Neck blast, Sheath blight, Rice tungro disease, Brown spot	West Bengal, Orissa, Maharashtra
		State releases		
Indra	Medium Slender	Irrigated (Saline soils)	Brown plant hopper, Gall midge, Bacterial blight	Andhra Pradesh
Pardhiva	Short Bold	Rainfed, shallow lowlands	Blast	Southern parts of Krishna, Godavari zone of Andhra Pradesh
Sree Kurma	Medium Slender	Shallow lowlands (Late planted conditions)	Gall midge, Blast	Andhra Pradesh
Warangal Sannalu	Medium Slender	Irrigated medium	–	Andhra Pradesh
Chandrama	Short Bold	Irrigated *boro* as well as rainfed shallow lowlands (*sali*)	Leaf blight and Neck blast; MR– Bacterial blight, Rice tungro disease, Sheath blight, Gall midge, Brown plant hopper and White backed plant hopper	Asom
Jaldubi	Medium Slender	Direct seeding/ transplanted in shallow lowlands	Blast, Gall midge	Chhattisgarh
Chandrahasini	Long Slender	Irrigated	Gall midge; MR– Brown plant hopper, White backed plant hopper, Neck blast, Blast	Chhattisgarh
Samleshwari	Long Slender	Rainfed uplands, rainfed bunded Matasi soils	Gall midge 1, 4; MR– Blast; T – Brown spot, Neck blast	Chhattisgarh
Indira Sona (Hybrid)	Long Slender	Irrigated médium	Gall midge	Chhattisgarh
Haryana Sankar Dhan 1 (Hybrid)	Long Slender	Irrigated medium	Sheath blight, Brown spot, Neck blast, White backed plant hopper, Leaf folder	Haryana
Phule Radha	Short Slender	Irrigated, transplanted	Bacterial blight; MR– Blast	Maharashtra
Pariphou	Long Slender	Irrigated, lowlands, *rabi* areas	–	Manipur
Ginphou	Long Slender	Uplands, irrigated lowlands	–	Manipur
VL Dhan 209	Short Bold	Rainfed, uplands	Leaf blight and Neck blast, Leaf folder and Brown spot	Uttarakhand
VL Dhan 65	Long Slender	Irrigated, hilly areas	Leaf blight, Neck blast, Brown spot; MR– Leaf folder, Sheath blight	Uttarakhand

MR-Moderately resistant, T-Tolerant

Wheat and barley: Five varieties of wheat, three of barley and one of triticale have been released.

Released varieties of wheat, barley and triticale

Variety	Farming system	Area of adaptation	Salient features
DBW 17	Irrigated, timely sown 	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division), Jammu and Kathua district, Una distt and Paonta valley and Uttarakhand (*tarai* region)	Yield advantage over PBW 343. Plant resistance to new yellow rust race 78S84 for which PBW 343 and PBW 502 are susceptible.Resistance to 5 (121R 63-1) and 104-2 (21R55), at seedling and adult plant stages. Karnal bunt resistance better than PBW 343. Good *chapati* making quality
K 0307	Irrigated, timely sown	Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, West Bengal, Asom and north-eastern plains	Yield advantage, disease resistance, better quality *chapati* and bread making than K 9107
GW 366	Timely sown, irrigated	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan, and Jhansi division of Uttar Pradesh	Yield advantage over GW 322
RAJ 4083	Late sown, irrigated	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu	Yield gain over HI 977
DDK 1029	Timely sown, irrigated	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu, Nilgiri and Palni hills	Yield gain over best *dicoccum* check variety DDK 1009
TL 2942	Rainfed/Irrigated, Timely sown	Western Himalayan regions of Jammu and Kashmir (except Jammu and Kathua distt); Himachal Pradesh (except Una and Paonta valley); Uttarakhand (except *tarai*/plain area); Sikkim and hills of West Bengal and NE states	Yield advantage and good amber grains
DWRUB 52	Irrigated, timely sown 	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division), Jammu and Kathua distt, Una district and Paonta valley and Uttarakhand (*tarai* region)	First 2-rowed barley having good yield potential and malting quality and resistance to yellow rust
RD 2668	Irrigated, timely sown	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division), Jammu and Kathua distt, Una district and Paonta valley and Uttarakhand (*tarai* region)	2-rowed barley having good yield potential and malting quality and resistance to yellow rust
		Feed Barley	
PL 751	Irrigated, timely sown	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	6-rowed barley, resistant to black rust

Registration of genetic stocks: Sixteen wheat genetic stocks showing resistance and quality traits have been registered.

Wheat genetic stocks registered

Name	I.D. No.	Institutions involved	Traits(s)
FKW 1	IC 546933	DWR, Shimla	Resistance to yellow and black rusts
FKW 3	IC 546934	DWR, Shimla	Brown rust resistance derived from durum wheat (HD 4672)
FKW 4	IC 549915	DWR, Shimla	Brown rust resistance derived from durum wheat (DWR 1006)
FLW 20	IC 548327	DWR, Shimla	Brown rust resistance (*Lr19*)
FLW 24	IC 549926	DWR, Shimla	Stem rust resistance (*Sr24*, *Sr25*)
FLW 25	IC 549927	DWR, Shimla	Brown rust resistance (*Lr28*)
FLW 26	IC 549928	DWR, Shimla	Brown rust resistance (*Lr42*)
FLW 27	IC 549929	DWR, Shimla	Brown rust resistance (*Lr45*)
VL 858	–	VPKAS, Almora	Excellent *chapati* quality
VL 824	IC 549923	VPKAS, Almora	Powdery mildew resistance
WBM 1587	IC 549931	IARI, Shimla	Yellow rust resistance
WBM 1591	IC 549932	IARI, Shimla	Yellow rust resistance
NAPHAL	–	DWR, Karnal	Glu-D1 double null with *pin A* gene
Tank	IC 398287	VPKAS, Almora	Exceptionally long awns
WH 730	–	CCSHAU, Hisar	Heat tolerance
DI 717	IC 546939	CCSHAU, Hisar	*NIL* of C 306 with *Rht-3* gene

Promising wheat and triticale genotypes identified from national nurseries

Trait(s)	Genotypes	Trait(s)	Genotypes
Resistant to three rust diseases	HD 2865, VL 895, VL 900, VL 905, PHS 0622, TL 2951 (T)	1,000 grain weight (> 50 g)	UP 2700, LBPY 05-3, GW 005-7, RD 1008(D), DBPY 05-1, DBPY 05-4(D), DBPY 04-2(D), RD 1018 (D), DBPY 04-5(D)
Tolerance to salinity-alkalinity	KRL 234, Raj 4188, KRL 237, KRL 236, DW 1367, KRL 229, KRL 233	Grains/spike (> 60)	GW 03-2, GW 03-5, LBPY 05-4, GW 03-11, LBPY 05-9
Early maturity (<110 days) and late heat tolerance	NIAW 1268, NIAW 1342, WR 1743	Spikes/m row length (>100)	LBPY 05-11, Raj 4128, WR 1392, WR 1387, LBPY 04-4
Early heat and drought tolerance	HI 1544, AKAW 3997, MACS 1967(D), WH 736, HI 1551, Raj 4140, RD 1271(D)	High protein (>13%) and high 1,000 grain weight (>40 g)	PHR 1011, UP 2672, UP 2671, WH 768, HUW 576, PBW 559, UP 2669, PBND 1625 (D), PQW 80,

(D) = Durum; (T) = Triticale

Rust resistance genes used for pyramiding in wheat varieties

Cultivar	Stripe rust genes	Leaf rust genes	Institution involved
HUW 234	*Yr10* + *Yr15*	*Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	DWR, Karnal
LOK 1	–	*Lr24* (*Sr24*) or *Lr28* + *Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	DWR, Karnal
PBW 343	*Yr10* + *Yr15*	*Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	PAU, Ludhiana
HD 2733	*Yr10* + *Yr15*	*Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	PAU, Ludhiana
HD 2687	*Yr15*	*Lr24* or *Lr28* + *Lr37*	IARI, New Delhi
WH 147	–	*Lr24* or *Lr28* + *Lr37*	IARI, New Delhi

Pyramiding rust resistance genes in wheat. Genes for resistance to leaf rust (*Lr24, 28, 35, 37*) and stripe rust (*Yr10, Yr15*) have been targeted for introduction into wheat cultivars (PBW 343, HD 2687, HD 2733, HUW 234, Lok 1, WH 147) through marker assisted selection approach.

Maize: Nine varieties of maize have been released.

Quality protein maize hybrid, HQPM 5, rich in lysine and tryptophan is suitable for cultivation across the country

Maize cultivars released

Cultivar	Maturity	Area of adaptation	Cultivar	Maturity	Area of adaptation
FH 3288 (Vivek 27)	Extra early	Bihar, West Bengal, Orissa, Jharkhand, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu	HKI 1188 (HM 8)	Medium	Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu
FH 3248 (Vivek 25)	Extra early	Himachal Pradesh, Uttarakhand, Jammu and Kashmir, north-eastern region	V 33 (Malviya Makka 2)	Medium	Eastern Uttar Pradesh, West Bengal, Bihar, Orissa, Jharkhand, Chhattisgarh
JH 3892 (PAU 352)	Early	Delhi, Haryana, Punjab, western Uttar Pradesh	NECH 128 (NK 21)	Medium	Rajasthan, Gujarat, Madhya Pradesh
HKI 1191 (HM 9)	Medium	Eastern Uttar Pradesh, Bihar, West Bengal, Orissa, Jharkhand, Chhattisgarh	HQPM 5	Late	Across the country
			NECH 129 (NK 61)	Late	Delhi, Haryana, Punjab, western Uttar Pradesh

Sorghum: Two varieties of sorghum have been identified. CSV 23 (SPV 1714) is a dual purpose *kharif* sorghum variety proposed for cultivation in Andhra Pradesh, Tamil Nadu, Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Uttarakhand and Gujarat for deep soils. It has showed distinct superiority for dry fodder yield and resistance to anthracnose and leaf spot. SPV 1626 is a *rabi* sorghum variety proposed for deep soils of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Gujarat.

CSV 23 is a dual purpose *kharif* sorghum

TNAU 145 is a short-duration variety of proso millet

Pennisetum: new cytotypes identified

Cytotype of *Pennisetum pedicellatum*, INGR 06018 – IC 546954 is an octoploid (2n=8x=72), hitherto unreported from this species. Average number of associations per cell observed were 2.2VIII + 1.7VI + 0.05V + 3.15IV + 0.95III + 13.65II + 1.21I. It is perennial in habit as compared to other genotypes, which are annual. It forms tussocks with multi-tillering (up to 100 tillers) in nature. The plant has good regeneration and can be harvested 3–4 times in a year.

Other new cytotype *Pennisetum squamulatum* (2n = 56) INGR 06017 – IC 546955 has been identified with 2n = 56. Chromosome number, meiotic behaviour and crossability of this with *P. glaucum* justifies its octoploid nature based on x =7 and its inclusion in the secondary gene pool of *P. glaucum.* Its plant is perennial in habit.

Pearl Millet: Ten pearl millet hybrids have been identified for release.

Small millets: Fingermillet variety PRM 1, resistant to *Cercospora*, maturing in 110–115 days, yielding 2.3–2.5 tonnes of grains/ha and 8.0–8.5 tonnes/ha green straw, has been released for

Pearl millet hybrids identified for release

Hybrids	Area of recommendation	Salient features
GHB 757	Rajasthan, Gujarat, Haryana	Early maturity, medium tall, compact cylindrical earheads with purple anthers, globular grey-brown grains
GHB 744	Rajasthan, Gujarat, Haryana, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Medium maturity, medium tall, medium thick stem with basal pigmentation, compact cylindrical panicles with yellow anthers, globular grey-brown grains
B 2095	All India	Medium maturity, medium tall, compact candle panicles, globular grey grains
NMH 68	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Late maturity, tall, pubescent nodes, compact cylindrical earheads slightly tapering towards apex, yellow anthers, globular grey grains
JKBH 676	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Medium maturity, medium tall, semi-compact cylindrical earheads with yellow anthers, green fodder at maturity
GHB 732	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Medium maturity, medium tall, compact lanceolate earheads, purple anthers, globular grey-brown bold grains
HHB 197	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Early maturity, medium tall, dark green leaves, cylindrical medium Togo earheads with long bristles, highly resistant to downy mildew
PHB 2168	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Early maturity, medium tall, compact cylindrical panicles with yellow anthers, obovate grey grains
MLBH 341	Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu	Medium maturity, medium tall, resistant to downy mildew
PB 727	Gujarat (Summer), Maharashtra, Rajasthan, Tamil Nadu	Late maturity, medium tall, compact cylindrical panicles with yellow anthers, obovate grey grains

cultivation in the crop-growing areas of Uttarakhand.

Kodo millet variety, RK 65-18, moderately resistant to head smut and shoot fly, yielding 20% higher than national check RBK 155, has been identified for release in Madhya Pradesh, Gujarat and Uttar Pradesh.

Proso millet variety, TNAU 145, a short-duration variety maturing in about 70 days with bold and golden yellow grains having yield superiority of 25% over check GPUP 21, has been identified for cultivation in Tamil Nadu and Karnataka.

Forage crops: Two varieties have been identified and released.

Forage crop varieties identified and released

Crop	Variety	Adaptation region/agro-ecology	Special features
Guinea grass	JHGG 04-1	Rainfed areas semi-arid conditions	Resistant to drought
Heteropogon	IGS 9901	Rangeland community grazing lands	Suitable for drought-prone areas

Underutilized crops: High-yielding entries identified in advance varietal trials, are IC 261963 (1.32 tonnes/ha) in buckwheat, LRB 22 (1.20 tonnes/ha) in ricebean, IC 107299 (0.62 tonne/ha) in chenopodium for hills and SKNA 503 (1.38 tonnes/ha) in *rabi* amaranth, SKNA 601 (0.813 tonne/ha) in *kharif* amaranth, LRB 334 (1.01 tonne/ha) in ricebean, HB 608 (1.92 tonnes/ha in fababean, EC 116887 (0.97 tonne/ha) and EC 142665 (1.19 tonnes/ha) in winged bean in plains, and SMLAB 6 (1.52 tonnes/ha) in adzukibean in hills.

Promising genotypes identified for quality are: BGA 2 (13.57%), Suvarna (12.57%) for protein content and Survarna (5.23%) for lysine content in amaranth; HB 430 (25.50%), HB 180 (25.37%) and Vikarant (25.20%) for protein content and HB 131 (0.90%) and PRT 7 (0.92%) for low vicine convicine in fababean; LRB 330 (20.90%) and LRV 351 (20.53%) for protein content, LRB 122 (4.80%) and RBL 6 (4.57%) for tryptophan, PRR 2 (0.95%) for methionine, and PRR 2 (0.23%) and PRR 9402 (0.22%) for free phenol in ricebean.

Groundnut: Five varieties have been released. A high-yielding variety PBS 24030 (Girnar 2) has been identified for release in the northern Rajasthan, Punjab and Uttar Pradesh. A field genebank of wild *Arachis* species consisting of 75 accessions from 21 species is being maintained, and a working collection of 9,800 accessions is conserved in the medium-term storage.

Groundnut varieties released

Variety	State(s)/area of adaptation	Special features
TG 38B	West Bengal, Bihar and north-eastern states	*Rabi*/summer cultivation
Dh 101 (Vasundhara)	West Bengal, Orissa, Jharkhand and Asom	Tolerant to stem rot, peanut bud necrosis disease,thrips and *Spodoptera*
SG 99	Gujarat, south Rajasthan and northern Maharashtra	Tolerant to peanut bud necrosis disease
GG 8	Northern Maharashtra and Madhya Pradesh	Moderately tolerant to bud necrosis, collar rot
GG 16	Tamil Nadu, Andhra Pradesh, Kerala and southern Maharashtra	Tolerant to bud necrosis, root rot, thrips, *Spodoptera* and leaf miner

Sunflower: DRSH 1 hybrid has been released and notified for *rabi* and summer cultivation in all sunflower-growing areas of the country. A variety, LSF 8, has been notified for Maharashtra.

Safflower: MRSA 521, first CMS-based hybrid, resistant to wilt and tolerant to aphids, exhibiting 19% and 14% increase in seed and oil yields over check, has been released for safflower-growing areas of the country. PBNS 40, a non-spiny variety, having 21–24% yield superiority to national check has also been released for all the crop-growing areas of India. In addition, spiny, sparsely spiny and non-spiny CMS lines using CMS cytoplasm from *Carthamus oxyacantha* have been developed.

Castor: RG 2819 (IC 346591, INGR 06010) having resistance to *Macrophomina* root rot and *Fusarium* wilt has been registered. Phenol content in purple leaves of castor contributes to its leafminer resistance.

Rapeseed-mustard: Three varieties—Indian mustard (2) and gobhi sarson (1)—have been released. *Toria* PHOT 2-2 (INGR 07033) with high oleic acid (70.1%) and low erucic acid (0.2%) and PHOT 8-2-11(INGR 07034) with low linolenic acid (3.03%) have been registered. The CMS-based hybrid NRCHB 506 outyielded best check Kranti variety by 30.6% under late-sown conditions.

Soybean: Soybean varieties Pratap Soya 2 (for North Eastern and Southern Zones) and TAMS 98-21 (for Vidharba Region of Maharashtra) have been released for cultivation.

Sesame: A high-yielding white-seeded variety TKG 306 possessing 2.8 g 1,000 seed weight and multiple resistance has been released for Madhya Pradesh.

Rapeseed-mustard varieties identified for release

Variety	Average oil content (%)	State(s)/ area of adaptation	Special features
Pusa Mustard	36.5	Haryana, Punjab, New Delhi and parts of Rajasthan	Low erucic acid, suitable for rainfed areas
CS 234-2	36.5	Haryana, Punjab and parts of Rajasthan	Suitable for late-sown areas, salt tolerant, 1,000 seed weight more than 6 g
NUDB 26-11	38.7	Himachal Pradesh and Jammu and Kashmir	Double low erucic acid, suitable for irrigated areas

Niger: IGPN 2004-1, a high-yielding variety of niger, has been identified for release in Maharashtra and Karnataka for *kharif* and early *rabi*.

Linseed: Kartika (RLC 76) and RLU 6 varieties have been released for cultivation. In addition, Deepika, LMS 9-2, NL165, RLC 92 and KL 215 have been identified as promising.

Chickpea: GNG 1581 variety has been identified for cultivation in Rajasthan, Punjab, Haryana, western Uttar Pradesh and plains of Jammu. It is semispreading with medium seeds (16.0 g/100 seeds), maturing in 151 days. It is tolerant to wilt, *Ascochyta* blight and stunt. Large-seeded, wilt-resistant *kabuli* chickpea genotype IPCK 2002-29 has shown promise in Central India and outyielded best check JGK 1 by 22%.

Pigeonpea: For Gujarat, first CMS-based hybrid GTH 1 has been notified for cultivation. TT 401 short-duration variety has been identified for Madhya Pradesh, Maharashtra and Gujarat.

Mungbean: H 2-15 (Sattya) variety has been identified for *kharif* cultivation in Rajasthan, Punjab, Haryana, western Uttar Pradesh and plains of Jammu. It outyielded best check, ML 818, by 15%. It has showed moderate resistance to yellow mosaic virus disease. UPM 02-17, developed from interspecific hybridization between mungbean and urdbean, has been identified for cultivation in North Eastern Hills Zone. It gave 17% higher yield than best check ML 5.

Fieldpea: Varieties, IPF 04-26, VL 45 and Pant Pea 42, have been identified for cultivation in different states.

Arid Legumes: Guar variety HG 884 identified as promising. It outyielded (25.34%) best check HG 365. It matures in 90–95 days and has field tolerance to major diseases. It contains 30–32.5% gum and viscosity profile of 2200–2500 Cp.

CRIDA 1-18R a promising variety of horse-gram, yielded 842.0 kg/ha against 696.2 kg/ha of the best check, PHG 9. It is also early in maturity (85–90 days).

Cotton: An intra-*hirsutum* hybrid CSHH 243 has been identified for cultivation in irrigated areas in North Zone. It has recorded a mean seed-cotton yield of 2.2 tonnes/ha; ginning outturn of 33.3%; 2.5% mean fibre length of 26.7 mm; micronaire value of 4.6; uniformity ratio value of 50.7%; and fibre strength of 24.0 g/tex; and has shown resistance to cotton leaf-curl virus.

Temperature-sensitive genetic male-sterile lines for economical hybrid seed production in diploid cotton have been identified from a cross between (*Bengalense* × *Cernuum*) × *G. anomalum*.

Indigenously synthesized genes *Cry 1 F* and *Cry 1 Aa3* have been successfully transferred in diploid cultivars PA 402, PA 255, PA 183, AKA 5, AKLA 7, RG 8 and *hirsutum* genotype LRA 5166 (Anjali).

Sugarcane: Sugarcane varieties, CoH 119, CoJ 20193, CoS 96268, Co 98014 and CoS 96275, for west and central Uttar Pradesh, Punjab, Haryana, Rajasthan and Uttara-khand and Co 99004 for plains of Tamil Nadu, Karnataka, Kerala, Gujarat, Madhya Pradesh and Maharashtra have been released and notified for commercial cultivation.

Co 99004 variety of sugarcane released for commercial cultivation

Red-rot resistant sugarcane genetic stocks IkshuISH 1 (PIO 91-190 × SIP 93-190) and IkshuISH 23 (PIO 91-829 × SIP 315) and high-sugar breeding germplasm LG 95053 have been registered.

Jute: Mesta variety Madhuri has been released and notified for roselle-growing tracts of India. Its yield potential has been higher than HS 4288, HS 7910 and AMV 4, and also showed increased tolerance to diseases and insect pests.

Jute varieties, JRO 2003 H, JRO 240 and AAU OJ 1, have been identified for release.

Tobacco: *Spodoptera litura* caterpillar-resistant chewing tobacco variety, Meenakshi (CR), having a yield potential of around 3,500 kg/ha, has been

Caterpillar-resistant chewing tobacco variety Meenakshi (CR)

released for cultivation in inland chewing tobacco tract, i.e. southern, central and western zones of Tamil Nadu in irrigated areas.

Mango: Mango hybrid H 39 (Amrapali × Vanaraj) was found promising with attractive red-blushed fruits, high TSS (24 °Brix), high carotenoids (7.8 mg/100 g), firm pulp (0.78 kg), regular-bearing habit, tolerance to anthracnose and dwarf tree stature.

Mango hybrid H 39

Guava: Guava CISH-G 1 was found as a promising selection with deep red fruits, attractive shape, high TSS (15° Brix) and long shelf-life. Guava Sardar gave significantly higher yield followed by Pant Prabhat, while Lucknow 49 gave the highest fruit yield followed by Allahabad Safeda and Lucknow 46-2. Allahabad Safeda gave high yield, maximum average fruit weight (232.50 g), high TSS (9.92 ° Brix), ascorbic acid content (285.00 mg/100 g pulp) and the lowest acidity (0.31%). Selections, MPUA&T S 1 and MPUA&T S 2, showed promise for high yield potential and quality fruits.

Papaya: An advanced generation papaya hybrid was developed which has red pulp with high TSS content and a good shelf-life. Banana hybrid NPH 02-01 (H 201 × Anaikomban) registered better bunch traits and was found resistant to *Fusarium* wilt race-1. Banana hybrids, H 212 and H 96/1, were found tolerant to nematode.

Grape: Two clonal selections were collected and added to National Grape Germplasm Repository. Field screening of germplasm was done for resistance/tolerance to diseases and insect-pests. Several promising hybrids were evaluated for their suitability for table and wine purposes. A computer-based molecular database has been developed. Hybridization work among popular varieties was undertaken to develop downy mildew-resistant varieties of table grapes. Forty-four accessions showing varying degree of resistance/ tolerance were characterized using molecular markers.

Sapota: High-yielding sapota clone DHS 1 (2/ 1) identified earlier confirmed its superiority.

Walnut: A total of 10 promising selections in walnut comprising 5 genotypes, each with a nut weight of 18.63–27.16 g and kernel weight of 10.69–12.76 g, were found promising. Vegetatively propagated walnut selections started bearing during the third year of plantation against 12–15 years by conventional seedlings.

Arid zone fruits: Ber hybrid Thar Sevika was found promising with 10–15 days early maturity, juicy fruits, high TSS (22%), high ascorbic acid (90 mg/100 g), and contents of total sugar (5.0 mg/100 g) and protein (16 mg/g). Thar Bhubhraj, a selection has ability to withstand extremes of temperature variation. A new cultivar of aonla has been released which has a proliferic-bearing habit and matures earlier than NA 7. Pomegranate, Ganesh and Anardana type Line H performed better under rainfed condition of Gujarat. Narendra Ber Selection 1 and Narendra Ber Selection 2 have been recommended for commercial cultivation in Uttar Pradesh.

Underutilized fruits: Promising genotypes, CISH-J 37 of jamun (*Syzygium cuminii*), CISH-K 10 of khirnee (*Manilkara hexandra*) and CISH-Kr 11 of karonda (*Carissa carandas*) were identified. The CISH-J 37 jamun recorded average fruit weight 24.05 g, length 3.90 cm and diameter 3.03 cm, pulp 92.26%, TSS 16.4 °Brix, ascorbic acid 49.88 mg/100 g and antioxidant 1,467.9 µg/100 ml AEAC unit. CISH-K 10 khirnee recorded average fruit weight 4.44 g, length 2.83 cm, pulp 89.18%, TSS 28.40 °Brix, ascorbic acid 16.8 mg 100/g and antioxidant 189.89 µg/ml AEAC unit and karonda CISH-Kr 11 recorded average fruit weight 6.0 g,

CISH-K 10 is a promising genotype of khirnee

length 2.30 cm, pulp 4.60 g, seed 1.40 g, TSS 6.10 °Brix, ascorbic acid 16.8 g 100/g and antioxidant 189.89 µg/100 ml AEAC unit.

CISH-J 37, a genotype of jamun, has 92.26% pulp

Vegetable crops: New hybrids and varieties in different vegetable crops were identified and recommended for cultivation in different states. These include brinjal PB 66 for Madhya Pradesh, Maharashtra, Uttar Pradesh, Punjab, Bihar and Jharkhand; hybrid brinjal Navina for Uttar Pradesh, Punjab, Bihar and Jharkhand; hybrid brinjal HABH 17 for Uttar Pradesh, Punjab, Bihar and Jharkhand; chilli LCA 353 for Chhattisgarh, Orissa, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, Punjab, Bihar and Jharkhand; and BC 25 for Rajasthan, Gujarat, Haryana, Delhi, Madhya Pradesh, Maharashtra, Orissa, Chhattisgarh and Andhra Pradesh; sponge gourd PSG 40 for Madhya Pradesh, Maharashtra, Jammu and Kashmir, Himachal Pradesh and Uttarakhand; ash gourd Pusa Ujwal for Karnataka, Tamil Nadu and Kerala; early-group pea VP 101 for Uttar Pradesh, Punjab, Bihar, Jharkhand, Jammu and Kashmir, Himachal Pradesh and Uttarakhand; mid-group pea PC 531 for Rajasthan, Gujarat, Haryana, Delhi, Madhya Pradesh, Maharashtra, Jammu and Kashmir, Himachal Pradesh and Uttarakhand; cowpea IIVR- CP 4 for Uttar Pradesh, Punjab, Bihar, Jharkhand, Orissa, Chhattisgarh, Andhra Pradesh, Madhya Pradesh and Maharashtra; onion B 780-5-2-2 for Rajasthan, Gujarat, Haryana and Delhi; okra JNDOL 03-1 for Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala; hybrid okra SOH 1016 for Uttar Pradesh, Punjab, Bihar, Jharkhand, Madhya Pradesh and Maharashtra, and NBH 180 for Madhya Pradesh and Maharashtra; and hybrid cabbage Green Emperor for Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

Varieties released: Kashi Unnati, a new cowpea variety, is photo-insensitive, highly tolerant to golden mosaic virus and *Pseudocercospora cruenta* diseases. Its plants are dwarf/bush type with an average length of 40–45 cm. This is recommended for cultivation in spring-summer and rainy seasons in different parts of the country. It flowers 30–35 days after sowing and exhibits commercial pod maturity 45–50 days after sowing. It bears 40–45 pods/plant with an average yield of 125–150 q/ha. It is adopted for cultivation in traditional and non-traditional, replacing almost all varieties. Due to short-duration, this is highly suitable for rice-wheat cropping system.

Kashi Unnati, cowpea variety, replacing almost all varieties, is tolerant to golden mosaic virus

Kashi Kanchan is another photo-insensitive cowpea variety which is highly tolerant to golden mosaic virus and *Pseudocercospora cruenta* diseases. It is suitable for sowing in both spring-summer and rainy seasons. It flowers 40–45 days after sowing and becomes ready for picking 50–55 days after sowing. It bears 40–45 pods/plant. The pods are dark green, tender, pulpy with less fibre and free from parchment layer. This gives an average yield of 150–200 q/ha.

Bhima Raj is a new onion variety which produces dark red and oval-shaped bulbs with single centre and thin neck. The TSS ranges from 10.0 to 11.0%. This variety is suitable for *kharif* and late *kharif* seasons in Maharashtra, Karnataka and Gujarat. This is also suitable for *rabi* season in Rajasthan, Gujarat, Haryana and Delhi. Bhima

Onion Bhima Raj, a variety of onion with thin neck and oval bulbs

Raj matures 120–125 days after transplanting and produces no bolters. Its average yield is 25–30 tonnes/ha.

Bhima Super is suitable for *kharif* and late-*kharif* cultivation in Maharashtra, Karnataka and Gujarat. With round bulbs tapering towards neck,

its TSS varies from 10 to 11%. The variety produces quality bulbs with maximum number of single centred bulbs and average yield of 26–28 tonnes/ha in *kharif* and 40–45 tonnes/ha in late-*kharif* season. Bulbs attain maturity 110–115 days after transplanting.

Development of promising lines: *Tomato:* Two new hybrids, H 71(38.6 tonnes/ha) and H 70 (36 tonnes/ha), were found promising. Hybrids TLBRH 5, TLBRH 6, TLBRH 9 and PH 5, were found suitable for polyhouse cultivation. Two individual plant selections from crosses of Arka Meghali × RF_4AF_2-15-14 and Arka Vikas × RF_4A showed promise for yield (up to 2 kg/plant) and tolerance to moisture stress. Two F_1 hybrids of Arka Meghali × IIHR 2249 and Arka Abha × IIHR 2223 were found promising for yield (29 tonnes/ha) and heat tolerance.

Tomato Hybrid 70 ready for fresh marketing

Okra. Hybrid, OH l gave highest fruit yield (16.98 tonnes/ha) followed by OH 5 (15.21 tonnes/ha) in summer, while highest fruit yield in *kharif* was recorded in hybrid OH 4 (18.84 tonnes/ha), followed by OH 5 (18.27 tonnes/ha) and OH l (17.79 tonnes/ha). Okra Arka Anamika was found suitable for polyhouse cultivation.

Okra hybrid OH 5

French bean. Arka Suvidha gave maximum pod yield of 19.5 tonnes/ha. Five test accessions, IIHR 125, Arka Bold, IC 525232, IC 525233 and IC 525236, were found resistant to rust under field conditions. Breeding line of cross IC 525224 × IC525239 was resistant to stem fly (0.67 maggot/plant) and possessed good pod quality. Thirty-three plants were selected with tolerance to high temperature, good pod quality and high yield attributes from the crosses between IC 525224 (heat tolerant) and Arka Komal or Arka Anoop. Arka Komal and 'Hebbal Avare 3' were found suitable for polyhouse cultivation.

Watermelon. Watermelon IIHR 70 was found to be a promising genotype with a high yield potential. Eight identified accessions were found free from watermelon bud necrosis virus (WBNV). Evaluation of 45 progenies of a T3 transgenic watermelon confirmed the presence of a single copy of gene showing complete resistance to WBNV.

Muskmelon. IIHR 138, muskmelon hybrids Gyno~998 × Punjab Sunehari (33.77 tonnes/ha), Arka Jeet × IIHR 616 and MS 5 × Punjab Sunehari recorded maximum fruit yield (32.53 and 31.5 tonnes/ha).

Capsicum. Seven promising individual plant selections were identified for heat tolerance from eight F_4 populations.

Cauliflower. IIHR 316-1 (430 g), IIHR 73-56 (417 g) and IIHR 371 (423 g) recorded maximum curd weight.

Carrot. Inbred lines carrot Sl 14 (26.961 tonnes/ha), Sl 264 (26.40 tonnes/ha) and Sl 260 (26.25 tonnes/ha) recorded high yield.

Garden pea. Yield was more in lines IIHR 697 and IIHR 756. Thirty plant selections were made from F_3 progenies of the crosses between high-yielding varieties/lines (IIHR 7-6, IIHR 7-2, IIHR 18, IIHR 19 and CHPMR 1) and high temperature tolerant lines KTP 4, IIHR 544 (Magadi local) and Oregon Sugar Pod.

Dolichos bean. The lines, IIHR 05-16 and IIHR 05-29, were found high-yielding. The IIHR 3-3 (19.1 tonnes/ha), IIHR 2-1(19.85 tonnes/ha) and IIHR 1-1 (16.13 tonnes/ha) were found promising advanced breeding lines with high pod yield.

Amaranth. JSR 04-86, IC 469607 and IC 469621 were found promising lines with respect to leaf weight (55–65 g) with high yield of 104-156 g/plant.

Arid vegetables: Of the cultivars of arid vegetables released, Thar Manak is a variety of mateera developed through selection from a cross of Mateera AHW 19 × Sugar Baby. Its fruits contain very big, bold and blackish seeds, which are free from cracking under extreme arid conditions. Thar Samridhi bottle gourd was derived from a cross of Banswara Local l × Gujarat Local 1. It could be harvested earlier than other varieties.

Yellow onion for export: Onion Mercedes, Couger, Linda Vista varieties/hybrids are suitable for growing from September to February. The trials conducted on broad bed furrow (BBF) with drip irrigation indicated the yield potential up to 50 tonnes/ha as against 13 tonnes/ha (national average). This successful technology is transferred to farmers' fields in Pune and Nashik districts. The trial consignments of yellow onion organized for export to Germany through private traders indicated a promising chance for enhancing export to European Union. Finalization of forward linkages

Onion Mercedes is ideally grown during September–February

and transhipment with established backward linkages can help in developing export market to 2–3 lakh tonnes additionally. This technology will help in diversification of traditional onion, which normally creates problem of glut during February-March.

Resistance sources: Of the 307 field-resistant genotypes of pepper leaf curl virus (PepLCV) (2004–05), selfed progenies of eight symptomless and highly resistant lines were challenged by viruliferous white fly in a glasshouse. Three genotypes, viz. GKC 29, BS 35 and EC 497636, showed no symptom. Using scion and rootstock of susceptible genotype (Pusa Jwala), these three putative symptomless genotypes were further challenged by alternate grafting. The resistant reactions of GKC 29, BS 35, EC 497636 were confirmed. The DNA of these lines were further subjected to PCR amplification with degenerate primers designed to detect begamovirus like PepLCV. None of the genotypes showed any amplification, suggesting that the resistant reaction in three identified resistant sources was because of the absence/non-replication of viral genome and these lines are not the symptomless carrier.

ToLCV resistance in tomato: The F_4 population derived from *L. hirsutum* and *L. chilense* carrying *Ty1* and *Ty2* genes were grown and highly resistant families with desirable agronomic traits have been selected in F_5 generation. These *Ty1* and *Ty2* genes complement each other and offer enhanced resistance for management of tomato leaf curl virus.

Potato: A high-yielding, early-maturing hybrid, JX 123, was registered as a unique germplasm. The hybrid produces yellow peel, oval tuber with shallow eyes having light yellow flesh. It has a very good general combining ability for yield and very early (60 days) and early (75 days) harvesting. Hybrid MP/97-644 was released as first processing potato variety Kufri Himsona for cultivation in hills of Himachal Pradesh. It has not only superior processing qualities and higher dry-matter content than a popular variety Kufri Jyoti, but also resistance to late blight. Its cultivation will fulfil the long-felt need of processing units, particularly in and around Delhi, Haryana and Punjab, where Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, and Kufri Himsona will provide round-the-year availability of good-quality processing raw material.

In India, there is no variety exclusively suited for preparation of French fry. A hybrid, MP/98-71, producing oval-long tubers, more than 20% evenly distributed dry matter and good yield in north-western plains has been developed. The hybrid is suitable for preparation of French fries which has been verified by the industry.

Hybrid SM/93-237 has been identified as high-yielding as compared to Kufri Jyoti and Kufri Giriraj. It has better resistance to late blight and higher dry-matter content than Kufri Jyoti and Kufri Giriraj. It is also better under controlled and ambient temperature conditions. Besides, its attractive medium-sized, oval-oblong, synchronous tubers are free from cracking.

Potato hybrid J/93-86 is ideal for growing in north India

Hybrid J/93-86 has been identified as a high-yielding and early-maturing white tuber hybrid with moderate resistance to late blight. It has performed well for yield in entire north Indian plains under both replicated and on-farm trials. Its keeping quality is better than Kufri Ashoka and Kufri Pukhraj. It is ideal for Haryana, Punjab, Rajasthan, Uttar Pradesh, Gujarat, Bihar, Madhya Pradesh and West Bengal. This is likely to be a good alternative for early-maturing Kufri Ashoka, Kufri Chandramukhi and Kufri Pukhraj.

Plantation crops: VTL 12, a high-yielding arecanut (Saigon), was identified with an average yield of 3.88 kg challi/palm/year. Arecanut hybrid VTLAH 1 was developed with an average challi yield of 2.54 kg/palm/year.

Ten superior *oleifera* palms No. Eo 23 (66.76), Eo 22 (66.53), Eo 05 (66.44%), Eo 11 (65.28%), Eo 02 (63.84%), Eo 04 (63.84%), Eo 19 (63.54%), Eo 20 (63.54%), Eo 18 (63.13%) and Eo 17 (62.17%) were found promising parents for interspecific hybridization.

Four hybrids, Vittal Cocoa Hybrid 1 (VTLCH 1), ICS 6 × SCA 6 (VTLCH 2), II 67 × NC 29/66 (VTLCH 3), I 56 × II 67 (VTLCH 4) and a clone

NC 45/53 (VTLCC 1) with an average yield potential of 1.245, 1.145, 1.478, 1.481 and 1.238 kg dry beans/plant/year respectively, were developed. These hybrids/clone meet the international standard of bean size of more than 1 g, contain internationally acceptable levels of fat content (>50%) and low shelling (10–12%).

Spices: Four black pepper hybrids, viz. IISR Thevam, IISR Sakthi, IISR Girimunda, and IISR Malabar, and two high-yielding value-added (high curcumin) turmeric varieties, viz. IISR Alleppey Supreme and IISR Kedaram, with resistance to leaf blotch disease were released. Sweet fennel accession AF 254 was found to contain more sweetness and high essential oil content. It is being utilized in crop improvement programme through hybridization. The large-seeded fenugreek accessions, AM 108, AM 92 and AM 35, have been identified for high yield.

A high-yielding anise NRCSS A-Ani 1, with a yield potential of 1.15 tonnes/ha, bearing attractive seeds and high volatile oil content (3.5%) is suitable for cultivation in semi-arid region under irrigated conditions. Celery line, NRCSS A-Cel 1, was developed with an average seed yield of 8 q/ha under semi-arid condition and high essential oil content of 2.4%.

Carnation Hybrid IIHR P1 is resistant to *Fusarium*

Flowers: Two superior breeding lines of rose, IIHR P 13 and IIHR P 15, were identified. Eight lines were identified resistant to thrips under polyhouse condition. In carnation, a hybrid IIHRP 1, was developed showing resistance to *Fusarium* wilt.

Medicinal and aromatic plants: A genotype HAV 5-11 of aloe (*Aloe barbadensis*) for higher leaf yield (2,675 g), and HAV 04-4 for highest mucilage (70%) against the local check HAV 1 (60%) were identified. Selection 4B, 13 carrot and 15 baruch of ashwagandha (*Withania somnifera*) have been identified for 21.24, 30.89 and 21.62% increased dry root yield, respectively, over the existing variety WS 100. The highest seed yield (8.96 g/plant) of isabgol was recorded in genotype RI 49 followed by RI 149 (8.82 g), RI 87 (7.98 g), RI 99 (7.83 g), RI 9808 HI 8 (7.12 g) and HI 6 (6.88 g) as against the best check HI 5 (5.86 g).

Tuber crops: Varieties identified and recommended in different tuber crops are: Sree Jaya, Sree Vijaya and Sree Prakash of cassava; IGSP 4, IGSP 17, RNSP 3, Indira Sakerkand, Bidhan Jagannath and 90/704 of sweet potato; PKS 1, RNCA 1, BK Col 1, Jhankri, Bidhan Chaitanya, Indira Arvi 1, Ahinakatchu and Kadma Arvi of taro; NDB 21 and NDB 3 of banda; NDA 9 of elephant-foot yam and Orrisa Elite of yam.

BIOTECHNOLOGY

A novel constitutive promoter identified and cloned from *Arabidopsis thaliana*

A novel ***Arabidopsis thaliana* promoter** identified is capable of driving high-level constitutive expression; and considered to be better than the widely used promoter CaMV 35S. **Transgenic mustard** (cv. Varuna) that expresses ß-farnesene synthase with repellency to mustard aphids has been developed.

Transgenics in crops: ICAR Network Project on Transgenics in Crops, a new initiative since 2005–06, has two main components-functional genomics and transgenics development.

Functional genomics. The focus of this component is on gene discovery for important agronomic traits in rice, wheat, maize, brassica, chickpea, tomato and banana. Genome databases for these have been created to retrieve information on ESTs (expressed genes), DNA markers, cloned genes, and other important information from a single web portal, that provides easy links to different statistical and genome analysis software.

Specific genes and pathways related to drought-stress response in maize have been identified. Allele mining has been done for *teosinte branched1* (*tb1*) gene, responsible for prolificacy trait in maize, and also initiated for *Yellow1* (*Y1*), a key gene of maize, regulating carotenoid biosynthesis.

Transgenics development. Transgenic

Pigeonpea genomics

A comprehensive genomics programme in pigeonpea has been initiated under the Indo-US Agricultural Knowledge Initiative (AKI) in network mode involving ICAR, Indian and US Universities and ICRISAT. More than 5,000 EST DNA sequences have been submitted in public databases. Several mapping populations are being developed. UC Davis has developed one bacterial artificial chromosome (BAC) library of pigeonpea to be used as a common resource for genome sequencing. The mapping populations and a mutant population being created in pigeonpea variety *Asha* will be used for discovery of genes involved in diseases resistance, yield and quality.

>592F well L06 CustomA02-
N20-E05-A18-C21+amit.y
Run01 Cimarron 3.12 275
GCGCCAAGCCCATGGAGTTN
AAGNTTTACAACAACTGCAGC
CAAGCCCGT
NATTCCCCAAAGACGGACCA
ATCCAGCAGCTTCTACTGCTA
CCCATGCTC
CCACTCCCTTCGCCGCCGCC
GACGCCAGCTTTCCCCTCAG
CTACCAGATC
GGTAGTGCCAGCGGCCGCCG
ACGCCACCCCTCCACAAGCC
GTGATCAANC
TCGCCGGACCATGCCGGTGC
AGGCGCTGATGGACCCACGC
GCCGGCCGCC
GGCCTAAACCAGGAAAGCCT
GGGGCCCGCCCTTNGCCGAC
CCACGCTAGG
TTCGCCAGNANANGCGAATC
CCAGGNGACGGCCNCCACGA
CCCATCCGAA

Allele mining for prolificacy gene *tb1* in Sikkim primitive maize line IML 592

development is going on in 14 crops for resistance to insect/pests, viral, fungal and bacterial diseases, and that enahnces tolerance to drought and salinity. These are at different stages of testing. Mustard transgenic expressing transcription factor encoding genes *ZF1* and *DREB1* has responded favourably

Comparative response of transgenic mustard wild type to water stress lines (*left*, wild type; *centre* and *right*, transgenic lines)

to water stress in Phytotron conditions compared to wild types.

Transgenics of chickpea and pigeonpea. Chickpea (DCP 92-3 and C 235) and pigeonpea (Bahar and MAL 13) have been transformed with *Cry1Ac* gene. Transformation frequency was less in chickpea (5–9%) as compared to pigeonpea (21%). Well-established plantlets of these transgenics are maintained under controlled conditions.

Fruit crops: In banana, morpho-molecular characterization of newly identified species (*Musa kuppiana*) from north-eastern India revealed that this species appeared to be a transitional species between the two sections, viz. *Ensete* and *Musa*. It will be an interesting species to study the origin and evolution of bananas. Embryogenic cell suspension was successfully developed in Nendran, Rasthali and Ney Poovan bananas for developing transgenic varieties against Sigatoka leaf spot and wilt diseases. Complete genome of banana streak

Improved Pusa Basmati 1 through Molecular Marker-Assisted Selection

An improved version of Pusa Basmati 1, resistant to bacterial blight, has been developed for the first time through MAS, and released for commercial cultivation. It combines with genes *xa13* and *Xa21* for bacterial blight (BB) resistance with basmati quality traits of Pusa Basmati 1, and 23.5% higher yield of well-known Taraori Basmati.

InsCot for cotton cultivars information

An Information System on Cotton Cultivars (InsCot) has been developed to provide information on all cultivars released by different agencies so far. This user-friendly CD has been developed using Visual Basic, NET as front-end and Microsoft Access as back-end for data storage. The information includes name of the cultivar, agency that developed, year of release, notification number, area adopted, species, pedigree/parentage, agro-ecology, yield, duration of crop, ginning outturn, staple length, micronaire value, bundle strength, counts, resistance and susceptibility to biotic/abiotic stresses, and special features.

virus (Accession No. DQ 859899) was cloned, sequenced and deposited in NCBI genbank. The viral genome was 6950 bp long with three ORF's and more similar to BSV-OL and GD sequences. Intergenic BSV sequence (900 bp) was cloned for assessing the promoter activity.

Three accessions of banana resistant to *Fusarium* were identified. The antimicrobial peptide gene was cloned and successful transformants with AMP gene were generated in Ney Poovan and Rasthali. In papaya, seeds were collected from electroporated plants of Solo papaya with a gene for coat protein of papaya ring spot virus (PRSV). Among them, 25 PCR positive seedlings were found resistant to PRSV.

A scion grafted susceptible Pusa Jwala variety of brinjal

Vegetable crops: Gene transfer has been achieved in tomato H 86 and brinjal Baigan 9 by the *Agrobacterium*-mediated transformation using *Cry 1Ac* gene. More than 125 putative transgenic plants have been regenerated. PCR analysis confirmed the presence of *nptII* and *Cry1Ac* gene, and Southern hybridization confirmed the single copy gene integration. The plants were also tested for strip test and ELISA test, which confirmed the gene expression. The transgenic plants are being used for insect bioassay and segregation analysis.

For drought tolerance, tomato plants were transformed with *DREB1A* gene, a transcription factor under the control of a desiccation inducible promoter Rd29A. Of the 21 lines of tomato, T1 plants from three lines have shown good tolerance to moisture stress with normal flowering, fruit setting and fruit bearing. Forty tomato selections were made with combined resistance against tomato leaf curl virus (TLCV), bacterial wilt and early blight, and one selection with combined resistance to TLCV, bacterial wilt and root-knot nematode.

The work on development of transgenic tomato for combined resistance to TLCV and PBNV in 4 different genotypes resulted in 65 T2 transgenic plants, of which 37 plants had the gene for TLCV, 10 had the gene for PBNV and 11 plants had resistance genes for both the diseases. Development of transgenic tomato Arka Vikas for resistance to *Alternaria solani* resulted in generation of 21 plants with *Trichoderma harzianum* and 5 with *Metarrhizium anisopliae* chitinase gene constructs. Among them, one plant each with *T. harzianum* and *M. anisopliae* showed resistance to *Alternaria solani* which was associated with the presence of transgene. Molecular characterization of one isolate of tomato was carried out.

Development of T-rep gene construct. Viral samples from infected field were used for cloning of replicase gene of TLCV. An amplicon of ~450 bp was amplified and cloned. In this way, 479 nucleotides long DNA stretch was cloned in at Pst I site of a binary vector pCAMBIA2301 having 35S promoter and terminator. The vector was transformed to *E. coli* strain DH5α**.** The binary vector pCAMBIA 2301 carrying conserved rep gene was finally mobilized in *Agrobacterium tumefaciens* strain LBA4404.

Potato: Genetic transformation studies with a new *Ntinhh* gene construct resulted in development of nearly 200 lines of Kufri Jyoti and 50 lines of Kufri Chipsona 1. Another 170 putative transgenic lines of Kufri Chipsona 1 encoding refined PTGS construct and invertase genes were also developed. Some of these lines, if characterized to be cold chipper, are likely to give boost to potato-processing units by making available large quantity of cold stored raw material.

In-vitro rooting in safed musli

Medicinal and aromatic plants: Shoot regeneration of safed musli (*Chlorophytum borivianum*) was achieved from immature inflorescence explants of safed musli on half-strength Murashige and Skoog (MS) medium supplemented with BA (1.5–3.00 mg/litre), Ads (50–100 mg/litre), NAA (0.01–0.1 mg/litre) and 3% (w/v) sucrose under a 16-hour photoperiod. Micropropagated plantlets were hardened in greenhouse success-fully.

SEED

Breeder seed production: Over 5,291 tonnes of breeder seed of crop varieties have been produced, including oilseeds (2,177 tonnes), cereals (2,049 tonnes), pulses (938 tonnes), forage crops (104 tonnes) and fibre crops (23 tonnes).

Quality seed production: Over 61,000 tonnes quality seed, including breeder seed of oilseed, cereal, pulse, forage and fibre crops has been produced under the Project, 'Seed production in agricultural crops and fisheries', which is double the quantity produced in the preceding year.

More than 8,000 tonnes seed was produced under the participatory seed programme at the farmers' fields, at the University of Agricultural

Sciences, Dharwad; Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpurl; Narendra Deva University of Agriculture and Technology, Faizabad, and Maharana Pratap University of Agriculture and Technology, Udaipur.

Seed production technology: More than 2,500 tonnes of breeder seed has been produced for state release varieties directly by the centres as per the indent of the respective states. *Panicum maximum* seed harvested 25 days after panicle emergence showed better seed quality.

Seed storage: Storage insects infesting wheat, pearl millet and paddy can be effectively controlled for three months using Emamectin benzoate at 2 parts per million (ppm), Lufenuron at 5 ppm or Deltamethrin at 1.0 ppm. Packaging at most of the farmers' houses can be suitably done using polylined jute canvas bags (PLJC) as well as high density polyethylene interwoven bags (HDPE).

Seed health: Seed treatment with neem oil at 5.0 ml/kg effectively controlled pulse beetle infesting mungbean, pigeonpea, chickpea and cowpea for 3–6 months without impairing seed germination.

A total of 224.92 lakh saplings and 0.5 lakh tonnes seeds of various horticultural and vegetable crops; and 2,800 packets of mushroom spawn have been produced.

Poverty alleviation in tribal areas through quality seeds

Rural appraisal showed that 67% of tribal farmers used their own farm-saved seeds and 40% did not follow seed treatment practices. Distribution of quality seeds of improved varieties to tribal farmers in Betul, Chicholi and Ghoda Dongri blocks of Madhya Pradesh enhanced seed yield over local varieties up to 60% in soybean, urdbean, rice, transplanted rice and maize.

PPV and FR Act and DUS testing through ICAR-SAU system

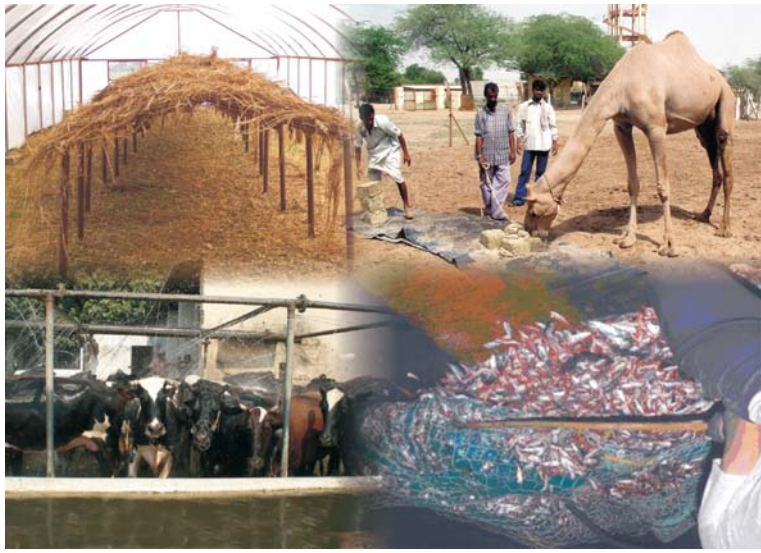
National Test Guidelines for 35 crops for the examination of their Distinctiveness, Uniformity and Stability (DUS) parameters as per the prevailing international standards have been developed. These can be applied for the implementation of the Protection of Plant Varieties and Farmers' Rights Act, 2001. Also, Reference Varieties for specific traits have been identified.

HONEYBEES AND POLLINATORS

Seed yield increased by 21% over control in mustard at Bhubaneshwar and by 15% in sunflower at Coimbatore through honeybee-mediated pollination.

Research work at the Kerala Agricultural University on stingless bees *Trigona irridipennis* for honey and pollination of crops resulted in development of earthen pots, bamboo splits and PVC for artificial nest material. Similar research at Assam Agricultural University, Jorhat, using wooden and whole bamboo nesting systems is in progress to home various stingless bee species. And successful development of colonies is in progress.

Bumble-bees are good pollinators but are available only in temperate conditions as in Himachal Pradesh. The Solan Centre of AICIRP on Honey Bees and pollinators in Himachal Pradesh is conducting experiments on artificial rearing, pollinators of important crops of that region. ❑



8. Livestock Management

ANIMAL MANAGEMENT

Cattle

CLA content in milk: The conjugated linoleic acid (CLA) content was significantly higher in milk of both cows and buffaloes fed high forage diet. Providing high forage diet increased milk yield in buffaloes as compared to high concentrate diet. CLA content was almost double in ghee prepared by indigenous method as compared to creamery method.

Sustainable milk production system

Annual milk productivity per cow, per labour and per acre land was sustained at 5,100, 14,450 and 8,640 kg, respectively, through application of integrated system approach comprising integrated breeding system (IBS), straw based feeding system, eco-friendly housing system and optimum herd management system. The sustainable milk production system was validated at a Gaushala.

Chelated zinc: Chelated zinc was prepared by enzymatic hydrolysis of soy protein in a single stage or double stage process using different enzymes to achieve maximum degree of hydrolysis (DH) for the preparation of zinc chelate. Per cent recovery of zinc declined as the level of zinc used for chelation increased. Absolute content of zinc in chelate increased as the addition of inorganic zinc increased from 5 to 20%. Protocols/technology for the preparation of chelated zinc by enzymatic hydrolysis of soy protein was developed and tested for its efficacy.

Energy expenditure: Energy expenditure (EE) of cattle was less when fed chaffed paddy straw *ad lib.* and at restricted level of intake, compared to that of un-chaffed paddy straw fed *ad lib*. Chaffing of maize stover resulted in 15–17% lower energy expenditure by animals, thus saved biological energy for productive purposes. Chaffing resulted in 11–12% reduction in CO_2 and 20–25% reduction in methane production by cattle.

Detoxification of aflatoxins: Plant extracts like olive oil, garlic and turmeric showed highest efficacy in reducing aflatoxin levels in feeds. Ethiglacetate extract of herbal products like neem-bark, annaa-seeds with witharia prevented mycotoxin contamination in stored feeds.

Pesticide residues: An analytical technique was developed for measuring the residue of imidacloprid in water and soil samples. A detection limit of 0.5 ppb was achieved.

Jatropha cake for animal feeding: Jatropha cake, a byproduct of jatropha, which is being promoted for bio-diesel production, contained phorbol esters an anti-nutritional factor responsible for toxic effects in animals. The seed-kernels were rich in crude fat and protein.

Microbial protein: Supplementation of finger millet straw based ration with rumen degradable nitrogen showed that digestibility of nutrients, PDC index and estimated microbial protein synthesis (spot as well as total urine) was comparable in all the supplemented groups. The optimum level of microbial protein synthesis was at 15 g RDN (rumen degradable nitrogen) level of supplementation with finger millet straw based diet.

Feed processing: Cooking significantly reduced IVDMD of maize, sorghum and finger millet grains while processing of wheat grains did not have any effect on the IVDMD. Treating maize, sorghum and rice grains with microwave significantly reduced IVDMD.

Evaluation of sperm quality of Frieswal bulls: Evaluation of frozen semen of Frieswal bulls showed that progressive motility ranged from 58.48 and 43.13% and acrosomal damage from 7.55 to

18.26%. The GOT and GPT enzyme activity in seminal plasma did not differ among bulls, whereas ACP and AKP differed. The total sperm abnormalities in Frieswal semen did not differ among bulls of different age groups. Proportion of free heads decreased with the advancement of age.

Embryo transfer: Superovulated Frieswal cows — 3 with folltropin V and 2 with folligon — produced 30 embryos, out of which 6 were of transferable quality. Transfer of these embryos to 5 recipients resulted in birth of two calves (one male and one female).

Augmenting reproductive efficiency: Additional energy supplementation through locally available ragi (finger millet) during the first month of postpartum (transient period) augmented reproductive efficiency in crossbred cattle in field condition. Ragi feeding during transient period avoided a steep fall in body condition score during first month postpartum. Blood plasma glucose and cholesterol showed significant negative correlation with the day of occurrence of first postpartum heat, but blood urea nitrogen, milk urea nitrogen and milk yield showed a positive correlation.

Stress related enzyme assay: Methodology for determination of stress related enzymes i.e. superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) was standardized both in blood plasma and haemolysate.It could be used as a tool to asses the effect of stress on animals.

Buffalo

Strategic supplementation for improving production: Feeding wheat straw/*bajra kadbi* based **complete feed blocks** improved milk yield in buffaloes. Incorporation of **limiting amino acid rich supplements**, like cottonseed cake and soybean cake in the diet of buffaloes resulted in 6–10% increase in milk yield. **Energy requirement** of pregnant buffaloes could be met with 55% TDN and 12% CP during ninth month, and with 60% TDN and 14% CP during the last month of gestation. **Higher plane of nutrition** did not improve conceptus growth, milk production or body condition score in early lactation. For optimum growth of Nili-Ravi buffalo heifers (647 g/day) the **concentrate level in diet** should not exceed 60–70% of DM intake as higher concentrate diet predisposes animals to ruminal acidosis. **Economic feeding regimen** was developed using urea impregnated sherry waste in combination with barley grain in place of conventional concentrate supplements for male buffalo calves for meat production. **Postpartum buffaloes** fed 120% of energy requirement had low reproductive performance in comparison to buffaloes fed either 80 or 100% of energy intake indicating that higher energy allowance than recommended levels may not be necessary.

Limiting amino acid in buffaloes: Buffaloes fed high bypass protein (UDP) rich in limiting amino acids diets showed an increase in milk production over that of controls. Milk fat percentage increased in all animals with progress of lactation indicating that ration for high yielding buffaloes need to be supplemented with bypass protein rich in limiting amino acid (lysine and methionine).

New fungus genus identified: *Cyllamyces icaris* p. nov., a new anaerobic gut fungus with nodular sporangiophores was isolated from the dung sample of *Bubalus bubalis*. It resembled the previously described *Cyllamyces aberensis*. These fungi hold special significance in the degradation of poor quality feed in ruminants.

Foot-and-mouth disease

Samples received from various states were processed and field samples revealed type Asia 1, type O and type A. 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. Serotype A isolates showed an r-value of <0.2 with current vaccine strain IND 490/97 implying the demand for new vaccine strain. Molecular epidemiological studies revealed endemic co-circulation of genotype VI and VII since 1990 in type A. But since 2001, dominance of genotype VII and disappearance of genotype VI from field was noted. FMDV type A recent field isolates were processed for molecular epidemiological analysis. In phylogenetic tree, all the isolates were clustered in genotype VII as with previous years indicating incessant supremacy of genotype VII in the field.

Genotype differentiating ELISA and RT PCR were developed to distinguish between genotype VI and VII. It gives a fast preliminary indication on the genotype prevalent before proceeding with thorough sequencing of 1D region, which definitely continues to be the confirmatory method to assign genotype by phylogenetic analysis. Similarly genotype-differentiating ELISA was also developed to find out the genotype of type A. Since this assay is very simple and technically not demanding, samples can be subjected first to ELISA and then ELISA—negative samples can be subjected to PCR. Both the assays were effective in molecular epidemiological investigation of FMDV type A in the country.

Strains IND 40/00 and IND 81/00 were selected as candidates for FMDV type A vaccine. IND 81/00 showed marginally superior antigenic relatedness with the recent field viruses than IND 40/00, and hence both of these are effective vaccine candidates in present context. At present national repository contains 1,292 (818-O, 257-Asia 1,202-A, 15-C) field isolates.

Improvement of semen quality: Buffalo bull semen collected during different seasons, revealed significant seasonal variation in seminal plasma AKP, ACP, GOT and GPT in pre-freezing and post-freezing sperm motility, but not in ejaculate volume, mass activity, seminal plasma protein, cholesterol and testosterone level. Semen samples with higher values of sperm total motility, progressive motility, rapid motion and viability showed that these can be used as indicators for assessing semen quality and predicting fertilizing potential.

Zinc: Its supplementation significantly improved semen characteristics, viz. motility, sperm constriction and serum testosterone in buffalo bulls; organic form of Zn performed better in terms of per cent live spermatozoa and acrosomal integrity in addition to *in vitro* fertilizing ability.

Immunoblotting technique for detection of anti-oxidant enzymes: A sensitive technique for detection of anti-oxidant enzymes superoxide dismutase (SOD) and catalase (CAT) in serum, follicular fluid, oviduct, uterine secretions of pregnant and non-pregnant animals, was developed. The results confirmed that activities of both Cu-Zn SOD and catalase modulate according to the stage of estrous cycle and early pregnancy in buffaloes.

Vitrification of *in vitro* matured buffalo oocytes: For successful vitrification, BSA supplementation in maturation media showed positive influence on post-thaw survival and maintenance of developmental competence of *in vitro* matured buffalo oocytes, in comparison to FCS supplement. Post-thaw IVF-rate of *in vitro* matured buffalo-oocytes vitrified using ethylene glycol (EG) was high.

Blood profile: Plasma albumin levels were lowest in heifers and highest in late pregnant dry animals. Globulin levels varied nonsignificantly between different groups of diverse reproductive status. Blood urea was significantly higher in late pregnant animals as compared to heifers.

Environmental pollutants: High concentrations of heavy metals particularly cadmium caused cell death, lowered the growth potential of oocytes/ follicular somatic cells and sperm functions leading to infertility in buffaloes.

Sheep

Strategic supplementation for improving production: Supplementing 200 g of **concentrate mixture** during 3–6 months of age of lambs maintained on community grazing lands resulted in additional benefit of Rs 300/lamb. Supplementation of 300 g concentrate mixture during pregnancy in sheep maintained on grazing lands was adequate to meet the requirement of dam as well as for growing feotus**. Fallen tree leaves and stovers** of coriander cumin, *methi*, fennel, *ajwain* could be used as partial source of roughage in complete feed block. Utilization of abundantly available **damaged wheat** as a replacement of conventional and costly cereal supplement in lambs could economize cost of mutton production.

Standarised transcervical AI technique: Frozen-thawed semen using transcervical artificial insemination (TCAI) technique was standardized. A protocol for obtaining multiple births through precise control of ovulation using exogenous hormones was developed. The efficacy of indigenous vaginal sponges in inducing estrus among anoestrus ewes during non-breeding season was tested and found effective in regulating anoestrus cases.

Goat

Socio economic study

Black Bengal: Socio-economic condition, management practices and housing pattern were studied among adopted villages. This breed is highly prolific having 83.72% multiple births. The kidding rate was 1.80, the highest among all the goat breeds of the country. The age and weight at first kidding were 378±2.12 days and 13.52±0.22 kg. The overall mortality was 7.8% under field conditions. The socio-economic studies revealed that in Nadia district of West Bengal goat rearing proved more beneficial to the goat keepers having basic knowledge of animal husbandry. The annual income of a family was Rs 2,384.06 from goat rearing.

Black Bengal goat is highly prolific having 83.72% multiple births

Sangamneri: Baseline information on growth, production and reproduction were recorded. Economic gain through increase in body weight for 3 and 6 months of age, was Rs 42.40 and 30.40, respectively. Similarly economic gain through increase in milk production was Rs 176.40 for 90 days estimated milk yield.

SUCCESS STORY

Commercial Goat Farming

Goats play a significant role in ensuring livelihood security to the millions of small and marginal farmers, landless labourers and rural folk. Goat rearing under intensive and semi-intensive system for commercial production is gaining momentum. A progressive farmer, Shri Rohan Singh resident of Salempur village in Farah block of Mathura district of Uttar Pradesh, started a goat farm in his village with 68 Barbari does and 2 bucks, and after 6 months 33 does and 1 buck more were added to the flock. The objective of this goat-rearing project was to produce and market pure breed Barbari goats.

The initial investment made on purchasing of breeding stock and construction of sheds and equipments was Rs 1.62 lakh and another Rs 10,000 was used as working capital. The goats on this farm were maintained under semi-intensive system of management by the two unemployed youths of the family. Besides grazing, the animals were provided supplementary concentrate feeding, mineral mixture, fodder tree leaves lopping and guar straw.

Total annual expenditure incurred on supplementary feeding of goats worked out to be Rs 10,700, and on prophylaxis schedule (vaccinations against enterotoxaemia, FMD and PPR disease and twice medication against internal and external parasites) and treatment Rs 3,500. Thus the total recurring expenditure other than family labour for a flock of 104 goats was Rs 14,200 during one year. The returns from the sale of goats in one year were estimated to be Rs 75,000. Moreover the goat manure valuing Rs 4,000 was produced and used in the agricultural farm of the owner. Thus the annual net returns to the family from goat rearing was Rs 64,800. The farmer sold all the surplus animals (pure Barbari goats) for breeding purpose to the other goat farmers at the rate of Rs 100 per kg live body weight. Concurrently the other traditional farmers of this area maintaining non-descript goats could fetch a market price of Rs 60–65 per kg of live body weight for their improved goats sold mostly for meat purpose.

Ganjam: The information regarding production and reproduction parameters was collected from the adopted area. The kidding percentage on the basis of does tupped was 73.18. In the Ganjam district of Orissa the goat is a primary source of income of tribals (Gola). The goat rearing contributed 61.54% of their annual income.

Surti: The survey work on Surti goats was conducted in Bharuch district. The improvement of 15.10% was observed at 3-month body weight due to the use of elite bucks under field conditions. Females were registered and bucks were selected from the population.

Surti—Body weight improvement was observed with the use of elite rams for breeding

Malabari: In the three village centres females were registered and bucks were selected from the population. The average gestation length, age at first kidding and inter-kidding interval were 149.34±1.49, 381.36±18.33 and 263.13±15.62 days.

Sirohi: The population growth of the flock in field was 64.93%. The breeding efficiency on the basis of does kidded was 112.66, which was lower than previous year.

Low cost animal feed mixer developed: A low cost animal feed mixer was designed and developed to mix heterogenous feed ingredients before preparation of complete feed pellets and complete feed blocks. The feed ingredients comprising 50% straw (*Cajanus cajan*) and 50% concentrate with molasses could be uniformly mixed in 10–15 min with an output of 0.6 q/hr to 1.2 q/hr. The cost of mixer is Rs 20,000 and cost of mixing 100 kg feed is Rs 25 only.

Evaluation of embryos: *In-vitro*-produced embryos at 2- to 16-cell stage were cryopreserved using conventional freezing protocol. Approximately 50 IVRP embryos were used for freezing. After thawing none of the embryos had broken zona pellucida. However, blastomere membrane reptured and their cytoplasm were found disintegrated.

Early pregnancy diagnosis: The B-mode sono graphic imaging technique was standardized enabling screening of pregnant goats within 30 days of mating, thereby, allowing rebreeding of empty animals for increasing flock fertility.

Cardinal physiology response: Thermo-regulatory characteristics of Jakharna and Sirohi bucks at different temperatures revealed that they could adapt to hot-dry, hot humid and cool periods by increased heart and respiratory rate. Temperature around 9°C seems to be critical for bucks in cool period, and ambient temperature of 40°C and vapour pressure of 20.67 mmHg during hot humid conditions.

Pig

Economic rations were formulated for grower and finisher pigs by partial replacement of costly feed ingredients with the locally available feed resources, e.g. maize with tamarind seed and molasses, wheat bran with de- caffeinated waste, fish meal with dried cuttla fish waste, silage and concentrate mixture with green cabbage leaves. Supplementation of chelated minerals with dicalcium phosphate and incorporation of coconut oil in the grower diet improved growth and feed conversion efficiency.

Camel

Unique sperm depot: Semen evaluation revealed zero or low motility in freshly ejaculated semen from camel due to formation of a unique depot of spermatozoa from which spermatozoa are continually released over a prolonged period of time and does not exhibit mass motility and individual sperm motility as seen in the cattle, buffalo, sheep and goat. The spermatozoa develop motility only after liberation from this depot, and this delay was not due to use of rubber funnel as was speculated earlier.

Semen sample after centrifugation

Gelatinous sperm pellet

Estradiol profiles: Estradiol profiles in unmated female camels are different from those of other species of livestock. These profiles monitored for 60 days in unmated female camels revealed that basal levels are relatively very high and peak levels of estradiol were observed at irregular intervals.

Mithun

Tree leaves based total mixed rations: *Lagerstroemia speciosa* (*thumero*), one of the important tree foliages having good nutritive value (8% DCP and 48% TDN), is relished by mithun under natural browsing condition. Inclusion of *Lagerstroemia speciosa* as green foliage in total mixed ration (TMR) showed higher daily body weight gain, dry matter (DM) intake, nutrient utilization and feed conversion efficiency in growing mithuns, suggesting that these tree leaves can be incorporated successfully in TMR for feeding of growing mithuns.

Vegetative propagation of selected foliages: The propagation study by using higher dosage of auxins on good quality fodder trees revealed encouraging trend with highest survival percentage, increased length and number of sprouts per stem cuttings of selected fodder tree species (*Ficus hirta*, *Ficus roxburghii*, *Lagerstroemia speciosa*, *Trema orientalis*, *Ficus hookeri*). Stem cuttings treated with IAA provide better option for multiplication in degraded pastureland of low carrying capacity.

Standardization of semen collection method: Collection of semen from mithun bulls is difficult, as they do not mount cows not-in-estrus. An innovative method of sprinkling urine from estrus

SUCCESS STORY

Successful pig farming

Shri Juby Mathew an agricultural graduate from Kodannur, Thrissur, Kerala, started a pig farm with technical assistance from the All India Coordinated Research Project on Pigs, with an initial investment of Rs 4.0 lakh in 2001. He currently maintains the parent stock of Large White Yorkshire pigs (34 adult female and 4 breeding males). More than 700 piglets per year were produced at the farm and parental stocks were also changed regularly. From each lot of piglets 50% of piglets are disposed after weaning and 50% are kept for fattening. The entire herd is fed with hotel swill, which he collects free of cost by his own tempo van and no feed additives are given to pigs. Using a locally available feed material, the hotel waste, he could achieve a litter size at birth and weaning ranging from 8–12 piglets and 7–10 piglets, respectively, and a body weight of 120 kg at 10 months of age. After 10 months, pigs were sold @ Rs 50–60/kg of body weight depending on demand of the market. Piglets are sold between Rs 800–1,000/piglet. Besides a piggery, he maintains fishery, poultry, duckery, and practices horticulture with spices and flowers. Alone from piggery, the turnover is about 2.5 to Rs 3 lakh/annum.

Ethno-veterianry medicine

Herbs used for common ailments and conditions of livestock were documented with information on their botanical and local names, active constituent, validation for use, etc, and 39 of them were identified by different centers for their evaluation in fluorosis, diarrhoea, mastitis, fever, helminthosis and ectoparasite infestation and as antipyretic, analgesics and hepatoprotectant. Experimental trial in rabbits established the ameliorative potential of tamarind fruit pulp (*Tamarindus indica*) in experimental fluoride toxicity. Methanolic extract of stone fruit (*Aegle marmelos*) powder given @ 400 mg/kg body weight in rats reduced 73.33% faecal output in castor oil induced diarrhoea. *In vitro* screening results showed that methanol extract of *ghila* (*Entada fascioloides*) seeds possessed activity against *Fasciola. In vitro* antibiogram of extracts of turmeric (*Curcuma longa*) and Indian gooseberry (*Phyllanthus emblica*) revealed antimicrobial efficacy against common mastitis pathogens, viz. *Staphylococcus aureus, Streptococcus agalactiae*, other *Streptococcus* spp. and coliform bacilli.

Utility of aqueous and alcoholic extracts of plants was determined in— *babrang* (*Emblia ribes*), *palash* (*Butea frondosa*), *kaliziri* (*Vernonia anhelmintic*a) against nematodes; Auatralian fever tree (*Ecalyptus globules*), *amrita giloy* (*Tinospora cordifolia*), *pippali*, *long*, *pipar* (*Piper nigrum*), *adulsa* (*Adhatoda vasica*), *henna* (*Lawsonia inermis*), *nirgundi* (*Vitex negundo*), *ashwagandha* (*Withania sominifera*), *punarnava* (*Boerhaavia diffusa*) as antipyretic/analgesics; and *kalmegh* (*Andographis paniculata*), *punarnava* (*Boerhaavia diffusa*), *bhrangraj* (*Eclipta alba*), *chirayata* (*Swertia chirata*) as hepatoprotectants.

cows over the perineal region of mithun cow not-in-estrus helped bulls donating the semen successfully. Urine collected from estrus cows stored at refrigerated temperature was effective till 7 days of post collection.

Estimating FSH in plasma: A simple and sensitive radioimmunoassay (RIA) procedure to estimate FSH in mithun plasma was developed. The biological validation of the assay was carried out in plasma samples that were collected during different stages of the estrous cycle.

Feed resources

District-wise database of feed and animal resources was prepared for 6 agro ecosystems of the country. The current requirement and dry matter availability from different feed resources and the projected demand and supply over the years showed that by 2020 the gap between requirement and availability should marginally increase from the current level of 19%. However, there would be a widening gap between demand and supply of concentrates.

Efficacy of AI in mithun established

The first mithun calf was born through artificial insemination using cryopreserved semen samples. The semen samples were collected from adult bulls through rectal massage method and

AI born mithun calf

cryopreserved in liquid nitrogen using tris-egg yolk-glycerol diluent. Three mithun cows inseminated using the cryopreserved semen conceived following insemination and gave birth to healthy calves.

Estrus synchronization using different protocols: Two injections of $PGF_2\alpha$ were given at 11 days apart in cyclic mithun cows for estrus synchronization, and found that all mithun cows responded to treatment. Cyclic mithun cows irrespective of any day of estrous cycle were subjected to ovsynch protocol of estrus synchronization and were inseminated following synchronization. Of the 16 animals inseminated artificially (AI) with the cryopreserved mithun semen, 12 conceived.

Yak

Complete feed block formulation: Complete feed formulation in the form of feed block was prepared utilizing the cost effective locally available feed resources for yak feeding.

Complete feed blocks

Mineral supplementation: Hair tissue mineral analysis (HTMA) proved an excellent tool for monitoring general health, nutritional status and toxic metal exposure to animals. Hair mineral profile of the yaks following supplementation of trace minerals zinc, copper, cobalt and manganese for six months revealed that Mn, Zn, Cu and Co levels of supplemented group were higher than that of the non-supplemented group. The study justified the requirement of the same.

Performance improvement in yaks through trace mineral supplementation: The supplementation of copper, cobalt, zinc and manganese at farm increased the milk production three-times and growth performance, and drastically decreased repeat breeding and anoestrus.

Estrus synchronization: Induction of estrus, synchronization of ovulation and timed artificial insemination (TAI) were attempted in yaks. The ovulation occurred usually within 50–72 hr of ECP injection. TAI was performed at 48 and 60 hr of ECP treatment. Pregnancy rate in yaks following TAI was 40%.

Endocrine status during different stages of growth: A direct simple and highly sensitive enzyme immuno assay (EIA) for GH (growth hormone) determination in yak plasma was developed and validated. Growth rate was positively correlated with mean GH and GH per unit 100 kg body weight. However, GH per unit 100 kg body weight was found to be a better indicator of growth rate. Both the concentrations decreased with advancement of age.

Artificial insemination in yak: Frozen semen technology in yak was standardized. With the use of frozen semen straws, pure yak and yak hybrid calves were born for the first time in India. Aforesaid technology is being successfully utilized in the farm and field conditions for improving yak germplasm.

Yak calf was born using frozen semen straws, for the first time in India

Wild Life

Supplementation of probiotic (mannanoli gosaccharides with or without added β-glucans) positively influenced gut health indices by altering microbial population and fermentative end products in the hindgut of dogs.

Rumen fungi: Out of 243 isolates of anaerobic rumen fungi isolated from domestic and wild ruminants anaeromyces and orpinomyces were predominant. *In vitro* gas production studies of the isolates showed that isolate CTS-110 outperformed all the isolates with respect to total gas production. Genomic library of the isolates was constructed for isolation of the cellulase gene.

Poultry

Supplementation of xylanase, produced from *Aspergillus* spp @ 3,500–4,000 U/kg improved the performance and digestibility of nutrients, reduced the NSP in intestinal digesta (21.7% in jejunum and 10% in ileum) and enhanced the mineral retention (Ca and P) in tibia and protein accretion in muscle (3.7%) over the non-xylanase supplemented DORB diet suggesting that deoiled rice bran can be included in broiler diets up to 15% with supplementation of xylanase @4,000 U/kg.

Se inclusion in diets of broilers improved antibody titers and **Zn supplementation** was needed for better immune response. Both Se and Zn complimented each other for improving immune response, particularly at low Se (0.15 ppm) and high Zn levels (80 ppm) in the diet.

Supplementing **selenium (Se)** or **chromium (Cr)** in organic form in the diet of broiler chicks decreased the activity of lipid peroxidase and increased the activities of glutathione peroxidase, glutathione reductase, RBC catalase and lymphocyte ratio thereby decreasing the holding loss during pre-slaughter fasting period.

Nutrient requirements of female parent line

Bluetongue (BT)

Bluetongue virus (BTV) isolates (15) of types 1, 2, 9, 15, 18 and 23 submitted till date, are being maintained and were characterized. No disease outbreak of bluetongue has been recorded in Uttar Pradesh, Uttarakhand, Haryana, Himachal Pradesh, Gujarat, Rajasthan, West Bengal, Orissa, Jharkhand and North Eastern states in last five years. BT outbreaks are being recorded every year from Andhra Pradesh, Karnataka and Tamil Nadu. Epidemiological maps for Tamil Nadu and Andhra Pradesh were prepared. Disease forecasting model was developed for Maharashtra centre.

Nine monoclonal antibodies clones produced against BTV reacted well with BTV r-Ag and purified BTV antigen in indirect–ELISA. Type specific primer designing, VP2 and VP7 gene cloning and expression, multiplex RT-PCR for BTV and PPRV, RNA-PAGE and nucleotide sequence were standardized. Confirmation of BT virus isolates was done by RT-PCR using VP7 gene specific primers. Inactivated BTV vaccines gave promising results in local and Bharat Merino sheep. Samples of midges from Uttar Pradesh, Uttarakhand, Gujarat, West Bengal, Haryana, and Rajasthan were identified as *C. oxystoma, C. clavipalpis, C. actoni, C. anophelis, C. orientalis*, *C. similis* and *C. imicola.*

of Vanaraja chicken during first 6 weeks of age was estimated to be 2,600 kcal/kg metabolizable energy, 20% crude protein, 1% lysine, 0.4% methionine, 0.8% Ca and 0.4% non-phytate phosphorus, respectively, for optimum performance.

Protein and energy requirements of Krishibro, a multicoloured broiler, showed that high dietary energy (3,000 kcal ME/kg in starter diets and 3,100 kcal ME/kg in finisher diets)) and low dietary protein levels (20% in starter and 18% in finisher phases) could support optimum performance and immune response. **Feed deprivation** up to 48 hr post-hatch reduced the yolk-sac utilization, gastrointestinal tract development, body weight gain, dressed weight and breast meat yield in broiler chickens. Feed deprivation for initial 24 hr after hatch had no adverse effect on performance of broiler chickens. Feeding crude gum from rice bran oil was a useful **energy supplement** in broiler diets and could be safely used in commercial broiler chicken diet with some positive effects on performance. **Crude lysolecithin** (LL) improved broiler performance.

Hormonal modulation of egg production: Prolactin levels above the normal physiological ranges in the circulation showed negative effects on egg production and increased the pause days in PB3 birds. Through endocrinological manipulation of prolactin hormone and its secretory hormone vasoactive intestinal peptide (VIP), higher levels of egg production was obtained in birds immunized against prolactin or VIP or birds fed bromocriptine by 8.9, 10.98, and 5.38, respectively, in dual purpose birds (PB3). Field testing of the protocol developed for improving egg production indicated that egg production could be improved with available resources under normal feeding practices.

Cloacal gland foam: The effect of surgical removal of cloacal gland showed that this gland and its secretion do not play any role in the fertility of quails. The actual function of this gland needs to be explored.

Rural poultry production: Vanaraja, a dual type chicken is the most popular rural variety and is a cross of two pure coloured lines VML and VFL, improved genetically through selective breeding. In VML, the shank length showed an improvement of 2.81 mm over previous generation. The genetic and phenotypic correlations between shank length (primary trait) and body weight at 6 weeks were high and positive. The 40-week egg production showed an improvement of 1.87 eggs in the present generation over the last generation. In VFL, the age at sexual maturity decreased by 3.2 days and 40 week egg production showed an improvement of 4.18 eggs over previous generation. The shank length and antibody response to SRBC improved, which is desirable for better survival in the harsh environment of rural areas. In addition, genetic improvement and evaluation of a tinted egg female line of **Gramapriya** was undertaken. In S3 generation, age at sexual maturity, body weight at 20 weeks of age and egg weight at 28 weeks of age were 164 days, 1,189 g, 49.2 eggs, respectively.

The Vanaraja bird is popular among rural masses as it is better adapted to harsh conditions of rural areas

SUCCESS STORY

Vanaraja birds in Kashmir Valley

Vanaraja chicks, 5-week-old were distributed to farmers in Kashmir valley. The performance of birds under backyard condition was highly satisfactory. Body weight of birds at 12 and 27 weeks of age was 726 and 2,850 g respectively. The hens matured between 177 and 182 days of age and the mortality between 5 and 11 weeks of age ranged from 3 to 7%. The Vanaraja chicken was very well accepted in the valley. Vanaraja chicken, which is being successfully reared in most parts of the country was also found suitable for temperate climate of Kashmir valley.

A proud Kashmiri woman farmer with a flock of Vanaraja chicken

LIVESTOCK PROTECTION

Cattle

Isolation of *Campylobacter jejuni* from semen and preputial washings of breeding cattle and buffalo bulls as well as vaginal secretions of infertile and repeat breeder cows and buffaloes, and *Arcobacter* (aerotolerant *Campylobacter*) from cattle faeces were attempted. A recombinant 41

Bacteriocin based preparation for treatment of bovine mastitis

Attempts were made to develop a formulation containing natural food-grade antimicrobials of lactic acid bacteria, i.e. bacteriocins for the treatment of mastitis in lactating animals. Biochemical characterization of the pathogens revealed the predominance of coagulase positive *Staphylococcus aureus* (35%), followed by *Streptococcus agalactiae* (12%), coagulase negative staphylococci (7%), *S. dysgalactiae* (3%), *S. uberis* (4%), *B. cereus* (5%), Gram-negative organisms such as *E. coli* (11%), *Ent. aerogenes* (4%), *Klebsiella* sp. (4%), citrobacter (1%), pseudomonas (4%), proteus (1%) and yeast (1%). Incidence of mastitis was highest in the crossbred cows (57%), followed by indigenous cows (27%) and least in buffaloes (17%). Antibiogram of selected gram-positive pathogens revealed that 95% of the isolates were MAR (multiple antibiotic resistant) variants.

Among the 53 bacteriocinogenic strains, 11 had broad spectrum of activity against several spoilage and pathogenic organisms including mastitis pathogens. The bacteriocin of potent *Lactococcus lactis* M386 was optimally produced. The bacteriocin was extremely thermostable (100°C/60 min) and active over a wide pH range (1–12).

Bacteriocin based preparation was quite effective against both gram-positive and gram-negative pathogens under *in vitro* and *in vivo* conditions. *In vivo* application of formulation through intra-mammary infusions for 6 consecutive days in clinical mastitis cases resulted in cure rate of 66.6%. The formulation was well tolerated in udder and was non-irritating to animals. It was stable for more than 3 months at refrigeration temperature.

kDa OMP protein of *Leptospira interrogans* was identified as an important antigen for serodiagnosis of leptospirosis in animals. Aqueous extract of *Phyllanthus emblica* showed *in vitro* antimicrobial activity against *Staphylococcus aureus* and *Streptococcus agalactiae* isolated from clinical cases of mastitis.

Buffalo

Bacteriological examination of fecal samples from neonatal buffalo calves led to isolation of *Escherichia coli* belonging to serogroups, viz. O139, O37, O9, O106 and O143, while parasitological screening of samples was suggestive of coccidiosis with single/mixed infection with *Eimeria* spp.

Ultrasonography of mastitis affected udder indicated fibrosis, accumulation of particulate matter, calcification and abscess in lactiferous ducts, gland cistern, glandular parenchyma and teat cistern. Teat cistern was almost obliterated with fibrosis and teat wall thickness also increased in comparison to normal teat of the same animal.

Goat

A saponified sonicated vaccine against caprine pleuropneumonia proved safe and conferred immunity in goats. Enrofloxacin could effectively be used in combination with nimesulide for treating

SUCCESS STORY

Goat-pox vaccine

Research for development of a live attenuated goat-pox vaccine was initiated in 2001. Initially, a controlled experimental trial was carried out in experimental goats to determine the virus safety, potency and protection against virulent virus challenge. The experimental vaccine provided complete protection against high dose of virulent challenge virus. It produced no adverse reaction even at 10^5 $TCID_{50}$, while it conferred protection at a dose as low as 10^1 $TCID_{50}$. Upon vaccination, goats react initially by local hyperemia at the site of inoculation with a marginal rise in temperature from 5–7 days post vaccination. These reactions are generally transient.

The protection was confirmed by virulent challenge and by determining of humoral immune response. The longevity of protection was for more than 2 years, the maximum period studied so for. Preliminary studies carried out in pregnant goats that were in different stages of gestation showed that the vaccine is safe.

The goat-pox vaccine has been widely used across the country with no adverse reports

The experimental goat-pox vaccine has passed all in-house quality control studies. A large-scale field validation of the vaccine has been going on for the past 24 months. Till date, more than a lakh doses of vaccine have been used across the country with no adverse reports. The performance of the vaccine has been satisfactory as evident from the growing demand for supply of the vaccine and also the feedback received from the end-users.

Gastrointestinal parasitism

Epizootiological studies were conducted in different agro-climatic zones of country. In Madhya Pradesh *Haemonchus* was the most predominant (44.4%) species followed by *Oesophagostomum* spp. (22.4%) and *Cooperia* spp. (6%). Amphistome infection was more common than *Fasciola gigantica* and *Schistosoma indicum*. In West Bengal strongyles constituted the major nematode of which haemonchus was the predominant species in all the animal species surveyed. In Uttarakhand, prevalence of infection was higher in sheep and goats compared to cattle and buffaloes. In Tamil Nadu, overall prevalence of 47.45% of helminth infection was recorded. In Rajasthan bioclimatograph was prepared for semi-arid and arid zones of Rajasthan for future prediction of haemonchosis and trichostrongylosis in farms. Forecasting system FROGIN was evaluated for performance in semi-arid and arid zones. In Sikkim, goats were highly susceptible to G–I helminths with 62% prevalence as compared to yak and cattle having 22 and 25% prevalence respectively. Higher helminthic infection was recorded during autumn (September–November) with 78.57% infection in goats and 33.33% in cattle, whereas, in yaks it was 25.75% in summer. Least infection could be recorded during winter. In Sikkim, *H. contortus* was predominant followed by *Oesophagostomum* spp, *Bunostomum* spp and *Nematodirus* spp. These infections were prevalent in yaks also.

ES antigen of *H. contortus* was purified by immunoaffinity chromatography. In the bound fraction 26, 32, 60 and 120 kDa polypeptides were fractionated by SDS-PAGE; and 120 kDa polypeptide was recognized as early as 4 day PI, showing promise for diagnosis of preclinical haemonchosis in western blotting. In 60 and 120 kDa polypeptide L3 larvae, were also recognized in western blotting by 4-day preclinical sera of sheep. In dot-ELISA affinity purified fraction of ES antigen could detect anti-*H. contortus* antibodies in 4-day experimental sera of sheep. In western blotting 120 kDa polypeptide of ES antigen did not show cross-antigenicity to *Oesophagostomum columbianum, Paramphistomum epiclitum* and *Fasciola gigantica*. Revalidation of dot-ELISA based diagnostic kit for *Oesophagostomum* and *Bunostomum* was initiated in goats, cattle, yaks and mithuns. In a sequel of immunoprophylactic studies H-gal-GP antigen of *H. contortus* has given promising results. Egg count reduction was 54.15% and worm count reduction 92.15% for female worms and 87.1% for male worms with absence of lesions in immunized animals. H-gal-GP antigen was purified through peanut lectin agrose column chromatography. Molecular biology technique for detection of benzimidazole resistance allele-specific PCR was standardized. Application of the technique has revealed higher proportion of homozygous resistant larvae in farmer's flock as compared to farm flock. Selected isolates of nematophagous fungi *Arthrobotyrus oligospora* from field flocks from arid and semi-arid zones reduced the number of GI nematodes. Attempts to get wild isolates of hypomycete on trematode egg from organic environment of Durg, Chhattisgarh, were successful.

susceptible bacterial infections associated with inflammatory disease conditions in goats.

Surgical and clinical interventions: Techniques for application of acrylic external skeletal fixators for management of compound fractures of small animals and circular external skeletal fixation for large animals were standardized.

Technique for dissolution of cystic and urethral calculi was developed using oral and (or) cystic irrigation of ammonium chloride or hemiacidrin in goats and buffalo calves suffering from obstructive urolithiasis/uraemia. Calcium carbonate (80%) and potassium iodide (15%) were cost-effective alternative radiographic contrast to barium sulphate to delineate stomach and large intestine and gastrointestinal and urinary tract in small animals.

Diagnostics: *Toxoplasma gondii* SAG1 gene was cloned and expressed in eukaryotic system, and the recombinant protein was successfully tested with good immunoreactivity for detection of antibodies in goats.

Field validation of cathepsin-L cysteine proteinase of *Fasciola gigantica* confirmed that this protein was specific with no cross-reactivity with *Paramphistomum epiclitum*, *Gastrothylax crumenifer*, *Gigantocotyle explanatum*, hydatid (metacestode) and *Strongyloides stercoralis*. The ELISA sensitivity recorded with this protein was 95%.

The Bm86 homologue of *Hyalomma anatolicum anatolicum* was cloned and expressed in both prokaryotic and eukaryotic systems.

Sheep

A sterile and safe inactivated pentavalent vaccine against bluetongue in sheep was developed. The combined HS+FMD vaccine passed the safety tests with no adverse reactions. The protective titre 1.5 (SN titre) indicated the need for boosting of the vaccine every 6 months. An indirect immuno-peroxidase monolayer assay (IPMA) was developed for detecting pestivirus antigen and neutralizing antibodies in small ruminants.

Pig

A PK-15 adapted cell culture swine fever virus vaccine developed at sixth passage having $10^5 TCID_{50}$ titre was found potent in pigs. Twenty-one days vaccinated pigs were protected against

Diagnostic kits developed by PD_ADMAS

virulent challenge infection. PD50 of this vaccine contained ≥ 200 PD50/dose.

RT-PCR was optimized to detect classical swine fever virus (CSFV) in 1:10,000 diluted infected cell culture fluids and to screen clinical samples.

Equines

Surveillance and monitoring of equine diseases: Unique programme of nation-wide active equine disease surveillance facilitated poor equine owners in saving the precious indigenous equine germplasm through timely diagnosis and management of diseases. An outbreak of glanders was reported during July-August 2006 in Maharashtra. Subsequently, cases of glanders were also reported from Punjab, Uttar Pradesh and Uttarakhand. Nation-wide testing on 4,395 serum samples revealed 97 samples to be positive for glanders during the year. The disease was confirmed to be glanders serologically and subsequently by isolation of the causative agent, *Burkholderia mallei* from the suspected cases. The follow-up surveillance of the area revealed no new cases from Maharashtra, indicating control of the outbreak in that state. It is being monitored continuously to assess the situation in the entire country, with particular emphasis on the equines of Uttar Pradesh and Uttarakhand. Equine infectious anaemia, African horse sickness, equine influenza and *Salmonella* Abortus equi, were not detected in the samples. Equine rotavirus strains exhibited G10, G3, G6 and G1 type specificities that accounted for 19.0, 42.9, 14.3 and 9.5% of the isolates, respectively.

Diagnostics: Haemagglutination inhibition (HAI) assay was standardized for serodiagnosis of Japanese encephalitis (JE). On testing equine serum samples, from different states, for antibodies to JE serocomplex by HAI, 14.32% samples were detected positive. An RT-PCR was also developed for detecting the virus in infected tissues. A recombinant protein-based ELISA was standardized for differentiation of EHV-1 and EHV-4. A recombinant-protein based ELISA was developed for detection of *Babesia equi* antibodies in equine sera. This assay could detect *B. equi* antibodies in equines as early as 6 days post-infection till 90 days of observation period.

Validation of EHV-1 vaccine: An equine herpes virus-1 (EHV-1) killed vaccine incorporating indigenous strain of EHV-1 was evaluated in experimental pregnant indigenous mares. Challenge studies did not reveal any fever or virus shedding. Three of the vaccinated mares gave birth to healthy foals and only one mare aborted due to EHV-1 infection after challenge. Hyperthermia and virus shedding was observed in non-vaccinated mares after challenge. On challenge, one non-vaccinated mare aborted due to EHV-1, while one gave birth to a weak foal that died within 24 hr of birth. Virus could be isolated from the lungs and liver tissues of both the foals. The vaccine provided satisfactory level of protection against EHV-1 associated abortion but before commercialization further immune response studies need to be undertaken in selected organized equine farms.

Equine health camps and farmer meets (*Ashwa Palak Goshties*)

The equine owners were enlightened on various aspects of disease control and management. In addition to the treatment of major equine ailments in these camps, deworming and tetanus vaccination were done in equines. Feedback from farmers was obtained for further research and development in equine health and production.

Camel

To popularize the knowledge of our age-old scholarly system of medicine against one of the most common skin disease sarcopticosis in camel, an indigenous medicine, M-Cure has been developed, evaluated and made available for use at the NRCC. Five to seven local applications are required to cure the disease without any sign of relapse.

In camels intra-mammary infections cause health problems of diarrhoea etc. in suckling calves. *Staphylococcus*, Streptococcus, *Corynebacterium* and *Bacillus* were the commonly encountered intramammary infections in camels. Characterization of 55 isolates of staphylococci revealed that *Staphylococcus aureus, Staph. hyicus, Staph. intermedius, Staph. haemolyticus, Staph. auricularis, Staph. sciuri, Staph. hominis, Staph. epidermidis, Staph. capitis, Staph. warneri* were associated with camels. Mean pH of quarter milk samples was within the normal range in all the non-clinically infected quarters whereas in clinically infected quarters there was a significant rise in mean pH. Increase in sodium concentration in milk of clinically infected quarters compared to

milk of healthy quarters showed increased permeability of sodium due to inflammation of the secretary tissue. There was significant variation in mean Co concentrations among negative, sub clinical, non-specific and clinical groups. However Cu varied significantly with somatic cell count of milk. Daily feeding of Cu, Zn and Se for 30 days resulted in almost 40% lower infections.

Mithun

The overall seroprevalence of antibodies to BTV in mithun was 86%. Highest seroprevalence was observed in mithuns above 4 years of age and the lowest in 1–2-year-old. The likelihood of BTV infection was almost six-times more in mithuns in the age group of 2–4 years than that of > 4 years. Seroprevalence was higher in mithuns from free-ranging system in comparison to mithuns kept in semi-intensive system of management. Likewise mithuns from free-ranging system were almost seven -times more seropositive to BTV in comparison to mithuns kept in semi-intensive system of management.

The overall prevalence of antibodies to *Neospora caninum* in mithun was 10%. Highest seroprevalence was in mithuns above 3 years of age and lowest in mithuns of 2- to 12-month-old. No statistically significant difference was observed in seroprevalence between males and females. An overall seroprevalence of antibodies to *A. marginale* in mithuns was 63% and it increased with the increase in age of animals. In both the cases the seroprevalence was higher in mithuns in free-ranging condition in comparison to mithuns kept in semi-intensive system.

The distribution of *Escherichia coli* serogroups isolated from faecal samples of mithun calves with diarrhoea revealed 72 *E. coli* strains belonging to 38 different serogroups (based on "O" antigen). Of the 72 strains isolated, 10 were not typeable and four were rough. The virulence gene profile of different *E. coli* serogroup **(**isolated from faecal samples of mithun calves with diarrhoea) was studied — *stx1* genotype was prevalent in serogroups O4 (4 strains) and O32 (3 strains); *stx2* genotype in serogroups O55 (2 strains), O2 (2 strains) and O49 (2 strains); and *hlyA* genotype in serogroup O55, O2 and O49 (2 strains in each serogroup).

Yak

Epidemiology: Infectious diseases like foot-and-mouth disease, brucellosis, infectious bovine rhinotracheitis, haemorrhagic septicaemia, tuberculosis, babesiosis and non-infectious diseases (like keratoconjunctivitis, diarrhoea, tympany) were prevalent in different yak tracts. *Staphylococci*, *Pseudomonas aeruginosa* and *Escherichia coli*, *Candida albicans* were found associated with the chronic haemorrhagic diarrhoea in yaks with prolonged antibiotic therapy. *Mannheimia haemolytica* was found in yaks for the first time in respiratory complications. Survey at Nyukmadung revealed that 19% of the yaks (27 out of 140) bear this opportunistic organism in respiratory tract. *Haemophilus somus* and *P. aeruginosa* were the common associates with this pathogen. Most of the isolates of these pathogens were muti-drug resistant. Survey revealed that 12.42% yaks were positive reactors. Incidence of gastrointestinal disorders in yaks was highly correlated with rainfall and temperature. A fast and reliable PCR was standardized for molecular diagnosis of *Babesia bigemina* in yak and its hybrids.

FMD: The antibody titre level in yaks following application of trivalent oil adjuvant FMD vaccine, sharply increased to the protective titre within one month but tended to fall from third month onwards. Protective antibody level was present up to 90 days of vaccination only. However, following booster administration, protective antibody response was rejuvenated within a short period of time.

***Senecio* induced oxidative injury in murine macrophage cell line J774:** *Senecio* poisoning in yaks is very common in Arunachal Pradesh and other

Haemorrhagic septicaemia

A low volume saponified HS vaccine was prepared and tested in dairy animals and 100% protection was observed on direct challenge at one year duration. The vaccine was also inoculated in animals at Izatnagar, Himachal Pradesh, Tamil Nadu and Orissa. No untoward reactions or any clinical signs were observed in any vaccinated animal. Apart from that, a vaccine trial of combined HS and FMD vaccine was also carried out and a booster dose was given at 6 months post vaccination. At 7 months challenge, 100, 75 and 75% protection were observed, respectively, against FMD virus type A, O and Asia 1.

Major outer membrane proteins (OMPs), OmpA and OmpH, were identified and characterized in *Pasteuralla multocida* serotype B:2 that originated from sheep, goats, cattle and buffaloes. The tbpA gene of *P. multocida* serotypes D and F were cloned and sequenced. The nucleotide amino acid sequences of *P. multocida* D:1 showed 98.5 and 96.9% homology, whereas F:3 serotype showed 97.7 and 95.2% similarities with tbpA of *P. multocida* serotype A. Apart from that 77 isolates of *P. multocida* from various animal species and birds were identified and characterized using morphological, cultural and molecular techniques. A patent for low volume saponified haemorrhagic septicaemia (HS) vaccine was submitted.

sub-Himalayan areas of India. The plant contains seneciophylline that induces severe hepato-toxicity. Ethanol extract of *Senecio* increased severe oxidative burden in murine macrophage cell line J774. Following incubation with *Senecio* DNA laddering and single stranded DNA breakage were evident.

Herbs: Indigenous medicinal plants were collected from the West Kameng and Tawang districts of Arunachal Pradesh especially in the high altitude areas of Indo-Tibetan borders. The indigenous knowledge of the local tribal people was taken into account in many cases for collection of the plants. The anti-bacterial, anti-fungal, anti-inflammatory and wound healing properties of *Saussurea costus* and *Rubus idaeus* were found out through experimental trial.

Wild life

A bicistronic DNA vaccine was developed to induce virus neutralizing antibody response against rabies and canine parvovirus in dogs. A recombinant RNA replicon – based vaccine vector with immunogenic gene from canine parvovirus was constructed.

Local application of combination of oils of *Jatropha curcas* + *Phyllanthus emblica* + *Commiphora mukul* was highly effective in mitigating immuno suppression and oxidative stress in canine demodicosis.

Poultry

A PCR was developed and applied for detection and differentiation of avian tumours and determining the prevalence of MD and ALVs in various flocks. The results were confirmed by using real time PCR, which proved that the PCR is a useful technique for detection and differentiation of tumours caused by multiple viral infections such as MDV and ALVs. The incidence of MD detected in pureline layers was 7.5, 4.1, 2.6 and 3.7% in IWK, Anand, IWH and IWI respectively. Sporadic cases of MD were recorded in PB-2, Dahlem Red and naked neck populations.

The inactivated chicken infectious anaemia virus (CIAV) vaccine protected the SPF chicks against CIAV when vaccinated at day-old age, whereas layer *Gallus* chicken vaccinated at 18 weeks of age showed induction of antibodies up to 20 weeks post-vaccination and transferred protective maternal antibodies to their progeny. The chicken embryo origin turkey pox vaccine provided 90–95% protection under field trial, whereas cell culture origin turkey pox vaccine provided 72–72% protection. The formalin inactivated Newcastle disease (ND) virus (field isolate), adjuvanted and emulsified induced humoral and cell-mediated immunity, which was comparable to that induced by inactivated commercial ND vaccine. The experimental vaccine afforded protection up to 66.6% against challenge infection.

Quality control and production of Veterinary biologicals

RD 'F' strain vaccine, lapinized swine fever vaccine, tissue culture sheep pox vaccine, HS oil adjuvant vaccine, *Brucella abortus* strain-19 (live) vaccine, enterotoxaemia vaccine, Johnin PPD, Mallein PPD, *Brucella* agglutination test antigen, *Brucella abortus* Bang Ring antigen, Rose Bengal Plate Test antigen, *Brucella* positive serum, *Salmonella* Abortus-equi 'H' antigen, *S.* Pullorum plain antigen, *S.* Pullorum coloured antigen, *S.* Pullorum positive serum, and *Salmonella* poly 'O' sera were produced and quality tested. PPR vaccine, PPR c-ELISA kits and PPR s-ELISA kits were produced and supplied by Mukteswar campus, as per demand. Monovalent FMD vaccine comprising doses of type 'O', type 'A' and type 'Asia 1' were produced at the IVRI, Bangalore campus.

A rapid and simple recombinant antigen based user-friendly ELISA test kit was developed for serodiagnosis of infectious bursal disease. A sensitive, specific and accurate recombinant haemagglutinin neuraminidase antigen-based ELISA was developed to measure the specific antibody in sera of chickens against Newcastle disease virus.

Six strains of *B. stearothermophilus* were used for antibiotic disc assay. In all, 17 antibiotics from different groups were used for disc assay. Pencillin G, ampicillin and amoxicillin depicted sensitivity at MRL dose of 0.004 µg/ml. Cloxacillin, cefalexin, tetracycline, doxycyclin, gentamycin, streptomycin and lincomycin exhibited sensitivity close to MRL concentrations, i.e 0.5, 0.5, 1.0, 10.0, 0.1, 1.0,10.0 and 1.0 µg/ml, respectively.

Animal disease monitoring and surveillance

The databank was developed on animal disease trends, disease prevalence, meteorological data, land use data, animal and human demography, soil pattern data and crop production data. Integrating these factors an interactive website—National Animal Disease Referral Expert System (NADRES) — was developed, which can predict the probable occurrence of 10 major livestock diseases in any particular district of the country. This is a user friendly programme for general public, and can be accessed through internet (www.nadres.org).

An offline version ***India.AdmasEpitrak*** was also developed for collaborating units of PD_ADMAS. This programme provides data on ecopathozones, disease prevalence studies and

frequency of disease occurrence. It helps to estimate the spatial and temporal specific disease prevalence profiles of economically important diseases.

Latex based agglutination test for detection of *Brucella* antibodies in cattle, sheep and goat was standardized using heat killed sLPS antigen. An indirect ELISA protocol for *Brucella* screening in small ruminants was standardized. Seropositivity for *Brucella* antibodies in sheep and goat was found highest by RBPT (9.95%) followed by iELISA (7.36%) and least in STAT (5.67%). The PCR protocol to detect *B. abortus* and *B. melitensis* from the aborted material, foetal contents and vaginal discharges, was standardized. It is advantageous over serological tests, and avoids risk of laboratory-acquired infections. This protocol can be used to screen suspected herds for confirmatory diagnosis. Leptospiral abortions were scarcely reported and no systematic study has been carried out in our country. Clinical cases from various species of livestock and human samples were screened for the leptospira organisms, and in 119 cases out of 1,120 samples the organism could be isolated. The advantage of this study is that it would be possible to establish not only leptospiral etiology, but also *Brucella*, IBR and other infectious causes.

A study on molecular epidemiology of BHV-1 was initiated as the long term serological studies have shown serological evidence of the disease (35–40% sero-positive) all over the country, although there are limited reports of isolation of virus from Karnataka, Punjab and Uttar Pradesh. BHV-1 infection in bulls is epidemiologically important as the virus excreted intermittently in the semen may spread infection to cattle receiving semen from them. Identification and elimination of the bulls positive for BHV-1 antibodies and genome sequences by serological tests and PCR assays, respectively, would help in formulating the control strategies. Hence, the Directorate has taken up detection of BHV-1 genome/antigen in the semen samples of all bulls in the breeding farms on regular basis. Semen samples from bull mother centers were tested for the presence of the BHV-1 antigen/genome and all were found negative.Genome sequencing of IBR-1-ADMAS isolate was compared with those of reference sequences (one from Switzerland and two from Brazil). There was 100% homology with the sequence of AJ 004801 (Switzerland), 98.3% with AY 58382, and 98.7% with AY 330349 (both from Brazil). In clustering, the Indian isolate was closer to the sequence from Switzerland.

A survey showed the apparent prevalence of *Neospora caninum*—a cyst forming coccidian parasite—infection in dairy cattle which is now recognized as a major cause of abortion and economic losses to producers worldwide. Screening of sera samples from apparently healthy goats from different geographic zones of India suggested an overall countrywide seroprevalence of 7.93%.The carrier animals of trypanosomiasis become nuclei for its propagation in a particular area, and its detection is very important to control and eradicate the disease. The PCR technique was standardized and its field validation is in progress.Serum Bank facility, **the first of its kind in India** having more than 170,000 serum samples from all over the country was developed, and is being used for long-term national surveys on IBR, brucellosis, yersiniosis, RP, PPR,BT and other diseases. **Diagnostic kits for bovine brucellosis** were developed and standardized, and the state-of-the-art software based Avidin-biotin enzyme linked immunosorbent assay (Ab-ELISA) for bovine brucellosis can be used on serum samples and milk samples containing too little cream, colostrum, clotted milk or frozen milk.

Computer interface based BHV-1 whole antigen Ab-ELISA was developed as per the standards of IAEA, and standardized and validated.

CAPTURE FISHERIES

Marine fisheries

Marine fish landings and catch structure: Analysis of the marine fish landings in India during the year 2006 indicated an increase in total fish landings and a change in catch structure. The total marine fish catch, estimated at 2.71 million tonnes,

Successful pen culture in Bihar

Pen culture of fish in pens was demonstrated in the *maun*s (floodplain lakes) in Bihar for augmenting fish production and creating opportunities for employment and income generation. Pens of 0.1 ha size, installed in 3 *maun*s, viz. Kaithkola, Rajoura and Bahuara, were stocked with fish @ 15,000–20,000/ha. The grass carp *Ctenopharyngodon idella* recorded the highest survival rate followed by *Catla catla*. Overall survival rate ranged between 40 and 65% at an average of 50%. Highest fish growth both in terms of length and weight was recorded in Bahuara followed by Kaithkola and Rajoura. Among the fish species stocked, average maximum growth in length was recorded for *C. mrigala* (72%) and in weight for *C. catla* (567%). The maximum fish harvest was from the Bahuara (5,047 kg/ha). With a total cost of inputs of Rs 164,080, the gross and net returns per pen area were estimated at Rs 227,510 and net at Rs 63,430/ha respectively. The average B:C ratio for the *maun*s was 1.39. The demonstrations motivated the local communities to adopt pen culture technology.

registered an increase of about 4.1 lakh tonnes compared to the previous year. Pelagic finfishes constituted the majority (55%), followed by demersal fishes (24%), crustaceans (16%) and molluscs (5%). While mechanized sector accounted for 71% of marine fish landings in the country, motorized and artisanal landings contributed 24 and 5% respectively. Oil sardine, ribbon fishes, lesser sardines, cephalopods, seer fishes and croakers recorded increase, while there was a marginal decrease in the landings of Bombay duck and penaeid prawns. West coast accounted for more than 68% of marine fish landings. While the south-west region comprising Kerala, Karnataka and Goa coasts recorded 34.6%, the north-west region comprising Maharashtra and Gujarat coasts accounted for 33.5% of the national marine fish production. In the east coast, the south-east region consisting of Andhra Pradesh, Tamil Nadu and Pondicherry coasts contributed 21.8%, while the north-east region, comprising the West Bengal and Orissa coasts contributed 10% to the total marine catches.

Impact of climate change on marine fisheries: Oil sardine, the most abundant marine fish in India, showed signs of adaptation to climate change as per the interim findings of the National Network Project on Impact, Adaptation and Vulnerability of Indian Fisheries to Climate Change.

Inland fisheries

Changing catch structure in Ganga fisheries: Decline in catches and a shift in the species spectrum, observed in 3 different stretches of the river Ganga between Deoprayag and Farakka, were attributable to deteriorating fish habitats. Small and economically unimportant fish species dominated upper (Rishikesh to Haridwar), middle (Kannauj to Varanasi) and lower (Varanasi to Farakka) Ganga contributing 42–100% to the total catch. In the upper stretch, the contribution of major carps was negligible, but a good fishery of *Tor* spp. was recorded below Haridwar. In the middle stretch (Kannauj - Varanasi) contribution of major carps ranged from 7.5 to 15.5%, while in the lower stretch landing of major carps *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, was still lower, with the exception of Farakka, where these fishes formed up to 14.1% of the catch. Presence of exotic species *Cyprinus carpio* in the middle stretch (maximum recorded at Allahabad) suggested an impact on natural food web and ecological balance in the river ecosystem. Decline of major carps in the middle stretch is attributable primarily to man-made environmental changes and the resultant loss of fish habitats for breeding and feeding. Based on these findings, necessary packages for restoration of habitat and fishery are being formulated.

Impact of regulated river flows on the estuarine fisheries: A study was undertaken at Devi estuary in Orissa to assess the impact of Narauj barrage on Devi river, 70 km upstream of its confluence with the Bay of Bengal. At present, 4–5% of the total regulated river discharge at the barrage is released during the lean season, which was reasonably adequate to sustain the biotic communities. The salinity amplitude in the estuary was in the range of traces to >18.0 ppt and tidal regimes comprised marine (12%), gradient (55%) and freshwater (23%), which were favorable for fish productivity. During monsoons, estuarine fish fauna was dominated by freshwater forms like Indian major carps, minor carps and large catfishes, which migrated downstream of the estuary for breeding and nursing. During post-monsoon, as salinity increased, brackishwater fishes such as mullets, sciaenid, perches, threadfins, anchovies and shellfishes moved upwards in the estuary. In commercial landings of Devi estuary, 97 species of fishes were identified. The freshwater fishes contributed significantly (> 20%) to the fisheries of estuarine zone.

In contrast, drastic control of river water discharge in upstream of the river Krishna negatively impacted the estuarine salinity regime turning it into hypersaline. As a result, oligohaline and freshwater species such as carps, catfishes, murrels adapted to riverine environment, and featherbacks disappeared from the estuarine zone. This changed salinity regime contributed to domination of mullets mainly represented by *Mugil cephalus* and *Liza parsia*. Results emanating from these two case studies paved the way for setting the key parameters for assessing the environmental flows in rivers and estuaries.

Culture fisheries

Freshwater aquaculture

Cage culture: As part of developing a cage culture technology for the upland lakes,

Cages installed in lake Bhimtal registered an increase in biomass

experiments were conducted in Bhimtal lake, Uttarakhand. Four sets of rectangular cages made of HDPE (3 m × 3 m × 3 m) with 4–15 mm mesh size were installed at Bhimtal lake. Golden mahseer (*Tor putitora*) and snow-trout (*Schizothorax richardsonii*) of varied sizes were stocked in the cages. Fry of golden mahseer, reared in cages registered an increase in biomass of about 1.73 kg/cage in 3 months and the growth was 2.4 kg/cage in fingerlings for the same period. Growth of snow-trout, was slower –- the increase in fry biomass being about 300 g/cage in 3 months; and fingerlings registered a growth of 334 g/cage in 3 months, suggesting the potential of cage culture in upland lakes.

Pen culture: An alternative material to replace split bamboo screens was developed to construct pens in wetlands to raise stocking material. HDPE net material was cost effective and could be used as a substitute for split bamboo screens. Initial estimates indicate that HDPE net material reduces pen construction cost by one-third.

A haul of fish after 136 days rearing in pen

Coastal aquaculture

Organic shrimp farming: Success has been achieved in producing shrimp, *Penaeus monodon* using organic inputs. The organic shrimp farming being developed is based on use of natural nutrients, probiotics and bioremedial measures and avoiding artificial chemical fertilizers and pesticides, chemotherapeutic medicines including antibiotics in the culture process. Yeast (*Sachharomyces cerevisae*)-based organic preparations induced significantly higher growth in tiger shrimp *P. monodon*. These organic extracts have a greater role to play in organic farming when use of chemicals and antibiotics are to be restricted or prohibited. Organic manures including vermicompost were used for fertilization in organic shrimp culture. Under organic shrimp farming, stocking density of 6.5 nos./sq. m. yielded a higher growth rate of quality shrimps of more than 30 g in 110 days of culture with an average production level of 1,305 kg/ha/crop with a feed conversion ratio (FCR) of 0.95. The organically grown shrimps maintained a higher growth rate and health status (including coloration and texture) as compared to the other shrimps during the culture.

Culture of banana shrimp *Fenneropenaeus merguiensis*: Culture practice for the banana shrimp, *Fenneropenaeus merguiensis* was successfully developed through a public-private partnership in Bilimora, Navasari, Gujarat. The shrimps attained on average weight of 22 g in 120 days of culture. The pond was harvested after 166 days with the final average size of shrimp being 26.5 g with 78% survival and a production of 806 kg/ha. Apart from mitigating disease and price risks, diversification in shrimp culture is needed to accelerate the growth of *P. monodon* during winter in Gujarat, where the pond water temperatures falls below 20°C. Successful demonstration of the culture of banana shrimp indicated high potential of this species as an alternative to tiger shrimp especially during winter in Gujarat.

Indigenous shrimp feed technology: A shrimp feed was developed using indigenous ingredients to meet the dietary requirements of tiger shrimp, *Penaeus monodon* and Indian white shrimp, *Fenneropenaeus indicus*. The feed technology has been transferred to two entrepreneurs.

Fish harvest

Copper chrome arsenic (CCA) wood preservative for protection against borers: Painted and FRP sheathed panels accorded total protection against woodborers. Biodeterioration of rubber wood panels treated with CCA to three retentions, viz. 16 kg/m^3, 29 kg/m^3, 42 kg/m^3, dual preservative (16 kg/m^3 CCA followed by

Voluntary adoption of better management practices (BMPs)

Studies conducted to assess the 'adoption gaps' in BMPs of shrimp farming in Andhra Pradesh (AP) and Tamil Nadu (TN) indicated average adoption gaps of 32 and 31% respectively. About 68 and 69% shrimp farmers, respectively, in AP and TN had voluntarily adopted the BMPs. However, BMPs that address environmental and food safety issues like proper site selection, conversion of other land uses, overcrowding of farms and low stocking density were not fully adopted. Though these BMPs are not directly concerned with the productivity, they are essential for the long-term sustainability and marketability of the produce. This result highlighted the need for taking up suitable awareness programmes on BMPs to achieve in long-term sustainability of culture systems, food safety and marketability.

Construction of improved wooden canoes in Asom and Arunachal Pradesh

Improved fishing canoes were designed and fabricated at Guwahati, using locally available low cost wood such as *poma*, mango, *moje* and pine. These canoes were sheathed with fibre reinforced plastic (FRP) to increase the strength and durability. Canoes were handed over to the Department of Fisheries, Asom, which were eventually distributed to the Fishermen Cooperative Societies for use in rivers and *beel*s of Asom. The second set of canoes was handed over to the Department of Fisheries, Arunachal Pradesh, which will be used for fishing in Ganga lake, Itanagar, and Renganadi reservoir in Lower Subansiri district.

150 kg/m^3 creosote) and panels coated with paint and sheathed with FRP (fiberglass reinforced plastic) was studied under the estuarine conditions for 6, 12 and 18 months. On prolonged exposure for 12 to 18 months, the CCA treated panels at lower retention of CCA, showed susceptibility to borer attack especially to *Teredo* spp. Higher retentions of CCA preservative in wood imparted higher degree of protection. Dual treated panels performed equally well as CCA treated panels of 42 kg/m^3 retention. Painted and FRP sheathed panels accorded 100% protection against woodborers. The FRP sheath also ensured that there was no leaching of the constituent chemicals into the aquatic environment.

Development of monoclonal antibody: Production and characterization of monoclonal antibodies (MAbs) to serum immunoglobulins (Ig) from rohu,*Labeo rohita*, was achieved for the first time. Purified r-Ig was used as an antigen to develop MAbs to r-Ig. These MAbs were conjugated with horse radish peroxidase to produce anti-rohu Ig conjugate. This conjugate was used as a powerful tool for monitoring primary and secondary humoral responses by ELISA-based analysis.

Molecular fingerprinting of *Salmonella:* Enterobacterial repetitive intergenic consensus sequence (ERIC) PCR and PCR-ribotyping profile of two most prevalent serotypes in seafood (*Salmonella* Rissen and *Salmonell*a Weltevreden) were carried out to fingerprint the serotypes based on origin. PCR-ribotyping results showed 3 fingerprint pattern in *Salmonella* Rissen (n, 20) whereas, 4 different fingerprint profiles were observed in *Salmonella* Weltevreden (n, 24). ERIC-PCR fingerprinting pattern was more diverse as compared to PCR-ribotype as *S*. Rissen and *S*. Weltevreden serotypes have showed 14 and 16 different fingerprinting patterns respectively. ❑

Aquaculture development in NEH region

Fish culture technology packages was developed for carps and exotic trouts suitable for the northeastern region of the country. In Arunachal Pradesh, about 60% of culturable area is suitable for carp, where Chinese carps and Mahseer can be cultured together in ponds located at 600–1,800 m above sea level. Earthen/RCC ponds can be stocked at a density of 4–5 fish/m² during early March when water temperature is above 15°C. Common carp (25%), grass carp (35%), silver carp (20%), rohu (10%)

Carp farming in a fish pond of NEH region

and/or chocolate mahseer (10%) can be stocked with provisions of supplementary feed @ 2–4% of body weight. Organic fertilizers up to 9,000 kg/ha/year and liming 500–600 kg/ha need to be provided at suitable intervals. This technology has enabled the farmers to fish production of about 0.4–0.8 kg/m² in 8 months. Staggered stocking and harvesting can also be adopted.

7. Crop Management

PRODUCTION

Rice: *Transplanting methods.* Mean grain yield from System of Rice Intensification (SRI) with adapted cultivars was higher (5.94 tonnes/ha) by 15% at 21 out of 27 locations over standard method of transplanting (5.17 tonnes/ha); integrated crop management method followed with an 8% increase.

Penoxsulam applied up to 5 days after transplanting (DAT) at 0.025% was effective as pre-emergence herbicide at three locations, and as post-emergence at two locations. It did not exhibit any toxicity to rice-crop.

Agro-technology for aerobic rice. Annada, Naveen and IR 64 varieties and Rajalaxmi and KRH 2 hybrids have been found most suitable for direct-seeded aerobic conditions during wet season in coastal Orissa, under irrigated ecosystem. They responded significantly to N up to 120 kg/ha without any major incidence of pests and diseases. Butachlor at 1.25 kg a.i./ha at 3–5 days after sowing (DAS) with one hand weeding at 30–35 DAS effectively controlled weeds.

Wheat and barley: *Improving soil organic carbon through residue management*. The increase in soil organic carbon was 0.1% after two years with full residue incorporation of rice and/or wheat. The content increased from 0.31 to 0.37% with surface residue retention of rice alone and to 0.38% when residues of both rice and wheat were retained.

Seed treatment with *Azotobacter* and phosphate solublizing bacteria showed that about 50% of recommended N and P can be compensated with their application.

Small millets: In fingermillet-growing areas of Orissa, fingermillet growing early in the season, followed by blackgram/cowpea, was found profitable. Alternatively, cowpea as early season crop, followed by fingermillet in the sequence gave higher returns.

Vermi-compost and chullu (wild apricot) cake as N source along with *Azotobacter* seed treatment has been recommended for organic fingermillet production in Uttarakhand.

Forage crops: In guinea-grass + berseem intercropping system, nutrient supplement through farmyard manure (50 tonnes in guinea-grass + 30 tonnes/ha in berseem) recorded 12% higher green forage yield (171.55 tonnes/ha) over inorganic fertilizers (200 kg N +50 kg P_2O_5 + 50 kg K_2O/ha in guinea-grass and 20 kg N+80 kg P_2O_5/ha in berseem). This also improved soil microbial biomass (310.9 mg C/kg soil).

Production technology has included:

- In Eastern zone, significantly higher net monetary returns (Rs 42,981/ha/year) were realized with NB hybrid (perennial) + berseem, which were 48% higher than rice–wheat–greengram system.
- In Central zone, sorghum (fodder)–berseem–maize (fodder) + cowpea (fodder) recorded 94% higher net monetary returns than rice–wheat–greengram.
- In Gangetic plains of West Bengal, rice– oat–sesame was superior and gave net monetary returns of Rs 87,561/ha/year with 63.3% increase over rice–mustard–groundnut system.
- In acidic soil, cowpea and ricebean were at par. Single superphosphate (SSP) at 20 kg P/ha along with farmyard manure at 5 tonnes/ha recorded significantly higher green fodder yield by 42 and 16.8% over control and only 20 kg P as SSP/ha respectively.

Underutilized crops: In Gujarat, grain-amarnath Annapurna, in closer spacing of 22.5 cm × 10 cm resulted in higher yield than wider spacing (45 cm × 10 cm).

In *Jatropha*, height and number of branches per plant increased with spacing, fertilizer dose and age of planting.

Groundnut: Maximum yield of groundnut and wheat was obtained in groundnut-wheat-greengram cropping system, followed by groundnut-wheat system. Soil health in terms of total soil nitrogen and organic carbon also improved in the former system.

Sunflower: In alluvial soils, *Azospirillum* and *Azotobacter* inoculation along with 50% of the recommended N was found profitable in *kharif* sunflower.

Castor: It is found advantageous to sow castor after seed priming with 1% NaCl for 3 hr to get better returns.

Rapeseed-mustard: *Toria* sowing at dough stage of rice has been remunerative in rice-*toria* sequence, and has been recommended for central Brahmaputra valley zone of Asom. In north Gujarat, basal application of 20 kg S/ha in *kharif guar*–mustard and 40 kg S/ha in *kharif* mungbean/pearl millet–mustard sequence have been recommended.

Experimental mustard hybrid evaluation block at the NRCRM

Sesame: Recommended dose of fertilizers (100%) + oilcake (250 kg/ha) + bioinoculants *Azospirillum* at 5 kg/ha + phosphate solubilizing bacteria at 5 kg/ha + *Trichoderma viride* at 5 kg/ha + *Pseudomonas fluorescens* at 5 kg/ha resulted in the highest mean seed yield.

Niger: *In-situ* moisture conservation, one hand weeding at 15 DAS + vegetative mulching at 4 tonnes/ha enhanced seed yield from 366 to 844 kg/ha with increase in benefit : cost ratio from 1.30 to 1.80.

Linseed: Under irrigated conditions of Kanpur, $ZnSO_4$ at 25 kg/ha either in *kharif* or in *rabi* and 5 tonnes/ha FYM during *kharif* in blackgram-linseed sequence proved remunerative and gave higher oil content.

Chickpea: In rainfed areas, urea application at flower initiation and 10 days thereafter showed about 20% higher grain yield of chickpea over control. Seed priming helped in improving emergence and grain yield.

Pigeonpea: Varieties suitable for delayed planting in different zones have been identified: Azad (North Eastern Plains Zone), JKM 189 (Central Zone) and LRG 30, LRG 38 (Southern zone). For intercropping, promising varieties identified are: Pusa 992 (North Eastern Plains Zone), Asha, JKM 7, JKM 189 (Central Zone) and TTB 7 and KM 186, LRG 41 and Co 6 (Southern Zone).

Mungbean: Resistant donors for *Cercospora* leaf-spot disease (BM 4, ML 515, TM 98-50 and AAU 30), mungbean yellow mosaic virus (Pusa 0572, MH 98-7 ML 1265, KM 2241 and MH 98-1) and root-knot nematodes (COGG 912 and ML 1265) have been identified.

Lentil: *Rhizobium* strain DL 1 found efficient in increasing grain yield of lentil, by 8.9% over uninoculated check. L 4685, LH 84-8 and NDL 6-1-5 lentil genotypes have shown tolerance to root-knot nematodes *Meloidogyne javanica* and *M. incognita*.

Rajmash: Urea (2%) sprays at pre-flowering, 25% pod initiation and pod development stages increased *rajmash* pod yield.

Cotton: Recommended doses of fertilizers in soil 50% + 50% through fertigation along with 10 kg $ZnSO_4$/ha in soil significantly increased seed-cotton yield. Four sprays of KNO_3 during crop growth enhanced cotton productivity in Central and South Zones. Relatively drought-tolerant lines, CAT 3640, CAT 3874, CAT 1058, AC 7602, AC 7185 have been identified.

Sugarcane: Physio-biochemical causes for poor sprouting of buds at low temperatures have been established. These include low acid invertase activity and decreased level of reducing sugars, low activity of ATPase, IAA oxidase, accumulation of nitrite and relatively lesser absorption of water. Potassium with last irrigation (one month before harvest), pre-harvest application of Ethrel and post-harvest application of $ZnSO_4$ improved stubble bud sprouting.

Sugarcane planted in paired-row system (30:120 cm) significantly reduced gaps (9.5%), produced highest number of millable canes (120.5 thousand/ha) and cane yield (92.9 tonnes/ha) over conventional 90-cm spacing planting. Increasing 25% seed rate or gap-filling at first irrigation in plant-crop has been identified as a suitable technology for enhancing ratoon productivity.

Sulphitation pressmud cake (10 tonnes/ha) + *Acetobacter* every year registered highest millable canes (102.7 thousand/ha) and cane yield (70 tonnes/ha) in the third ratoon. This also recorded highest soil microbial biomass carbon. This meets nutritional requirement of the crop and also maintains rhizospheric soil quality parameters, physico-chemical characteristics and microbial

activities under multi-ratooning.

Jute: High weed-control efficiency in jute (75.3% at 28 DAS and 79% at 45 DAS) with maximum fibre yield (2.49 tonnes/ha) has been obtained with pre-emergence application of S-Metolachlor at 0.50 kg a.i./ha.

In jute, *Corchorus olitorius*-toria cropping sequence, substitution of recommended fertilizer doses (100% NPK) to the tune of 25% through organic components (FYM, green manures or composts) recorded significantly higher jute fibre yield.

Tobacco: Maize-tobacco and soybean-chickpea systems are profitable alternatives to flue-cured Virginia tobacco in northern black soils of Andhra Pradesh. At Dinhata, jute-*Aman* rice-*Motihari* tobacco gave the highest net returns, followed by *Boro* rice-*Aman* rice-tobacco, maize-*Aman* rice-tobacco, jute-*dhaincha* (green manure)-tobacco and jute-fallow-tobacco.

Mango: Mango Alphonso planted at a 5 m × 5 m spacing on Vellaikolumban rootstock without Paclobutrazol application yielded 8.49 tonnes/ha during seventh year. No residue of Paclobutrazol was observed in pulp or peel following its soil application during October in the third consecutive year. Fruit yield was found to be significantly related with leaf K content. Predominant micronutrient disorders in mango belts of Chitoor, Salem and Erode districts were found associated with zinc and boron deficiencies. Arka Anmol planted at 10 m × 10 m distance recorded significantly higher fruit yield with daily drip irrigation at 75% evaporation replenishment. Drip irrigation followed by fertigation with NPK at fruit setting resulted in higher fruit yield (10,120 kg/ha) than conventional irrigation and fertilizer application in basin (5,430 kg/ha).

Latra rootstock imparted maximum dwarfness to Bombai scion against maximum vigour on random seedling. Double hedgerow system of planting gave significantly higher yield at most of the centres. In high-density planting, maximum number of fruits and yield were recorded in trees pruned on alternate limbs with the application of Paclobutrazol after harvesting. The maximum yield was recorded with heading back of branchlets at 50 cm level in Alphonso and with the application of Paclobutrazol during the rest period in Kesar. In pruning for rejuvenation of overcrowded orchards, maximum cumulative yield was recorded in heading back up to crowded branchlets and centre opening with use of Paclobutrazol during the rest period in mango Banganpalli, Chausa and Langra.

Guava: Guava L 49 showed highest yield at a spacing of 2.5 m × 1.25 m one year after planting. Drip irrigation increased yield up to 40% and by saving water up to 52–60%. The rejuvenation technology involving heading back of old trees to 1.0–1.5 m height above the ground level during May-June or December-February produced new shoots from below the cut-point and allowed the development of fresh canopy with healthy shoots. The newly emerging shoots were allowed to grow up to the length of 40–50 cm, 4–5 months after rejuvenation. These shoots were further pruned to 50% of the total length for the emergence of multiple shoots from below the pruning point. The multiple shoots developed as a result of second pruning led to flowering and fruiting in the following season. Yield enhancement was 70–90% over un-pruned trees in the second year after rejuvenation. A planting density of 555 plants/ha was found economical for getting higher yield in guava Allahabad Safeda. Topping and hedging proved a valuable technique for controlling tree size and improving the yield potential. The yield recorded was 40– 45 tonnes/ha under high-density planting coupled with canopy management without any adverse effect on fruit size, quality and canopy recovery.

A meadow orchard system was developed with 5,000 plants/ha (1.0 m × 2.0 m) and managed judiciously with regular topping and hedging. An average yield of 12.5 tonnes/ha was obtained after the first year and 50 tonnes/ha after the third year. To maintain dwarf tree stature, plants are topped 2 months after planting (October) for the emergence of new shoots from below the cut-end. After appearance of new shoots, they are pruned to 50% of their length again in December – January for further induction of new shoots. This allows to initiate growth, differentiate flowering and attaining well-spread plant canopy by May. Heading back of entire shoots is repeated every year in September and May for making tree canopy dwarf and allowing more fruiting.

Papaya: In papaya, an application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal under Coimbatore conditions.

Passion fruit: Irrigation scheduled at 75% of evaporation replenishment showed significantly higher yield (27 kg/plant). Similarly, 75% of recommended dose of fertilizer showed yield at par with 100% recommended dose. Passion fruit Kaveri could be grown under Bangalore conditions with high yield (20 kg/plant) under kniffin system of training.

Strawberry: In Kashmir valley, growing strawberry inside greenhouse with mulching and drip irrigation advanced fruit harvesting by 45 days with a yield potential of 14.24 tonnes/ha, about 2.37 times as compared to open field. The advancement in fruit harvesting resulted in 3–4 times more price in the market.

Banana: Robusta banana under paired row planting (1.5 m × 1.5 m × 2.0 m spacing) recorded the maximum yield (65.91 tonnes/ha), which was 39.5% higher (47.24 tonnes/ha) than the conventional planting system. Weekly fertigation with 75% recommended fertilizers recorded the maximum yield (57.68 tonnes/ha) in Robusta with a benefit: cost ratio of 2.13. A micronutrient mixture named Banana Shakthi has been developed. The mixture contains all micronutrients in proper proportion required for banana crop. This mixture can be applied to banana either as soil application (10 g/plant) or foliar spray (2% solution) based on soil pH. A computer simulated fertilizer tailoring equation model for Ney Poovan and Rasthali banana has been developed for balanced nutrition and targeted yield.

Two kg farmyard manure enriched with *Pseudomonas fluorescens* (109 cfu/g) and *Pseudomonas lilacinus* (106 cfu/g) per plant at the time of planting and 4 months later significantly reduced *Radopholus similis* (64%) and *Meloidogyne incognita* (76%). Pre-harvest application of Carbendazim (0.1%) followed by post-harvest treatment of neem leaf or garlic or turmeric extract (5%) resulted in complete control of anthracnose rot. Plant spacing of 2 m × 3 m with planting of 3 suckers per pit in Nendran, Grand Naine and Basrai at 1.8 m × 3.6 m spacing with 3 suckers per pit in Robusta have recorded higher yield. Inclusion of VAM, PSB, *Azospirillum* and *Trichoderma harzianum* at 250, 50, 50 and 50 g/plant, respectively, in Rajapuri, Basari and Karpurachakkarakeli to 75% of recommended dose of fertilizer (RDF) improved plant growth and productivity. Application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal at most of the locations. However at Kovvur, 50% RDF with biofertilizers was sufficient for Karpura Chakkarakeli banana (AAB, Mysore). The best intercrops in banana are onion, cowpea and cabbage.

Grape: Thompson Seedless grafted on 110R sprouted earlier as compared to other rootstocks. Water-use efficiency at single leaf stage was maximum on 'Dogridge' rootstock followed by 110R, 1103P and 99R. Of the rootstocks, 110R was found to be the best. Twelve *Aspergillus* isolates from rhizosphere and non-rhizosphere soils of grapevine showed significant effect on P solublization in the laboratory.

Citrus: Site-specific nutrient management (800 g N, 400 g P, 600 g K, 250 g each of $FeSO_4$, $MnSO_4$ and $ZnSO_4$/tree) in 'Mosambi' sweet orange (*Citrus sinensis*) helped improve fruit yield (14.7 tonnes/ha) over conventional farmers' practices (10.6 tonnes/ha) and application of recommended doses of fertilizers (11.6 tonnes/ha).

Sweet orange yields better in site-specific treatment

In fruit, vegetable-based intercropping models, fresh grain yield of 10.73 tonnes/ha of cowpea, 3.18 tonnes/ha of okra, 18.87 tonnes/ha of potato and 115,867 numbers of spikes/ha of *gladiolus* were obtained. However, net income of Rs 187,838 was obtained from okra-gladiolus rotation, followed by Rs 50,350 from cowpea-potato rotation.The highest yield was obtained in double hedgerow system of planting. Maximum yield of fruits was recorded in modified leader system, which was at par with open vase, while minimum yield was recorded in the control. In pruning trial, shoots pruned up to 50 cm at the time of harvesting followed by removal of new flush in November-December gave the maximum yield of quality fruits.

Sapota: A spacing of 5.0 m × 5.0 m for 10-year-old Kalipatti and 8 m × 4 m for 18-year-old PKM 1 at Periyakulam recorded the highest yield. Application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal in sapota. Application of 5 kg vermicompost with 150 g N, 40 g P_2O_5 and 150 g K_2O/plant/year for Kalipatti and PKM 1 sapota recorded significantly higher growth and yield.

Jackfruit: Soft wood grafting of jackfruit using 4-month-old rootstocks under shade during October registered the highest graft take. At Kannara, grafting jack on jack seedlings and jack on Ainipala seedlings recorded higher success.

Apple: The productivity of apple Oregon Spur and Red Chief registered double the average global productivity from 8-year-old orchard raised on semi-dwarfing rootstocks MM 106 at a distance of 2.5 m × 2.5 m, accommodating 1,600 plants/ha. The plants came into bearing after 3 years with pollination, drip irrigation, organic mulching and integrated nutrient and pest management against 7–8 years on seedling rootstocks.

Almond: Under medium high-density plantation, accommodating 625 plants/ha at a spacing of 4

m × 4 m against 278 plants/ha conventionally, 7-year-old almond Waris, Shalimar, Non-Pareil, Pranyaj and Merced recorded a yield of 2.4 tonnes/ha. The plants came into bearing after 3 years (against 6–7 years on seedling raised plants). The plantation was raised with proper pollination, drip irrigation, organic mulching and integrated nutrient and pest management.

Apricot: Medium-density plantation using 5 m × 5 m spacing, accommodating 400 plants/ha against 204 plants/ha in conventional method has been made in apricot. With proper training/pruning, pollination, integrated nutrient and pest management, drip irrigation and organic mulching, Harcot, Apricot AS 1, AS 2 and KS 1 came into bearing 3 years after planting, producing quality fruits. Apricot Selection AS 2 was found promising with fruit weight of 29.00 g, acidity 0.03% and TSS of 17.5°Brix.

Arid zone fruits: Evaluation of aonla-based diversified cropping models in arid ecosystem indicated that ground-storey crops performed well in different cropping models without affecting growth and development of main component crops. Among understorey crops, Seb ber in model 1 recorded an average yield of 70 kg/tree and was significantly superior to the control. In model 2, *Prosopis cineraria* grown in combination with aonla-*suaed*-moth bean-mustard (M_3) as an understorey component recorded an average yield of 0.5 kg/plant (75 kg/ha). Among groundstorey crops, gram excelled other crops recording an average yield of 1 tonne/ha.

In aonla, yield per plot (68 kg) and per ha (7.55 tonnes) were significantly high in double hedgerow system followed by cluster and hedgerow systems of planting. In high-density planting, 10 m × 10 m spacing yielded 130.6 kg/plant (1.31 tonnes/ha). The irrigation through drip and low volume microsprinkler could save 30–45% irrigation water with increased fruit yield (35–40%) over conventional flood irrigation system. Early fruit maturity was also noticed in micro-sprinkler used plots.

The best results were obtained when 50% of the nutrients were applied through chemical fertilizers and rest through biofertilizers and FYM in ber Kaithali budded on *Z. rotundifolia* rootstock. Frost injury in ber could be minimized by spraying of Sulphuric acid (0.5%) in third week of October and first week of November. Application of Atrazine (pre-emergence) with Glyphosate (post-emergence) has been recommended for weed control in aonla. Initial sucker mortality of date palm has been controlled through treating suckers with Carbendazim (0.1%) + Chlorpyriphos (0.1%) + IBA (1,000 ppm).

Vegetable crops: Onion and garlic could be grown on drip as well as sprinkler irrigation technology with a water saving of 40–50% and 15–20% increase in yield coupled with 30% saving of fertilizers. This technology is moving at a faster rate among onion growers in Maharashtra.

The technology has been developed for enhancing productivity in *kharif* onion: (1) raising of nursery in summer on broad bed furrow (BBF) with drip or sprinkler under shade nets and keeping seedlings ready for transplanting in first week of June, so that there would be early harvesting in October, (2) transplanting of seedlings on BBF with drip or sprinkler irrigation, the raised bed in BBF method facilitates quick and efficient drainage of rainwater, which minimizes the incidence of soil-borne and foliar diseases, (3) application of FYM or vermicompost pre-mixed with *Trichoderma viride* before preparation of beds for reducing the incidence of soil-borne diseases, (4) fertigation through drip avoids leaching losses of nutrients, which is common in high rainfall conditions, and (5) application of pre-emergence weedicides. This technology ensures 25 tonnes of yield/ha without hampering the quality of bulbs.

In broccoli, maximum head yield (366.0 q/ha) was recorded by application of poultry manure @ 5 tonnes/ha + half NPK (60:30:30 kg/ha). In organic farming trials of okra, maximum yield was recorded by application of FYM @ 10 tonnes/ha + poultry manure @ 2.5 tonnes/ha. The highest water-use efficiency and water saving were obtained under 75% PE with drip irrigation scheduling at alternate day in cucumber. In water stress study of tomato, the flowering stage is the most critical stage for moisture stress followed by active vegetative stage.

Sprinkler irrigation in onion increases yield (15–20%) and saves water (40–50%)

Potato: Rice-potato-okra followed by rice-potato-jute and potato-French bean followed by potato-sorghum were found most remunerative potato-based crop sequences. Potato + French bean (2:1 ratio) followed by potato + *methi* (2:1 ratio) were most profitable intercropping systems. In

potato-based crop sequences at different centres, NPK requirement of crop next to potato was reduced by 25% of the recommended dose when potato received 100% recommended NPK along with FYM @ 20 tonnes/ha. These crop sequences were rice-potato-wheat, potato-pearl millet, potato-bottle gourd and potato-greengram.

With the use of phosphobacteria, the dose of P could be reduced to 75%. Among potato cultivars Kufri Pukhraj, Kufri Sutlej, Kufri Swarna and Kufri Badshah were found more nitrogen-efficient cultivars than other varieties tested.

Potato Kufri Pukhraj was identified to be a highly input-efficient cultivar having higher N influx. It has capacity to use higher soil N compared to Kufri Jyoti. Similarly, Kufri Swarna was the most nutrient-efficient variety in southern hills. Vermicompost proved to be superior to FYM, as it had direct effect on P availability at a latter stage of crop growth. The stolon formation and tuber initiation stages were identified to be most critical for water supply. Single drip layout application system for raised bed/triple row potato planting with 1.5 lakh plants/ha resulted in nearly 30% higher yield of potato, saving 50% of water compared to traditional method of furrow irrigation.

Coconut: The net primary production estimations of coconut monocrop in different agroclimatic zones indicated annual carbon sequestration potential of coconut above the ground biomass ranged from 8 to 32 CERs. The standing carbon stocks ranged from 18 to 51 CERs.

Cashew: Yield in high-density planting (416 and 500 trees/ha) was significantly higher (726 and 1,138 kg/ha, respectively) than normal density (457 kg/tree). The cashew graft production has been enhanced, producing 2.5 lakh grafts of improved and high-yielding varieties and made them available to farmers and developmental agencies.

Analysis of volatiles collected from virgin females of tea mosquito bug by GCMS revealed the presence of methyl butyrate. Lambda Cyhalothrin has been found to be most effective against foliage pests of cashew. Significant varietal variation has been observed for protein (4.26 – 12.29%), starch (6.75 – 78.66%), sugar (11.44 – 42.07%) and *in-vitro* digestibility of carbohydrate in cashew apple powder.

Mini palm oil mill

A portable snowball tender nut machine was developed. A mini palm oil mill with a capacity to process 1 tonne of fresh fruit bunches (FFB) of oil palm per hour was developed. The mill is devised in such a way that it is easily maintainable and can be repaired locally.

Gerbera: Organic modules have been developed as a component of IPM for an effective management of whitefly in gerbera grown under protected cultivation.

Lilium: Lilium bulb production technology has been standardized with using sawdust of *Cryptomeria japonica* and application of N:P:K (10:25:25) @ 100 g/m^2.

Medicinal and aromatic plants: Propagation of patchouli (*Pogostemom cablin*) from mother plants was standardized using single leaf. Single leaf from the top 2–5 nodes produced fully developed plantlets in 60 days. An Anthroquinone compounds isolated from *Aloe* were characterized through HPTLC and LC-MS/MS. Two major anthroquinone compounds were isolated and found to have mass of 441.0 AMU (which corresponds to sodium adduct of Aloin A) and 577.3 AMU. Application of 7.5 tonnes FYM/ha and harvesting 135 days after planting significantly influenced fresh and dry foliage yield, andrographolide and iron contents, and their total herbage yield in Kalmegh.

Betelvine: The integrated crop management package has been developed for betelvine cultivation in major betelvine-producing areas. Inorganic nitrogen @ 200 kg in splits form + 100 kg P_2O_5 + 100 kg K_2O + irrigation 100% replenishment of cumulative pan evaporation (CPE) + 4 applications of *Trichoderma* + sanitation resulted in better growth and yield attributes. Application of Bordeaux mixture was found superior compared to biocontrol agent for Phytophthora foot rot of betelvine and increased betelvine yield. The application of oil cake + Carbofuran + 3–4 inoculations of *P. lilacinus* inoculated oil cake effectively controlled root-knot nematode and increased leaf yield.

Mushroom: Of the 53 hybrid strains of *Pleurotus sajor-caju* evaluated on wheat straw, 10 gave more than 68–85% BE. In paddy straw, mushroom 42 single spore isolates were compared for their growth rate, type of mycelial thread,

Shiitake mushrooms grown on wheat bran

density of mycelial growth, presence of aerial mycelia and chlamydospores. Cultivation technology of *Flammulina velutipes* standardizing polypropylene bags proved the best cultivation containers. Supplementation of 20% wheat bran proved better for increasing yield of shiitake mushroom. Medicinal mushroom (*Schizophylum commune*) has also been successfully cultivated on sawdust. The Thai culture gave highest yield followed by Korean OE 53. Cultivation practices of button, oyster and paddy straw mushrooms were developed in low-cost bamboo huts with good economic yields.

Tuber crops: Use of vermicompost (15 kg N) along with 45:40:60 kg NPK/ha was recommended for sweet potato. Biofertilizers with half recommended dose of phosphorus was standardized for *Colocasia* for Andhra Pradesh, which gave a cormel yield of 17.23 tonnes/ha. In elephant-foot yam, straw mulching was recommended for its weed management and enhanced yield in West Bengal (61.40 tonnes/ha), Andhra Pradesh (47.44 tonnes/ha) and Kerala, while sesame leaf mulching or black polythene mulching was recommended for Bihar, with a corm yield of 41.6 tonnes/ha.

Elephant-foot yam as an intercrop in litchi orchards with full dose of fertilizer (80:60:80 NPK kg/ha) recorded maximum corm yield of 37.3 tonnes/ha with a net return of Rs 126,000/ha. In Chhattisgarh, elephant-foot yam as intercrop in mango orchard gave the highest corm yield of 9.52 tonnes/ha. Sweet potato was the best intercrop in pre-bearing cashew orchard with a highest cost:benefit ratio (1: 1.36).

PROTECTION

Rice: Many promising entries showing resistance/tolerance have been identified in screening nursery for different insect-pests and diseases.

Biological suppression of crop pests. In a large-scale demonstration of biocontrol-based IPM, the use of *Trichogramma chilonis* and *T. japonicum* as well as antagonistic organisms (*Pseudomonas fluorescens* and *Trichoderma* spp.), covering 1,200 ha of deep-water lands (*cole*) effectively controlled rice pests and diseases and enhanced yield.

Nematode. Nematode distribution atlas of economically important plant-parasitic nematodes of major crops has been compiled and digitized. Hot spots areas in paddy against *Aphelenchoides besseyi* in West Bengal and Himachal Pradesh and *Meloidogyne graminicola* infesting paddy in Tamil Nadu, Karnataka and Himachal Pradesh have been identified. Management of *Meloidogyne graminicola* infecting paddy was achieved through soil solarization of nursery area + Carbofuran 3 G at 1 kg a.i./ha 45 days after transplanting or neem cake at 100 g/m^2 i + Carbofuran in the main field.

Mites. Fenazaquin at 125 g ai/ha or Diafenthiuron at 300–600 g ai/ha or Dicofol at 2.5 ml/litre was found effective in reducing rice sheath mite *Steneotarsonemus spinki*, which was noticed to be severe during the third week of October (47 mites/leaf sheath) on Jaya and Gurjary varieties in Navsari (Gujarat). At Coimbatore, initial field screening of rice genotypes revealed few fairly resistant varieties (harbouring less than 10 to 15 mites/3 cm leaf length) against spidermite,

Promising rice entries identified against insect-pests

Trial	Pest	Promising entries identified
PHS	Plant hoppers	KAU Ptb 9412-13, KAUM MO8 20 KR, CR AC 34997, KAUM 95-1, KAU PTB 9401-2, CORH 3, KAUM 103-104-1
GMS	Gall midge	RP 4642-669, RP 4643-713, RP 4643-723, RP 4643-829, RP 4643-985, RP 4643-1020, RP 4645-688, RP 4644-745, RP 4647-1191, JGL 8644, JGL 11541, JGL 11551, JGL 13391
GMSS	Gall midge	INRC 5073, INRC 17494, INRC 8867, INRC 3021, INRC 7055, INRC 8843, INRC 2489
GEMP	Multiple pest resistance	IC Nos 331779, IC 340054, IC 115503, IC 321504, IC 337578
MRST	Multiple pest resistance	Salkathi (CR AC 35181), RP 4621-1842, RP 4621-1845, RP 4518-2-6, RP 4642-669, RP 4516-3-8, RP 4639-110, JGL 13595
NSN	Multiple pest resistance	IET 17885, IET 18909, IET 19308, IET 19379, IET 19571, IET 19794, IET 19632

PHS, Planthopper screening; GMS, gall midge screening; GMSS, gall midge special screening; GEMP, germplasm evaluation against major pests; MRST, multiple resistance screening trial; NSN, national screening nursery.

Promising entries identified against various diseases

Disease	Promising entries identified
Sheath blight	NSN: IET 18353, 19334, 19929, 20052, 20071, 20075, 20095 DSN: ARC 10573, CB 02-012
Brown spot	NSN: IET 18208, 18725, 18727, 18754, 8647, 19344, 19697, 19656, 19657, 19189, 19212, 19786, 19630, 19631, 19635, 19638, 19640, 19767,19725, 19726, 19731, 19739, 19746, 19530 DSN: ARC 10555, CB03-334, CB02-012, IR 78224-22-2-98, HPR-2505, ARC 10535 and ARC 10573
Sheath rot	NSN: IET 19144, 18647, 18755, 18646, 19389, 19424, 19513, 18808, 19370, 19664, 19162, 19163, 19963, 20064, 20067, 20085, 20006, 19743, 19739, 19744, 19754, 19758, 19759 DSN: CB 01-001,CB 03-008, CB 02-0212, ARC 10560.
False smut	NSN: IET 18732, 18736, 18353, 18781, 18782, 18796, 18990, 19491, 19492, 19117, 19744, 19745
Glume discolouration	DSN: IR 78224-22-2-980, VL 7504, VL 30019, 35VL 30246, HPR 2143, HPR 1156, Bhrigodan
Bacterial blight	NSN: IET 19046, 19590, 19045, 19026, 19144, 18990, 19148, 19120, 20080, 18697, 19542 DSN: CB 01-001, VOPH 3102
Rice tungro disease	NSN: IET 18720, 19706, 19708, 19711, 19712, 19722, 19646, 19662, 19161, 19799, 19742; TNRH-142 DSN: IR 78221-19-6-82, HPR-2413 and ARC 10560
Multiple diseases	IET 20066 (blast, bacterial blight and tungro) IET 19542 (blast, bacterial blight and tungro) IET 19739 (brown spot, sheath rot and tungro) CB 03-008 (blast, sheath blight and sheath rot) CB 02-012 (sheath blight, brown spot and sheath rot)

NSN, National screening nursery; DSN, District screening nursery

Oligonychus oryzae. Abamectin at 0.5 ml/litre and Fenazaquin at 1 ml/litre were effective in checking mite population that peaked between 35 and 70 days after planting.

Wheat and barley: Wheat and barley genotypes showing resistance to various diseases and insect pests have been identified.

IPM in barley. Seed treatment with Carboxim 200 WS at 3 g/kg of seed and Imidacloprid at 0.6 g a.i./kg + foliar sprays of Propiconazole (Tilt 25 EC) at 0.1% and Imidacloprid at 20 g a.i./ha reduced incidence of stripe and stem rusts, covered smut, foliar blight, aphids and termites. It also increased number of plants/plot by reducing seedling death, and increased test weight and grain yield significantly over check.

Maize: Four lines of maize have been registered as the sources of disease resistance.

Registered lines of maize at NBPGR

Line	INGR number	Novel/unique feature
BPPT 1 35	06043	PFSR resistance
BPPT 1 37	06044	PFSR resistance
BPPT 1 38	06045	PFSR resistance
BPPT 1 44	06046	PFSR resistance

Sorghum: *IPM in sorghum.* Wheat straw bundles of 90 cm length and 22 cm diameter were packed in plastic nets and placed in sorghum fields for 15 days for bundles with spiders. These bundles were then placed in rice fields at 20 bundles/ha. This practice along with growing of maize, sunnhemp or *Sesbania* as a border crop significantly increased population of natural enemies concurrent with reduction of yellow stem borer. Many of the volatiles from 30 isolates of 6 species of *Trichoderma* have been found inhibitory to *Sclerotium rolfsii*, *Fusarium oxysporum* f. sp. *vasinfectum* and *F. ciceri*.

Pearl millet: Pearl millet 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.

Groundnut: *In-vitro Trichoderma* isolates NRCG T 06 and NRCG T 17 have been found effective against collar rot (*Aspergillus niger*) and stem rot (*Selerotium rolfsii*) and NRCG T12, NRCG T16, NRCG T 32 and NRCG T 34 showed antagonism against *Aspergillus flavus*.

Gypsum at 500 kg/ha at pegging significantly reduced aflatoxin contamination. Garlic and onion rotation in long-term significantly reduced soil population of *A. flavus* and aflatoxin contamination in subsequent crop of groundnut.

Sunflower: Seed treatment with mixture of Iprodione + Carbendazim 0.2%, followed by two sprays of Quintal 0.2% along with two sprays of Propiconazole 0.1%, and seed treatment + two sprays with Hexaconazole 0.1% were effective in reducing *Alternaria* leaf-spot incidence.

Imidacloprid 5 g/kg seed along with its spraying

Wheat and barley genotypes with resistance to diseases and insect-pests

Disease/Insect-pest	Resistant genotypes
Wheat	
Stem, leaf and stripe rusts + leaf blight + powdery mildew + Karnal bunt + flag smut	TL 2934
Stem, leaf and stripe rusts + leaf blight* + Karnal bunt	HS 485
Stem, leaf and stripe rusts + powdery mildew + flag smut	TL 2942
Leaf blight* + flag smut	HS 459
Stem, leaf and stripe rusts + Karnal bunt + flag smut	HS 461
Leaf and stripe rusts + leaf blight*	HPW 251, HW 5037
Leaf and stripe rusts + flag smut	AKDW 2997-16
Leaf and stem rusts + flag smut	GW 373
Leaf and stem rusts + Karnal bunt + flag smut	MACS 2956
Leaf and stem rusts + leaf blight*	HI 1531
Leaf and stem rusts + leaf blight* + flag smut	HPW 254
Leaf and stem rusts + leaf blight* + flag smut + Karnal bunt	VL 890, UP 2632, NW (S) 02-4
Karnal bunt + flag smut	HPW 236, VL 875, JKW 20, VL 870, NIDW 325
Stem, leaf and stripe rusts + foliar aphids	PBW 559, HI 1531
Stem and leaf rusts + foliar aphids	VL 882, DDK 1025
Stripe and leaf rusts + foliar aphids	NW (S) 02-4, VL 891
Stem, leaf and stripe rusts + root aphids	HPW 236, HPW 245, HS 473 and HW 5028
Stripe and leaf rusts + root aphids	VL 870
Stem, leaf and stripe rusts + foliar aphids + root aphids	MACS 6198
Barley	
Stripe rust**	BHS 369, HBL 410, HBL 501, PL 815, RD 2624, RD 2683, RD 2707, RD 2729, RD 2730, RD 2732, RD 2734, RD 2738
Leaf blight	BHS 366, BHS 377, BHS 380, BH 888, DWRUB 52, HUB 194, HUB 195, K 850, K 860, K 866, K 867, K 868, NDB 1173, NDB 1276, NDB 1414, PL 751, PL 808, PL 810, PL 811, PL 812, PL 815, RD 2035, RD 2723, RD 2724, VLB 103, VLB 104, VLB 105, VLB 107, VLB 108
Stripe rust + leaf rust + leaf blight + stem rust	HUB 195, RD 2724, VLB 103

*Moderately resistant; ** Highly resistant

at 0.05% at 30 and 45 days, and seed treatment with Thiomethoxam 4 g/kg of seed, followed by two sprays of Thiomethoxam (0.05%) at 30 and 45 DAS reduced necrosis incidence and increased seed yield. Indoxacarb 0.015% and Profenophos 0.05% have been effective against defoliators and stem borer.

Safflower: Carbendazim at 0.1% was most effective for *Alternaria* leaf spot.

Castor: *Botrytis* grey mold disease could be effectively managed with two sprays of Carbendazim (0.1%) + *Trichoderma viride* (0.3%).

Rapeseed-Mustard: Mustard sowing in first fortnight of October, followed by prophylactic spray of *Allium sativum* bulb aqueous extract (2%) and 5% aqueous leaf extract of *Eucalyptus globosus* managed foliar diseases of mustard can substitute Mancozeb.

Trivir, a biopesticide, for wilt and root-rot diseases

A formulation with trade name Trivir 1% W.P. (DOR B-16 strain of *Trichoderma viride*) has been developed and registered under Section 9 (3B) of the Insecticide Act, 1968 for commercial production. This antagonist strain effectively controls wilt and root-rot diseases of castor, pigeonpea, sesame, chillies, cowpea and pulses. It effectively managed castor wilt as seed treatment (10 g/kg seed) along with soil application (2.5 kg mixed with 125–200 kg of FYM/ha). The improved strain of *T. viride* is tolerant to Carbendazim, and it can be used along with seed-treatment fungicides. This biopesticide also showed suppression of reniform nematodes that predispose castor to wilt disease.

Soybean: Field screening for rust at hot spot helped in identification of resistant lines KDS 327 and 2355.

Sesame: Sesame in 3:3 ratio with greengram, blackgram and clusterbean reduced incidence of leaf roller/capsule borer and bud fly and gave maximum sesame-seed equivalent yield. Seed treatment with *Trichoderma viride* (0.4%) + *Pseudomonas fluorescens* (0.4%) + soil application of *Trichoderma viride* at 2.5 kg/ha + *Pseudomonas fluorescens* at 2.5 kg/ha minimized incidence of *Macrophomina* stem and root rot, *Alternaria* leaf spot and *Phytophthora* blight, and gave highest seed yield.

Linseed: Companion 75WP (63% Mancozeb + 12% Carbendazim) has been most effective in reducing *Alternaria* blight infection and enhancing grain yield. Seed treatment with Thiophanate methyl 75 WP (2.0 g/kg seed) + two sprays of Indofil M-45 (0.25%), followed by seed treatment with Thiophanate methyl 75 WP and 2 sprays of aqueous neem leaf extract (5.0%) effectively reduced *Alternaria* blight and enhanced grain yield.

Chickpea: GNG 1581, IPC 2004-52, JG 2000-14, JG 2004-3 and Phule G 0425-9 have been found resistant to *Fusarium* wilt.

Soil treatment with Carbofuran at 1.5 kg/ha and Carbosulfan 25 ST at 3% ww/kg seed effectively reduced root-knot nematodes population.

IPM in chickpea. In chickpea for suppressing pest incidence seed treatment with *Trichoderma* and *Rhizobium* culture and Chlorpyriphos for termite control, pheromone traps at 5/0.4 ha for monitoring *Helicoverpa* population, spray of 5% neem seed kernel extract (NSKE) and *Ha-NPV* (250 LE/ha), spray of Endosulfan or Indoxacarb and Basalin (herbicide) were found best IPM strategies.

Pigeonpea: E2Y45 20% SC 40 g a.i./ha, followed by Spinosad (Spinosyn A + D, 50:50%) at 73 g a.i./ha controlled pod borer effectively.

Plant-parasitic nematodes. Warked village of Buldhana district (Maharashtra) has been identified as hot spot for *Heterodera cajani* infecting pigeonpea. The Malai village of Jalgaon district in Maharashtra has been observed hot spot for infestation by *Radopholus similis* in banana. Majority of polyhouses in Himachal Pradesh, particularly in districts of Bilaspur, Hamirpur and Kangra having combination of carnation and capsicum were heavily infested with root-knot nematodes.

Biological control of cyst nematode: Pigeonpea is widely attacked by pigeonpea cyst nematode (*Heterodera cajani*) in Tamil Nadu. Seed treatment with *Pseudomonas flourescens* + *Trichoderma viride* at 5 + 5 g/kg seed decreased *Heterodera cajani* population in soil by 32.5% and 37.1%. Its benefit : cost ratio was 2.29. This recommendation has been included in crop-production guide, and is widely accepted by farmers of the state.

Mungbean: The combined application of neem cake at 100 g/m^2 + *Trichoderma viride* at 2.5 kg/ha as soil application at sowing has been found most effective for management of root-knot nematodes infecting mungbean.

Urdbean: Cyhalafop butyl at 100 g/ha as post-emergence herbicide between 21 and 28 DAS effectively managed weeds in *rabi* urdbean.

Cotton: Thiomethoxam 500 FS at 5 ml and 7.5 ml/kg seeds was effective up to 35 days in reducing jassids and aphids. For controlling pink bollworms, Triazophos (0.05%) was effective. Imidacloprid and new insecticides E 2Y45 and Spinosad have been found to have moderate effect in reducing mirid bug population. Two *G. hirsutum* germplasm lines (CT I 425-45R, EL 395A) resistant to most virulent race 18 of *Xanthomonas axonopodis* under pot culture and two *G. hirsutum* lines (A02 N 99 and A 03 N 119) under field conditions, have been identified.

IPM in cottton. Pink bollworm is emerging as a major threat in cotton. Mating-disruption technique using PB Rope L has been demonstrated in large-scale validation trials in Dharwad and Sriganganagar.

Biological suppression of pests in Bt cotton. *Trichoderma* seed treatment + cotton interspersed with *Cassia occidentalis* (6:1) + 10% planting of maize and zinnia + one release of *Chrysoperla carnea* at 14,000/ha effectively reduced sucking pests and increased seed-cotton yield with increased net returns.

Sugarcane: Tolerant strains of *Trichogramma chilonis* at 28°C have been identified.

An artificial diet has been developed for white moth; closely resembling to top-borer. Eggs of this moth have been used for rearing *Telenomus beneficiens*, a potential egg parasitoid of top-borer.

Sett treatment with *Trichoderma* spore suspension, TMC in powder form in farmyard manure at 20 kg/ha at planting, metabolites of *Trichoderma* (2.5%) applied at tiller stage performed better in checking red rot and promoting growth of sugarcane. *T. harzianum* strains T 37 and T 38 induced systemic resistance and provided protection (45–55%) in challenge inoculation with *C. falcatum*. The *T. harzianum* also enhanced germination (10–12%), tillers, number of millable canes and yield (10–15 tonnes/ha) over the check.

Biological suppression of pests. Trichogramma chilonis at 50,000/ha had good impact in reducing incidence of Plassey borer *Chilo tumidicostalis* and in increasing egg parasitism percentage as well as sugarcane yield in Asom. Inoculative release

of predator *Dipha aphidivora* at 1,000 larvae/ha at 10 spots effectively controlled sugarcane woolly aphid population within 60 days at Coimbatore, Puthur, Vellalore and Elayamuthur.

Jute: Stem rot, seedling blight, damping off, collar rot and root rot are prevalent in all jute-growing areas, irrespective of species, variety or place. The intensity ranged from 6.35% at Barrackpore to 41.2% at Bahraich. Anthracnose (*Colletotrichum corchorum*) was recorded only in white jute at Bahraich. Its intensity ranged from 15.50 to 30.60%. Leaf mosaic was of very high incidence (75 to 100%) at Bahraich while other diseases were negligible.

Semilooper, stem weevil, yellow mite, *Myllocerus* sp. and Bihar hairy caterpillar were found in all jute-growing areas but not in very severe form, excepting stem weevil at Bahraich (16.67– 24.51%), Bihar hairy caterpillar at Katihar (38.49%) and jute beetle at Nagaon (60.33%).

Tobacco: *Lantana camara*, *Thevetia nereifolia* and *Nyctanthes* sp. extracts controlled aphid up to 90% at 10 µl concentration. At Hunsur, FCH 221 and FCH 222 have been identified as promising *Fusarium* wilt-resistant advanced breeding lines. In *Motihari* tobacco, bacterial wilt has been significantly reduced by bacterial drench inoculation at 108 cfu/ml and liming at 560 kg/ha and fallowing for 30 days and *in-situ* green manuring with *dhaincha*.

Mango: Disease forecasting models were developed for mango blossom blight. The management practices were standardized for minimizing the incidence of anthracnose and blossom blight. Application of Prochloraz(0.1%) and foliar extract of *Vitex negundo* (5%) followed by post-harvest treatment of neem leaf extract (5%) and *Trichoderma harzianum* reduced fruit rot due to anthracnose. Similarly, post-harvest usage of neem leaf extract (5%) preceded by pre-harvest application of foliar extract of *Vitex negundo* (5%) was found most effective for controlling stem-end rot.

Single application of Methionine, a precursor of ethylene in soil, @ 200 ppm increased flowering (85%) and fruit setting (51.30 fruits/panicle) in mango Dashehari significantly. Soil microbial populations in terms of fungal and bacterial growth were also increased to the tune of 5.3 log fungal cfu/g soil and 8.40 log bacterial cells/g soil with its application.

Three spraying of Imidacloprid and Endosulfan starting first spray of Imidacloprid (0.005%) at panicle emergence followed by two sprays of endosulfan (0.07%) at 15 and 21 days intervals proved highly effective in reducing hopper population with highest yield. In IPM, module-II consisting of Imidacloropid (0.005%), NSKE (5%) and Endosulfan (0.07%) were highly effective by recording lowest survival of hopper population (8.64%) and maximum fruit yield (259.0 kg/tree) in mango Langra. Module-II (Thiomethoxim-Azadirachtin-Ethofenprox) proved superior followed by Module-I (Imidacloprid-NSKE-Endosulphan).

Mancozeb and Chlorothalonil (@ 2 g/litre) controlled anhracnose (60.6%) effectively. Three sprays with Carbendazim (0.1%) or mixture of Carbendazim + Mancozeb (0.2%) or Thiophanate methyl (0.1%) at 15 days interval on appearance of disease were found most effective in controlling this disease.

Guava: Spatial distribution of *Steinernema carpocapsae*, an entomopathogenic nematode in rhizosphere of guava, revealed the prevalence of relatively higher population on western direction of tree site. Furthermore, population level was found to be relatively higher during July compared to January. The highest population density (29,700) was at surface level and 1 m from tree trunk followed by 23,200 at 30 cm depth and 50 cm distance from tree trunk. The prevalence of nemic population is governed by temporal and edaphic factors, particularly moisture content in soil.

Papaya: Combined application of neem cake (250 g) + Carbofuran (1 g ai) + *Pseudomonas fluorescens* (4 g) gave the highest fruit yield and maximum reduction of nematode population in papaya CO 2.

Banana: Application of 200–300 g N and K_2O/plant/crop with foliar spray of urea (2%) followed by bunch spray of 2, 4-D (25 ppm) for Nendran or two post-shooting sprays of CPPU (4 ppm) recorded higher bunch weight. Carbofuran 3 G (40 g/sucker) with Carbendazim (0.2%) drenching (4, 6 and 8 months after planting) was found to be effective for the management of *Fusarium*-nematode complex in banana Rasthali. A new species of *Helicotylenchus* was observed in one of the root populations of a banana hybrid (H 03-10). Steps are taken to identify the species. Effective control of Sigatoka leaf spot of banana was achieved by three sprays of Propiconazole (0.1%) at 30 days interval with *Bacillus subtilis* or *Pseudomonas fluorescens* (0.5%).

Grape: Symptoms of grapevine leaf roll associated with virus (GVLRaV) were observed in 1–5-year-old vineyards at Narayangaon, Dindori (Nasik) and presence of GVLRaV 1+3 strain was confirmed with ELISA tests.

Releases of *Cryptolaemus montrouzieri* at 5,000 larvae/ha against pink mealybug *Maconellicoccus hirsutus* on grapes at Tuljapur near Solapur (Maharashtra) reduced mealybug infestation by 99.0%.

One antagonist yeast and an actinomyetes were isolated from vineyard. Spraying of *Trichoderma*

SUCCESS STORY

Checking root knot nematode in banana

Farmers of Jagannathpur village of Pipli block in Orissa are traditional banana-growers. Gajabantal variety grown there is used as vegetable in the region. Severe infestation of root-knot nematode was observed in all banana fields. Hot-water treatment was given to suckers at 55°C for 20 minutes and Furadan was added at 16.6 g per pit. After treatment, suckers were planted and general package of practices were followed. Growth and natural lustre of banana plants was better in treated plants. Average bunch weight was 30% higher where treated suckers were planted and Furadan + neem cake were incorporated in the pit-soil. Multiplication of the nematodes decreased.

during the last 30 days before harvesting reduced the PHI of Flusilazole from 48 to 18 days. Seasonal incidence of insect-pests in vineyards and its correlation with weather parameters were continued. Thrips and jassids populations were observed during November-December, coinciding with flowering period and berry setting. Two major species of thrips were found economically important. However, mealybug incidence was highest during the harvesting period in February-April.

Eight species of ants were found associated with mealybugs in vineyards. Several new generations insecticides like Spinosad, Buprofezin, Methomyl, Imidacloprid, Ihiamethoxam, Clothianidin, Fipronil, Chlorpyriphos and Cichlorvos were found safe for *Cryptolaemus montrouzieri*.

Screening and incorporation of disease resistance through hybridization resulted in identification of 42 hybrid seedlings free from downy mildew, 32 free from powdery mildew, 31 free from anthracnose,41 resistant/tolerant to rust and 22 free from all four diseases. Disease forecasting models for downy mildew, powdery mildew, anthracnose, rust and greenaria leaf spot were developed. Spraying of oils and *Trichoderma harzianum* and spraing of *Pseudomonas fluorescens* were found suitable to control anthracnose and greenaria leaf spot respectively. White variety Chenin Blanc and red varieties Cabernet Sauvignon and Pinot Noir were found suitable for the production of standard quality dry table-wines. Grapes of Pusa Navarang were found to be very rich in anthocyanins and phenols.

Citrus: Citrus psylla (*Diaphorina citri*) Kuwayama (Hemiptera: Psyllidae) is one of the serious insect-pests of citrus throughout India. Among bioagents, *Tamarixia radiata* (Hymenoptera: Eulophidae), a host-specific parasitoid, has been identified to be the key factor in keeping psylla population under check in Nagpur mandarin. Parasitism by *T. radiata* was more in spring (March, 78.4%) than in summer (July, 23.8%) and autumn (October, 7.2%) flushing seasons. Spring season was favourable for its growth and development. A temperature of 30°C favoured the development of *T. radiata* adults.

Psylla population preferred *Murraya* seedlings as compared to Nagpur mandarin. The multiplication of psylla on *Murraya* was faster than on Nagpur mandarin at 27 ± 2°C temperature and 65–70% RH. Parasitoid population was high during February-March as compared to other months under cage-house conditions. However, with increase in temperature outside during April, the nymphal population after its peak during mid-March faced gradual decline with appearance of psylla adults. Field release of *T. radiata* @ 40 adults/tree resulted in 50–62% reduction of psylla population. Of the indigenously available botanicals [Badakulanjan (*Alpinia galanga*), sweet flag (*Acorus calamus*), *safed kanher* (*Nerium odorum*), nirgundi (*Vitex negundo*) and neem (*Azadirachta indica*)] evaluated against *T.radiata*, rhizome extracts of *A. galanga* was safer as compared to other with regard to adult emergence of *T. radiata*.

Inclusion of VAM, PSB, *Azospirillum* and *Trichoderma harzianum* at 500, 100, 100 and 100 g/plant, respectively, to 75% of RDF for Kinnow and Khasi mandarin (7 years old trees) improved the plant growth parameters and productivity. Application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal. Leaf miner in citrus was effectively controlled by spraying Imidacloprid (0.005%) followed by NSKE (5%) or *Bacillus thuringiensis* (Bt) at 0.1% or Fenvalerate (0.005%) followed by fenvalerate (0.005%). Two releases of *Mallada boninensis* (4–6 eggs/shoot) have been found effective in IPM of citrus black fly (*Aleurocanthus woglumi*). Application of *Pseudomonas fluroscens* or *B. subtilis* (5 g/pot for each) along with FYM (0.5 kg/pot) and neem cake (50 g/pot) was found better in reduction of dry root rot.

Litchi: The combination of Trichocards @ 50,000 eggs/ha, applied at flowering and again 25 days later and two sprays of Azadiractin 5,000 @ 0.05% at 7 days interval at lentil-sized fruit growth stage followed by a repeated spray of Azadiractin at colour break stage performed better in controlling fruit-borer in litchi. The leaf roller incidence reached its peak in October at Mohanpur, while it was low in March which gradually increased and reached the maximum level in July at Pantnagar. Fruit-borer, *Dichocrosis punctiferalis*, *Platypelpa* sp. and *Conopomorpha cramerell* were also recorded.

Sapota: Three sprayings of lambdacyhalothrin (0.005%) or polytrin C at 15 days interval were found to be effective in management of bud-borer in sapota at Periyakulam.

Pomegranate: Bacterial blight in Maharashtra and Andhra Pradesh was major diseases affecting pomegranate. Bacterial blight (*Xanthomonas axonopodis* pv. *punicae*) was managed under field conditions by spraying of streptocycline (500 ppm).

Fruit-borers (*Deudorix isocrates*), bark-eating caterpillars (*Inderbela* sp.), thrips, aphids and white flies were major insect-pests causing damage to pomegranate.

Vegetable crops: Luring/repellent index of molasses and neem was determined in a laboratory study by recording the relative movement of fruit fly to bitter gourd shoots in a Y-type choice chamber sprayed with bait, repellent and water. The index was calculated taking into account the number of flies present in lure, repellent and middle chamber. The luring index of molasses and neem was more (0.95 and -0.95) in presence of a respective repellent and attractant in the adjacent chamber. While in the presence of water the luring index of molasses was 0.60 and the repellent index of neem was -0.45. In presence of neem the luring index of molasses improved by 58.30%.

In brinjal, damage by shoot-and fruit-borer (*Leucinodes orbonalis*) was significantly reduced with clipping of damaged shoot and release of egg parasitoid *Trichogramma chilonis* @ 50,000/ 0.4 ha at the time of initiation of shoot damage at weekly interval followed by two applications of Bt formulations (Dipel @ 1,000 ml/ha) at peak flowering stage.

IPM in cucumber. The IPM in protected cultivation of cucumber using soil solarization with polyethylene mulch and formaldehyde treatment with soil applications of neem seed powder and *Trichoderma harzianum* gave highest yield of 111 kg/plant over harvest period of 19 weeks.

Nematodes management in cucurbits. In cucurbits (bottle gourd), seed treatment of Carbosulfan (25 DS) at 3% w/w reduced root-knot nematode disease by 3%, resulting in 24% increase in yield over untreated control with a benefit : cost ratio 9.7.

Mites in vegetables. At Navsari, Propargite at 570 g ai/ha on brinjal and Diafenthiuron at 300–600 g ai/ha on field-rose effectively controlled spidermites up to two weeks, while in Ludhiana, Spiromesifen 240 SC at 300–500 ml/ha and Propargite at 750 ml/ha on brinjal resulted in 75% reduction in spidermite population. Propargite (200 ml/0.4 ha) and Kelthane 20 EC (300 ml/0.4 ha) were found promising against spidermites on bell pepper under net house conditions. In West Bengal, Propargite 2–3 mil/litre accounted for 70–78% mortality of spidermite on okra in a week. Two-spotted spidermites *Tetranychus urticae* were found to prefer middle canopy leaves of tomato plant compared to top and bottom canopy leaves. The host-plant resistance to this mite in tomato genotypes LA 1740, LA 1777, LA 280 and LA 2963 is attributed to glandular trichomes and biochemicals like methyl ketones (2 tridecanones and 2 undecanone), phenols and acylsugars. Fenpyroximate at 15–30 g ai/ha or Milbemectin at 3–4 g ai/ha controlled spidermites on tomato for 7–10 days, causing 70% reduction in population. In Coimbatore, Diafenthiuron (300–600 g ai/ha) has been found promising against this mite infesting tomato.

Mites in chilli. All life stages of yellow mite *Polyphagotarsonemus latus* were effectively controlled by Fenpyroximate 30 g ai/ha up to two weeks, resulting in more than 80% reduction in mite population on the popular chilli variety Byadgi Kaddi, which was severely infested (55–60 mites/6 leaves). Indam variety of chilli was fairly tolerant to yellow mite, which caused up to 39% losses in yield of susceptible varieties in West Bengal.

Potato: Two to three sprays of Mancozeb or 1 spray each of Mancozeb and Cymoxanil effectively controlled late blight and increased tuber yield significantly compared to the control in susceptible varieties Kufri Ashoka and Kufri Chandramukhi. Boric acid (3%) treatment of seed tubers before cold storage reduced incidence of bacterial wilt from 10.19 to 4.4% and increased tuber yield from 10.59 to 17.25 tonnes/ha. At Hassan, soil solarization after one irrigation reduced wilt incidence from 3.14 to 0.7% and germplasm accessions, CP 3786 and CP 1571, were found free from wilt.

Model developed for predicting the occurrence of late blight was successful in forecasting the appearance and build-up of disease in Uttar Pradesh. The late blight severity was very high throughout the country both in *rabi* and *kharif* seasons with expected losses up to 22% in Punjab, 70% (Atlantic) in Maharashtra and 20% (Kufri Jyoti) in West Bengal. Cymoxamil- and dimethomorph-based formulation was effective in controlling late blight.

Coconut: Application of vermicomposting in trenches and biofertilizers (*Azospirillum* and phosphobacteria) and raising vanilla and black pepper resulted in higher copra and nut yield. Native *Trichoderma viride*, *T. harzianum* and *T. hamatum* were effective in inhibiting the radial growth of stem bleeding disease pathogen *Thielaviopsis paradoxa* to an extent of 69.35% by *T. viride* followed by *T. hamatum* (66.70%)

and *T. harzianum* (63.33%). *T. harzianum* was applied as a paste on the bleeding patch coupled with basal application of the same bioagent (50 g) in combination with 5 kg neem cake (10.6 cm decrease).

Mites in coconut. Spray of Flufenzin at 80–100 g ai/ha and Clofentezine at 200–300 g ai/ha was found promising against coconut eriophyid mite in Karnataka, Tamil Nadu and Gujarat.

Spices: Endophytic bacteria found effective against *Phytophthora capsici* in black pepper were identified as *Pseudomonas aeruginosa* (BP-35) *Bacillus megaterium* (BP-17) and *P. putida* (BP-25) by analyzing the nucleotide sequence of 16s rDNA. *Bacillus megaterium* (BP-17) and another endophyte *Curtobacterium luteum* (TC-10) was found effective against *Radopholus*. An integrated pest management schedule involving planting of root mealybug-free rooted cuttings in field, removal of weeds in interspaces of black pepper vines during summer, especially when intercropped with coffee, drenching with Imidacloprid (0.075%) and adoption of control measures against *Phytophthora* and nematode infections was developed for the management of root mealybug. Neem gold (0.5%) and neem oil (0.5%) were found to be superior to fish oil insecticidal soap (2.5%) in reducing the population of scale insects in black pepper.

Trichoderma and *Pseudomonas* were found to be effective in controlling diseases of elephant-foot yam. Cauliflower waste leaves were good in luring snail population in elephant-foot yam crop. Yam bean border crop around elephant-foot yam crop reduced the snail infestation significantly. The sex pheromone septa developed in collaboration with BARC, Mumbai, as one of the components of IPM of sweet potato weevil was found to be effective in suppressing the weevil damage.

Integrated pest management

Plant health clinics are established at four centres to cater to the requirements of the knowledge support and demonstration of IPM strategies to farmers.

On the pest forewarning front, a multiple regression model has been developed using maximum and minimum temperatures, relative humidity and population of one-week lag period for forecasting *Helicoverpa armigera* population at Sriganganagar (Rajasthan). The prediction rules for *Helicoverpa armigera* during *kharif* and *rabi* have been developed using threshold values of rainfall and degree-day accumulation.

Biological control

Introduction of natural enemies. The stem gall-fly *Cecidochares connexa* released in July 2005 for control of Siam weed *Chromolaena odorata* was established in field at Karnataka (2 locations) Tataguni village and GKVK, and has been successful for two winter and summer critical periods.

Pest management information system (PMIS)

PMIS has been developed on cotton, brinjal and okra. Decision-making software (pesticide Advisor) has also been developed with all information on available pesticides. For popularization of IPM, six different songs (in Telugu) along with video (explaining plant protection activities from sowing to harvest in cotton) were developed and broadcast through All India Radio in Andhra Pradesh.

Biosystematic studies on coccinellids. *Halyzia dejavu*, new sibling species of *Halyzia straminea* has been described from India and Nepal. Taxonomic revisions of *Synona*, *Scymnodes*, *Apolinus*, *Rhynchortalia* and *Cryptolaemus* (in part) have been carried out. A new species of *Horniolus* has been recorded from Karnataka.

Halyzia dejavu is a new sibling species

Endophytic bacteria. Antagonistic endophytic bacterium *Bacillus megaterium* induced high level of production of chitinase (2.794ì/g) and *Bacillus* sp. induced a high level of ß-1, 3-glucanase activity; indicating their high biocontrol potential. *Bacillus* sp. could inhibit *Fusarium solani* 50% and *Verticillium dahliae* by 48%, while *Ervinia herbicola* inhibited *F. solani* to 37.5%.

Biological suppression of plant-parasitic nematodes

At the TNAU, and AAU, Anand, talc formulation of *P. lilacinus* and *Pochonia chlamydosporia* at 20 kg/0.4 ha in pigeonpea resulted in 59% reduction in population of pigeonpea cyst nematodes and

Biological suppression of polyhouse pests

Applications of fungal formulations, viz. *Verticillium lecanii*, *Hirsutella thompsonii*, *Metarrhizium anisopliae* and *Beuveria bassiana* effectively reduced population of thrips (*Frankliniella* sp.) on gerbera plants in polyhouses in Kerala.

At Solan, *Paecilomyces fumosoroseus* at 10^{11} conidia/litre was effective in managing whitefly infesting cucumber in polyhouse, killing 67.1 and 39.3% whitefly nymphs within 15 days of treatment.

21% increase in pigeonpea yield. Talc formulations of *P. lilacinus* and *Pochonia chlamydosporia* when stored in aluminium sachet recorded 92–96% and 88–92% spore viability at 12 months of storage at 8–10°C and 4–8% moisture respectively.

Checklist of eriyophyid mites

Checklist of eriyophyid mites on tree species of Karnataka comprising 24 new genera has been prepared. Survey for plant-associated mites fauna revealed occurrence of *Eutetranychus orientalis* and *Brevipalpus phoenicis* on medicinal plants like *Bauhinia variegata, Piper longum, Rauvolfia, Withania somnifera, Ocimum, Dalbergia*, particularly in Varanasi.

Greater activity of predatory mites (Phytoseidae, Stigmaeidae, Tydeidae and Anystidae) and insects like coccinellids were observed on spidermite infested vegetable crops in Ludhiana (Punjab), Kalyani (West Bengal) and Varanasi (Uttar Pradesh).

Rodent management

In Andhra Pradesh, damage to *kharif* rice was recorded from 12.4 to 72.9% and up to 40% to *rabi* rice, and tiller damage was 11.09% and 13.6% in *sali* and *boro* rices. Pineapple suffered maximum with 13.2% fruit damage in lower Brahmaputra region. And cumin, an important seed-spice crop in Rajasthan suffered damage at vegetative growth stage, due to gerbils, *Tatera indica* and *Mus hurrianae*.

Botanicals. Anti-rodent properties of some plant products were evaluated in the laboratory. *Rattus rattus* recorded least preference for *Vitex nigundi* and *Polygonum* treated food in Asom. *Jatropha* seeds and seed coat powder registering negligible consumption by *Tatera indica* in no choice and choice trials in the laboratory indicate their deterrent/repellent properties. Sprinkling of neem leaf powder (0.5%) on gunny bags with alternate food under simulated storage provided total protection to treated bags up to 9 days. Feeding on 2, 4 and 6% root powder of *Calotrophis procera* in bait caused dose-dependent decrease in weight of reproductive organs and sperms function characteristics in *Rattus rattus.* Males of *Bandicota bengalensis* after administration of 0.01 and 0.02% gossypol for 16 days showed sterility effects in terms of decreased sperm motility, vitality and sperm concentration *vis-à-vis* reduced weight of reproductive organs and accessory glands.

Burrow fumigator. The modified burrow fumigator developed at Ludhiana showed more than 90% rodent control success, compared to zinc phosphide (2%) baiting (67% success).

Rodents damaged nursery

A farm woman using burrow fumigator

Rodents damage cumin crop

Traps and trap barrier system. Local made Butta recorded higher-rodent trap index than Tanjore kitty trap; indicating its superiority in trapping field rodents.

Rodenticides. Cholecalciferol, a vitamin D_3-based rodenticide revealed LD_{50} value of 30 and 50 mg/kg body weight for males and females. A new tablet formulation (12 g tab) of aluminium phosphide containing 6% a.i. evaluated in fields at Jodhpur, Bangalore, Jorhat and Marateru at one tablet per burrow dry and wet plugging yielded 65–71 and 55–62% control success at Jodhpur. In other centres control success was between 68 and 75%.

Trichoderma formulations with longer shelf-life developed

Trichoderma harzianum and *Pseudomonas fluorescens* formulations with enhanced shelf-life have been developed through appropriate formulation techniques. *T. harzianum* and *P. fluorescens* population were above 10^8 cfu/ml even after 10 months of storage.

Addition of glycerol in production medium at 3% concentration increased shelf-life of *Trichoderma* up to 8 months with 10^{11} cfu/g compared to control in which the cfu fell down to 10^6/g by the 6th month.

Heat shock (HS) at 30°C for 30 min induced desiccation tolerance in *T. harzianum* and helped in extending shelf-life by an additional one month.

Rodent control in Karnataka. Baits were prepared as prebait. This mixture was packed in plastic covers and each live burrow was prebaited with one such packet by farmers themselves. On the third day, 2% zinc phosphide was mixed with cereal-groundnut oil-groundnut seed mixture. This poison bait was packed again in plastic covers and all burrows were poison-baited. On the fourth day remaining live burrows were poisoned with bromadiolone cake at one cake/burrow. Along with field rodent control, baiting household rodent pests with bromadiolone cakes was also undertaken. At Kodihalli, campaign resulted in 65.5% population reduction in ragi and *jowar* mixed crop. At Konaghatta, it resulted 67.5% and 50.0% reduction in population density in ragi and potato, respectively. Similarly, at Linganahalli, rodent control success was 52.5% in ragi and *jowar* mixed crops.

Agricultural Ornithology

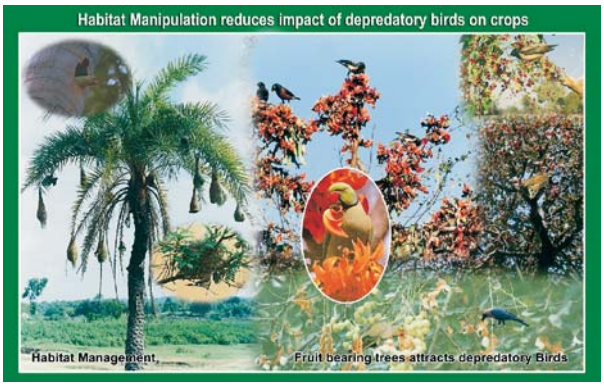
Status of birds and their extent of damage to different crops: In Punjab, monitoring of bird community in selected wheat and paddy fields at 3 locations has revealed occurrence of 23 and 25 species with maximum species richness of 15 and 12 at sowing/sprouting and tiller formation/earhead formation stages, which can be exploited for suppression of insects in these crops. Monitoring 2.02 ha wheat field under bed plantation at village Buani (Ludhiana) revealed 77.69% damage to sproutings and seedlings by house-crow, which resulted in wheat yield of only 500 kg/0.4 ha. While in Gujarat, bird community of wheat-crop agro-ecosystem was found dominated by cattle egret having relative abundance of 31.72%, followed by glossy ibis, Indian ring dove, little brown dove, large grey babbler, and red-wattled lapwing. Damage to germinating wheat seed was non-significant. In Kerala, damage to banana was by small green barbet (21%), to rice by baya-weaver bird, parakeets and teals (9.1, 19.7 and 5.0%), to pulses by parakeets (15.6%) and to pepper by koel, bulbul and barbets (15.9%), to tomato by house-crow (up to 13.5%) and to okra seed by parakeets (up to 11%). GPS and GIS technology in bird-roosting sites have provided information that birds are in close proximity to availability of preferred food, and the feeding activity of the birds showed significant correlation to cropping pattern. The feeding activity ranges between 2.5 and 16.5 km^2 with an average of 8.75 km^2. The extent of damage on different crops varied from 5 to 12%, from roost to roost in relation to number of birds. The incident i.e. of damage was very high within 7.5 km^2 from roost.

Eco-friendly bird management practices: Seed treatment with copper oxychloride at 3 g/kg seed in maize in *kharif* and *rabi* reduced birds abundance drastically from 44 to 67% in *kharif* and 23–74% in *rabi*.

In Punjab, in winter maize, installation of reflective ribbon + camouflaging of cobs in outer row on borders of field and installation of reflective ribbon + beating of drums regulated through rope by standing on a platform erected in the centre of the field resulted in 93.69 and 99.54% bird management success with corresponding damage reduction of 0.06 and 0.17% compared to 12.97% damage recorded in unmanaged (control) field.

Role of beneficial birds: In Andhra Pradesh, in pigeonpea least incidence of pest and extent of damage was observed where NPV + bird perches were employed. A total of 24 species of insectivorous birds were found in varying percentage (5.2–21.21) in different months. Among these birds, 15 species utilized (15.78–94.73) artificial bird perches and helped in controlling pests. In Punjab, in cotton artificial 'T' perches, followed by sorghum/millet perchings outperformed in their utilization than other perching facilities with mean number of visits performed by birds to be 4.00 to 9.27 ± 5.10 and 1.00 to 2.80 ± 1.17 per 20 minutes, respectively, for picking up insects. Relatively less number of bird species utilized 'T' perches and perching facilities in sprayed fields. Maximum utility of perches was by eight species in August-September which corresponded with increased foliage density and corresponding increase in insect infestation intensity. Similarly, in muskmelon, watermelon and bitter-gourd, artificial perches could attract 6, 8, 8 species out of total 8, 11, 13 species visiting crops.

Wooden nest boxes were readily accepted and adopted for breeding by common myna and spotted owlet, which resulted in 68.32% breeding success in common myna. While earthen pots with lids were adopted by house-sparrow and Indian robin,



and their egg laying was recorded in 22.06 and 1.47% pots. Egg laying by common myna was accomplished in three successive layings after successfully rearing of previous brood in 62.74, 27.45 and 17.65% wooden nest boxes.

Analysis of food samples of spotted owlet found high occurrence of rodents (60%) in winter, followed by insects (24%), while in summer and monsoon, insect-diet was predominantly high (58, 35%).

Presence of fruit-bearing trees like *Butea monosperna, Pithecolobium dulce, Morus alba* and *Salvadora persica* around farm lands attracted 18 species of insectivorous birds and helped in controlling crop pests to the extent of 40–63%.

Whitegrubs and other soil arthropods

Whitegrubs: Soil application of Chlorpyriphos 20 EC at 400 g a.i./ha and Bifenthrin 10 EC at 250 g a.i./ha in standing crop of potato against whitegrub *Brahamina coriacia* was found superior in terms of controlling tuber damage. Imidacloprid 0.75 G at 90 g a.i./ha as post-sown soil application in standing crop against whitegrub *Adoretus* sp. in greengram recorded lowest plant mortality at Jorhat centre.

Dissemination of pheromone technique of whitegrub through beetle management was demonstrated in village Sirsi near Jaipur covering 50 ha, involving 10 farmers' families. Out of the total 525 host-trees, only 160 trees were sprayed on the eve of good monsoon rain. One host tree in the radius of 15 m was selected in advance and up to 4 days from the day of monsoon rain, pieces of sponge dipped in pheromone (4/trees/day) were hung on the insecticide-sprayed trees regularly. The beetles attracted to these host trees in the evening after emergences fed on insecticide-treated leaves and died. This reduced egg laying in the field and thereby reduced grub damage in the groundnut field drastically and increased pod yield. This year due to beetle control operations, productivity increased to 1,500 kg/ha as against 400–500 kg/ha.

Termites: At Jorhat, Chlorpyriphos 20 EC at 400 g a.i./ha recorded lowest number of preserved setts of sugarcane infested by termite, and were at a par with Thiamethoxam 25 WG at 150 g a.i./ha and Imidacloprid 70 WS at 700 g a.i./ha. In groundnut, Imidacloprid 200 SL was found at a par with standard check Endosulfan 35 EC applied as seed treatment or as standing crop treatment at Durgapura.

Cutworms: Imidacloprid recorded minimum plant mortality (0.83%) and was significantly superior to Quinalphos (1.46%) and lambda Cyhalothrin (1.58%) against cutworms *Agrotis* species in brinjal. At Ranichauri, *Bacillus thuringensis* (0.02% foliar spray) was found effective against cutworm *Agrotis ipsilon* in potato, recording 7.83% tuber damage.

Pesticide residues

Trials of Imidacloprid on cotton carried out at Hyderabad at 35 and 70 g a.i./ha, showed that none of the samples (soil, lint and seed) exhibited presence of residues at harvest. Mixed formulation of Acephate (50%) and Imidacloprid (1.8% SP) on cotton was evaluated at PAU, Ludhiana. Their residues dissipated below detectable limit (0.02 mg/kg) 15 and 7 days after application.

Multilocation supervised trials of bifenthrin (60.0 and 120.0 g a.i./ha), Fenazaquin (40 and 80 g a.i./ha), Diniconazole (500 and 1,000 g a.i./ha) and Fenpropathrin (450 and 900 g a.i./ha) on apple were carried out at Solan, Mashobra, Matiana and Thanedhar (Himachal Pradesh). The residues were found below detectable limit within 30 days in all locations.

Tebuconazole (2% DS) on groundnut was evaluated at Jaipur, at 0.025 and 0.05 g a.i./kg seed. None of the samples of groundnut or soil showed presence of residues in any of the treatments.

Persistence of Bifenthrin and Fipronil, as termiticide in building soil, was studied jointly by AINP on Pesticide Residues, IARI and Central Building Research Institute (CBRI), Roorkee for five years. Their residues were detected up to

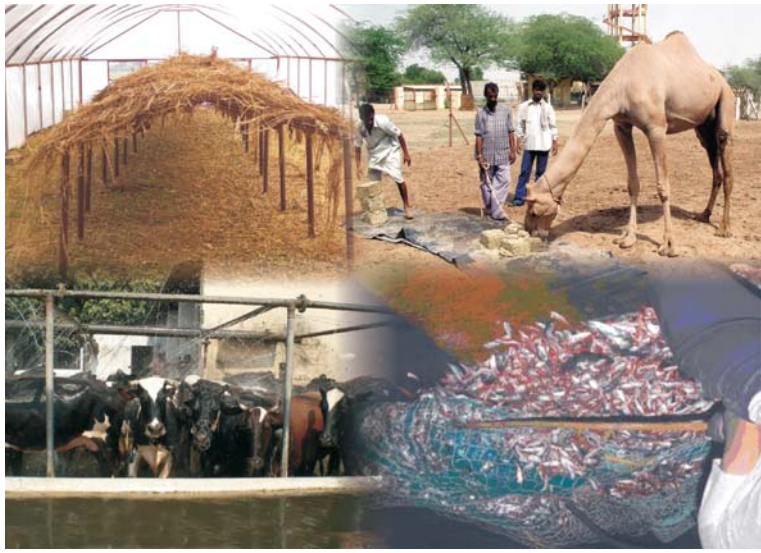
60 cm layer at higher rate of application. Surface residues persisted up to 37 months at lower dosages and up to 53 months at higher dosages (0.075 and 0.1%).

Simple and effective multi-residue methods of analysis of pesticide residues in various food commodities and environmental samples have been developed and validated by all co-ordinating centres. Validated methods for pesticide residues analysis have been documented in "Manual on Pesticide Residue Analysis" and has been published by the Directorate of Information and Publications of Agriculture, ICAR. The website of the All-India Network Project on Pesticide Residues has been launched (www.ainppr.com).

❑

Mites in flowers

Abamectin and Fenazaquin at 0.25–0.5 ml/ litre to suppression spidermites on marigold for 7 days with more than 90% reduction in mites population. At Coimbatore, Diafenthiuron (300–600 g ai/ha) has been found promising against this mite infesting polyhouse rose.



8. Livestock Management

ANIMAL MANAGEMENT

Cattle

CLA content in milk: The conjugated linoleic acid (CLA) content was significantly higher in milk of both cows and buffaloes fed high forage diet. Providing high forage diet increased milk yield in buffaloes as compared to high concentrate diet. CLA content was almost double in ghee prepared by indigenous method as compared to creamery method.

Sustainable milk production system

Annual milk productivity per cow, per labour and per acre land was sustained at 5,100, 14,450 and 8,640 kg, respectively, through application of integrated system approach comprising integrated breeding system (IBS), straw based feeding system, eco-friendly housing system and optimum herd management system. The sustainable milk production system was validated at a Gaushala.

Chelated zinc: Chelated zinc was prepared by enzymatic hydrolysis of soy protein in a single stage or double stage process using different enzymes to achieve maximum degree of hydrolysis (DH) for the preparation of zinc chelate. Per cent recovery of zinc declined as the level of zinc used for chelation increased. Absolute content of zinc in chelate increased as the addition of inorganic zinc increased from 5 to 20%. Protocols/technology for the preparation of chelated zinc by enzymatic hydrolysis of soy protein was developed and tested for its efficacy.

Energy expenditure: Energy expenditure (EE) of cattle was less when fed chaffed paddy straw *ad lib.* and at restricted level of intake, compared to that of un-chaffed paddy straw fed *ad lib*. Chaffing of maize stover resulted in 15–17% lower energy expenditure by animals, thus saved biological energy for productive purposes. Chaffing resulted in 11–12% reduction in CO_2 and 20–25% reduction in methane production by cattle.

Detoxification of aflatoxins: Plant extracts like olive oil, garlic and turmeric showed highest efficacy in reducing aflatoxin levels in feeds. Ethiglacetate extract of herbal products like neem-bark, annaa-seeds with witharia prevented mycotoxin contamination in stored feeds.

Pesticide residues: An analytical technique was developed for measuring the residue of imidacloprid in water and soil samples. A detection limit of 0.5 ppb was achieved.

Jatropha cake for animal feeding: Jatropha cake, a byproduct of jatropha, which is being promoted for bio-diesel production, contained phorbol esters an anti-nutritional factor responsible for toxic effects in animals. The seed-kernels were rich in crude fat and protein.

Microbial protein: Supplementation of finger millet straw based ration with rumen degradable nitrogen showed that digestibility of nutrients, PDC index and estimated microbial protein synthesis (spot as well as total urine) was comparable in all the supplemented groups. The optimum level of microbial protein synthesis was at 15 g RDN (rumen degradable nitrogen) level of supplementation with finger millet straw based diet.

Feed processing: Cooking significantly reduced IVDMD of maize, sorghum and finger millet grains while processing of wheat grains did not have any effect on the IVDMD. Treating maize, sorghum and rice grains with microwave significantly reduced IVDMD.

Evaluation of sperm quality of Frieswal bulls: Evaluation of frozen semen of Frieswal bulls showed that progressive motility ranged from 58.48 and 43.13% and acrosomal damage from 7.55 to

18.26%. The GOT and GPT enzyme activity in seminal plasma did not differ among bulls, whereas ACP and AKP differed. The total sperm abnormalities in Frieswal semen did not differ among bulls of different age groups. Proportion of free heads decreased with the advancement of age.

Embryo transfer: Superovulated Frieswal cows — 3 with folltropin V and 2 with folligon — produced 30 embryos, out of which 6 were of transferable quality. Transfer of these embryos to 5 recipients resulted in birth of two calves (one male and one female).

Augmenting reproductive efficiency: Additional energy supplementation through locally available ragi (finger millet) during the first month of postpartum (transient period) augmented reproductive efficiency in crossbred cattle in field condition. Ragi feeding during transient period avoided a steep fall in body condition score during first month postpartum. Blood plasma glucose and cholesterol showed significant negative correlation with the day of occurrence of first postpartum heat, but blood urea nitrogen, milk urea nitrogen and milk yield showed a positive correlation.

Stress related enzyme assay: Methodology for determination of stress related enzymes i.e. superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) was standardized both in blood plasma and haemolysate.It could be used as a tool to asses the effect of stress on animals.

Buffalo

Strategic supplementation for improving production: Feeding wheat straw/*bajra kadbi* based **complete feed blocks** improved milk yield in buffaloes. Incorporation of **limiting amino acid rich supplements**, like cottonseed cake and soybean cake in the diet of buffaloes resulted in 6–10% increase in milk yield. **Energy requirement** of pregnant buffaloes could be met with 55% TDN and 12% CP during ninth month, and with 60% TDN and 14% CP during the last month of gestation. **Higher plane of nutrition** did not improve conceptus growth, milk production or body condition score in early lactation. For optimum growth of Nili-Ravi buffalo heifers (647 g/day) the **concentrate level in diet** should not exceed 60–70% of DM intake as higher concentrate diet predisposes animals to ruminal acidosis. **Economic feeding regimen** was developed using urea impregnated sherry waste in combination with barley grain in place of conventional concentrate supplements for male buffalo calves for meat production. **Postpartum buffaloes** fed 120% of energy requirement had low reproductive performance in comparison to buffaloes fed either 80 or 100% of energy intake indicating that higher energy allowance than recommended levels may not be necessary.

Limiting amino acid in buffaloes: Buffaloes fed high bypass protein (UDP) rich in limiting amino acids diets showed an increase in milk production over that of controls. Milk fat percentage increased in all animals with progress of lactation indicating that ration for high yielding buffaloes need to be supplemented with bypass protein rich in limiting amino acid (lysine and methionine).

New fungus genus identified: *Cyllamyces icaris* p. nov., a new anaerobic gut fungus with nodular sporangiophores was isolated from the dung sample of *Bubalus bubalis*. It resembled the previously described *Cyllamyces aberensis*. These fungi hold special significance in the degradation of poor quality feed in ruminants.

Foot-and-mouth disease

Samples received from various states were processed and field samples revealed type Asia 1, type O and type A. 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. Serotype A isolates showed an r-value of <0.2 with current vaccine strain IND 490/97 implying the demand for new vaccine strain. Molecular epidemiological studies revealed endemic co-circulation of genotype VI and VII since 1990 in type A. But since 2001, dominance of genotype VII and disappearance of genotype VI from field was noted. FMDV type A recent field isolates were processed for molecular epidemiological analysis. In phylogenetic tree, all the isolates were clustered in genotype VII as with previous years indicating incessant supremacy of genotype VII in the field.

Genotype differentiating ELISA and RT PCR were developed to distinguish between genotype VI and VII. It gives a fast preliminary indication on the genotype prevalent before proceeding with thorough sequencing of 1D region, which definitely continues to be the confirmatory method to assign genotype by phylogenetic analysis. Similarly genotype-differentiating ELISA was also developed to find out the genotype of type A. Since this assay is very simple and technically not demanding, samples can be subjected first to ELISA and then ELISA—negative samples can be subjected to PCR. Both the assays were effective in molecular epidemiological investigation of FMDV type A in the country.

Strains IND 40/00 and IND 81/00 were selected as candidates for FMDV type A vaccine. IND 81/00 showed marginally superior antigenic relatedness with the recent field viruses than IND 40/00, and hence both of these are effective vaccine candidates in present context. At present national repository contains 1,292 (818-O, 257-Asia 1,202-A, 15-C) field isolates.

Improvement of semen quality: Buffalo bull semen collected during different seasons, revealed significant seasonal variation in seminal plasma AKP, ACP, GOT and GPT in pre-freezing and post-freezing sperm motility, but not in ejaculate volume, mass activity, seminal plasma protein, cholesterol and testosterone level. Semen samples with higher values of sperm total motility, progressive motility, rapid motion and viability showed that these can be used as indicators for assessing semen quality and predicting fertilizing potential.

Zinc: Its supplementation significantly improved semen characteristics, viz. motility, sperm constriction and serum testosterone in buffalo bulls; organic form of Zn performed better in terms of per cent live spermatozoa and acrosomal integrity in addition to *in vitro* fertilizing ability.

Immunoblotting technique for detection of anti-oxidant enzymes: A sensitive technique for detection of anti-oxidant enzymes superoxide dismutase (SOD) and catalase (CAT) in serum, follicular fluid, oviduct, uterine secretions of pregnant and non-pregnant animals, was developed. The results confirmed that activities of both Cu-Zn SOD and catalase modulate according to the stage of estrous cycle and early pregnancy in buffaloes.

Vitrification of *in vitro* matured buffalo oocytes: For successful vitrification, BSA supplementation in maturation media showed positive influence on post-thaw survival and maintenance of developmental competence of *in vitro* matured buffalo oocytes, in comparison to FCS supplement. Post-thaw IVF-rate of *in vitro* matured buffalo-oocytes vitrified using ethylene glycol (EG) was high.

Blood profile: Plasma albumin levels were lowest in heifers and highest in late pregnant dry animals. Globulin levels varied nonsignificantly between different groups of diverse reproductive status. Blood urea was significantly higher in late pregnant animals as compared to heifers.

Environmental pollutants: High concentrations of heavy metals particularly cadmium caused cell death, lowered the growth potential of oocytes/ follicular somatic cells and sperm functions leading to infertility in buffaloes.

Sheep

Strategic supplementation for improving production: Supplementing 200 g of **concentrate mixture** during 3–6 months of age of lambs maintained on community grazing lands resulted in additional benefit of Rs 300/lamb. Supplementation of 300 g concentrate mixture during pregnancy in sheep maintained on grazing lands was adequate to meet the requirement of dam as well as for growing feotus**. Fallen tree leaves and stovers** of coriander cumin, *methi*, fennel, *ajwain* could be used as partial source of roughage in complete feed block. Utilization of abundantly available **damaged wheat** as a replacement of conventional and costly cereal supplement in lambs could economize cost of mutton production.

Standarised transcervical AI technique: Frozen-thawed semen using transcervical artificial insemination (TCAI) technique was standardized. A protocol for obtaining multiple births through precise control of ovulation using exogenous hormones was developed. The efficacy of indigenous vaginal sponges in inducing estrus among anoestrus ewes during non-breeding season was tested and found effective in regulating anoestrus cases.

Goat

Socio economic study

Black Bengal: Socio-economic condition, management practices and housing pattern were studied among adopted villages. This breed is highly prolific having 83.72% multiple births. The kidding rate was 1.80, the highest among all the goat breeds of the country. The age and weight at first kidding were 378±2.12 days and 13.52±0.22 kg. The overall mortality was 7.8% under field conditions. The socio-economic studies revealed that in Nadia district of West Bengal goat rearing proved more beneficial to the goat keepers having basic knowledge of animal husbandry. The annual income of a family was Rs 2,384.06 from goat rearing.

Black Bengal goat is highly prolific having 83.72% multiple births

Sangamneri: Baseline information on growth, production and reproduction were recorded. Economic gain through increase in body weight for 3 and 6 months of age, was Rs 42.40 and 30.40, respectively. Similarly economic gain through increase in milk production was Rs 176.40 for 90 days estimated milk yield.

SUCCESS STORY

Commercial Goat Farming

Goats play a significant role in ensuring livelihood security to the millions of small and marginal farmers, landless labourers and rural folk. Goat rearing under intensive and semi-intensive system for commercial production is gaining momentum. A progressive farmer, Shri Rohan Singh resident of Salempur village in Farah block of Mathura district of Uttar Pradesh, started a goat farm in his village with 68 Barbari does and 2 bucks, and after 6 months 33 does and 1 buck more were added to the flock. The objective of this goat-rearing project was to produce and market pure breed Barbari goats.

The initial investment made on purchasing of breeding stock and construction of sheds and equipments was Rs 1.62 lakh and another Rs 10,000 was used as working capital. The goats on this farm were maintained under semi-intensive system of management by the two unemployed youths of the family. Besides grazing, the animals were provided supplementary concentrate feeding, mineral mixture, fodder tree leaves lopping and guar straw.

Total annual expenditure incurred on supplementary feeding of goats worked out to be Rs 10,700, and on prophylaxis schedule (vaccinations against enterotoxaemia, FMD and PPR disease and twice medication against internal and external parasites) and treatment Rs 3,500. Thus the total recurring expenditure other than family labour for a flock of 104 goats was Rs 14,200 during one year. The returns from the sale of goats in one year were estimated to be Rs 75,000. Moreover the goat manure valuing Rs 4,000 was produced and used in the agricultural farm of the owner. Thus the annual net returns to the family from goat rearing was Rs 64,800. The farmer sold all the surplus animals (pure Barbari goats) for breeding purpose to the other goat farmers at the rate of Rs 100 per kg live body weight. Concurrently the other traditional farmers of this area maintaining non-descript goats could fetch a market price of Rs 60–65 per kg of live body weight for their improved goats sold mostly for meat purpose.

Ganjam: The information regarding production and reproduction parameters was collected from the adopted area. The kidding percentage on the basis of does tupped was 73.18. In the Ganjam district of Orissa the goat is a primary source of income of tribals (Gola). The goat rearing contributed 61.54% of their annual income.

Surti: The survey work on Surti goats was conducted in Bharuch district. The improvement of 15.10% was observed at 3-month body weight due to the use of elite bucks under field conditions. Females were registered and bucks were selected from the population.

Surti—Body weight improvement was observed with the use of elite rams for breeding

Malabari: In the three village centres females were registered and bucks were selected from the population. The average gestation length, age at first kidding and inter-kidding interval were 149.34±1.49, 381.36±18.33 and 263.13±15.62 days.

Sirohi: The population growth of the flock in field was 64.93%. The breeding efficiency on the basis of does kidded was 112.66, which was lower than previous year.

Low cost animal feed mixer developed: A low cost animal feed mixer was designed and developed to mix heterogenous feed ingredients before preparation of complete feed pellets and complete feed blocks. The feed ingredients comprising 50% straw (*Cajanus cajan*) and 50% concentrate with molasses could be uniformly mixed in 10–15 min with an output of 0.6 q/hr to 1.2 q/hr. The cost of mixer is Rs 20,000 and cost of mixing 100 kg feed is Rs 25 only.

Evaluation of embryos: *In-vitro*-produced embryos at 2- to 16-cell stage were cryopreserved using conventional freezing protocol. Approximately 50 IVRP embryos were used for freezing. After thawing none of the embryos had broken zona pellucida. However, blastomere membrane reptured and their cytoplasm were found disintegrated.

Early pregnancy diagnosis: The B-mode sono graphic imaging technique was standardized enabling screening of pregnant goats within 30 days of mating, thereby, allowing rebreeding of empty animals for increasing flock fertility.

Cardinal physiology response: Thermo-regulatory characteristics of Jakharna and Sirohi bucks at different temperatures revealed that they could adapt to hot-dry, hot humid and cool periods by increased heart and respiratory rate. Temperature around 9°C seems to be critical for bucks in cool period, and ambient temperature of 40°C and vapour pressure of 20.67 mmHg during hot humid conditions.

Pig

Economic rations were formulated for grower and finisher pigs by partial replacement of costly feed ingredients with the locally available feed resources, e.g. maize with tamarind seed and molasses, wheat bran with de- caffeinated waste, fish meal with dried cuttla fish waste, silage and concentrate mixture with green cabbage leaves. Supplementation of chelated minerals with dicalcium phosphate and incorporation of coconut oil in the grower diet improved growth and feed conversion efficiency.

Camel

Unique sperm depot: Semen evaluation revealed zero or low motility in freshly ejaculated semen from camel due to formation of a unique depot of spermatozoa from which spermatozoa are continually released over a prolonged period of time and does not exhibit mass motility and individual sperm motility as seen in the cattle, buffalo, sheep and goat. The spermatozoa develop motility only after liberation from this depot, and this delay was not due to use of rubber funnel as was speculated earlier.

Semen sample after centrifugation

Gelatinous sperm pellet

Estradiol profiles: Estradiol profiles in unmated female camels are different from those of other species of livestock. These profiles monitored for 60 days in unmated female camels revealed that basal levels are relatively very high and peak levels of estradiol were observed at irregular intervals.

Mithun

Tree leaves based total mixed rations: *Lagerstroemia speciosa* (*thumero*), one of the important tree foliages having good nutritive value (8% DCP and 48% TDN), is relished by mithun under natural browsing condition. Inclusion of *Lagerstroemia speciosa* as green foliage in total mixed ration (TMR) showed higher daily body weight gain, dry matter (DM) intake, nutrient utilization and feed conversion efficiency in growing mithuns, suggesting that these tree leaves can be incorporated successfully in TMR for feeding of growing mithuns.

Vegetative propagation of selected foliages: The propagation study by using higher dosage of auxins on good quality fodder trees revealed encouraging trend with highest survival percentage, increased length and number of sprouts per stem cuttings of selected fodder tree species (*Ficus hirta*, *Ficus roxburghii*, *Lagerstroemia speciosa*, *Trema orientalis*, *Ficus hookeri*). Stem cuttings treated with IAA provide better option for multiplication in degraded pastureland of low carrying capacity.

Standardization of semen collection method: Collection of semen from mithun bulls is difficult, as they do not mount cows not-in-estrus. An innovative method of sprinkling urine from estrus

SUCCESS STORY

Successful pig farming

Shri Juby Mathew an agricultural graduate from Kodannur, Thrissur, Kerala, started a pig farm with technical assistance from the All India Coordinated Research Project on Pigs, with an initial investment of Rs 4.0 lakh in 2001. He currently maintains the parent stock of Large White Yorkshire pigs (34 adult female and 4 breeding males). More than 700 piglets per year were produced at the farm and parental stocks were also changed regularly. From each lot of piglets 50% of piglets are disposed after weaning and 50% are kept for fattening. The entire herd is fed with hotel swill, which he collects free of cost by his own tempo van and no feed additives are given to pigs. Using a locally available feed material, the hotel waste, he could achieve a litter size at birth and weaning ranging from 8–12 piglets and 7–10 piglets, respectively, and a body weight of 120 kg at 10 months of age. After 10 months, pigs were sold @ Rs 50–60/kg of body weight depending on demand of the market. Piglets are sold between Rs 800–1,000/piglet. Besides a piggery, he maintains fishery, poultry, duckery, and practices horticulture with spices and flowers. Alone from piggery, the turnover is about 2.5 to Rs 3 lakh/annum.

Ethno-veterianry medicine

Herbs used for common ailments and conditions of livestock were documented with information on their botanical and local names, active constituent, validation for use, etc, and 39 of them were identified by different centers for their evaluation in fluorosis, diarrhoea, mastitis, fever, helminthosis and ectoparasite infestation and as antipyretic, analgesics and hepatoprotectant. Experimental trial in rabbits established the ameliorative potential of tamarind fruit pulp (*Tamarindus indica*) in experimental fluoride toxicity. Methanolic extract of stone fruit (*Aegle marmelos*) powder given @ 400 mg/kg body weight in rats reduced 73.33% faecal output in castor oil induced diarrhoea. *In vitro* screening results showed that methanol extract of *ghila* (*Entada fascioloides*) seeds possessed activity against *Fasciola. In vitro* antibiogram of extracts of turmeric (*Curcuma longa*) and Indian gooseberry (*Phyllanthus emblica*) revealed antimicrobial efficacy against common mastitis pathogens, viz. *Staphylococcus aureus, Streptococcus agalactiae*, other *Streptococcus* spp. and coliform bacilli.

Utility of aqueous and alcoholic extracts of plants was determined in— *babrang* (*Emblia ribes*), *palash* (*Butea frondosa*), *kaliziri* (*Vernonia anhelmintic*a) against nematodes; Auatralian fever tree (*Ecalyptus globules*), *amrita giloy* (*Tinospora cordifolia*), *pippali*, *long*, *pipar* (*Piper nigrum*), *adulsa* (*Adhatoda vasica*), *henna* (*Lawsonia inermis*), *nirgundi* (*Vitex negundo*), *ashwagandha* (*Withania sominifera*), *punarnava* (*Boerhaavia diffusa*) as antipyretic/analgesics; and *kalmegh* (*Andographis paniculata*), *punarnava* (*Boerhaavia diffusa*), *bhrangraj* (*Eclipta alba*), *chirayata* (*Swertia chirata*) as hepatoprotectants.

cows over the perineal region of mithun cow not-in-estrus helped bulls donating the semen successfully. Urine collected from estrus cows stored at refrigerated temperature was effective till 7 days of post collection.

Estimating FSH in plasma: A simple and sensitive radioimmunoassay (RIA) procedure to estimate FSH in mithun plasma was developed. The biological validation of the assay was carried out in plasma samples that were collected during different stages of the estrous cycle.

Feed resources

District-wise database of feed and animal resources was prepared for 6 agro ecosystems of the country. The current requirement and dry matter availability from different feed resources and the projected demand and supply over the years showed that by 2020 the gap between requirement and availability should marginally increase from the current level of 19%. However, there would be a widening gap between demand and supply of concentrates.

Efficacy of AI in mithun established

The first mithun calf was born through artificial insemination using cryopreserved semen samples. The semen samples were collected from adult bulls through rectal massage method and

AI born mithun calf

cryopreserved in liquid nitrogen using tris-egg yolk-glycerol diluent. Three mithun cows inseminated using the cryopreserved semen conceived following insemination and gave birth to healthy calves.

Estrus synchronization using different protocols: Two injections of $PGF_2\alpha$ were given at 11 days apart in cyclic mithun cows for estrus synchronization, and found that all mithun cows responded to treatment. Cyclic mithun cows irrespective of any day of estrous cycle were subjected to ovsynch protocol of estrus synchronization and were inseminated following synchronization. Of the 16 animals inseminated artificially (AI) with the cryopreserved mithun semen, 12 conceived.

Yak

Complete feed block formulation: Complete feed formulation in the form of feed block was prepared utilizing the cost effective locally available feed resources for yak feeding.

Complete feed blocks

Mineral supplementation: Hair tissue mineral analysis (HTMA) proved an excellent tool for monitoring general health, nutritional status and toxic metal exposure to animals. Hair mineral profile of the yaks following supplementation of trace minerals zinc, copper, cobalt and manganese for six months revealed that Mn, Zn, Cu and Co levels of supplemented group were higher than that of the non-supplemented group. The study justified the requirement of the same.

Performance improvement in yaks through trace mineral supplementation: The supplementation of copper, cobalt, zinc and manganese at farm increased the milk production three-times and growth performance, and drastically decreased repeat breeding and anoestrus.

Estrus synchronization: Induction of estrus, synchronization of ovulation and timed artificial insemination (TAI) were attempted in yaks. The ovulation occurred usually within 50–72 hr of ECP injection. TAI was performed at 48 and 60 hr of ECP treatment. Pregnancy rate in yaks following TAI was 40%.

Endocrine status during different stages of growth: A direct simple and highly sensitive enzyme immuno assay (EIA) for GH (growth hormone) determination in yak plasma was developed and validated. Growth rate was positively correlated with mean GH and GH per unit 100 kg body weight. However, GH per unit 100 kg body weight was found to be a better indicator of growth rate. Both the concentrations decreased with advancement of age.

Artificial insemination in yak: Frozen semen technology in yak was standardized. With the use of frozen semen straws, pure yak and yak hybrid calves were born for the first time in India. Aforesaid technology is being successfully utilized in the farm and field conditions for improving yak germplasm.

Yak calf was born using frozen semen straws, for the first time in India

Wild Life

Supplementation of probiotic (mannanoli gosaccharides with or without added β-glucans) positively influenced gut health indices by altering microbial population and fermentative end products in the hindgut of dogs.

Rumen fungi: Out of 243 isolates of anaerobic rumen fungi isolated from domestic and wild ruminants anaeromyces and orpinomyces were predominant. *In vitro* gas production studies of the isolates showed that isolate CTS-110 outperformed all the isolates with respect to total gas production. Genomic library of the isolates was constructed for isolation of the cellulase gene.

Poultry

Supplementation of xylanase, produced from *Aspergillus* spp @ 3,500–4,000 U/kg improved the performance and digestibility of nutrients, reduced the NSP in intestinal digesta (21.7% in jejunum and 10% in ileum) and enhanced the mineral retention (Ca and P) in tibia and protein accretion in muscle (3.7%) over the non-xylanase supplemented DORB diet suggesting that deoiled rice bran can be included in broiler diets up to 15% with supplementation of xylanase @4,000 U/kg.

Se inclusion in diets of broilers improved antibody titers and **Zn supplementation** was needed for better immune response. Both Se and Zn complimented each other for improving immune response, particularly at low Se (0.15 ppm) and high Zn levels (80 ppm) in the diet.

Supplementing **selenium (Se)** or **chromium (Cr)** in organic form in the diet of broiler chicks decreased the activity of lipid peroxidase and increased the activities of glutathione peroxidase, glutathione reductase, RBC catalase and lymphocyte ratio thereby decreasing the holding loss during pre-slaughter fasting period.

Nutrient requirements of female parent line

Bluetongue (BT)

Bluetongue virus (BTV) isolates (15) of types 1, 2, 9, 15, 18 and 23 submitted till date, are being maintained and were characterized. No disease outbreak of bluetongue has been recorded in Uttar Pradesh, Uttarakhand, Haryana, Himachal Pradesh, Gujarat, Rajasthan, West Bengal, Orissa, Jharkhand and North Eastern states in last five years. BT outbreaks are being recorded every year from Andhra Pradesh, Karnataka and Tamil Nadu. Epidemiological maps for Tamil Nadu and Andhra Pradesh were prepared. Disease forecasting model was developed for Maharashtra centre.

Nine monoclonal antibodies clones produced against BTV reacted well with BTV r-Ag and purified BTV antigen in indirect–ELISA. Type specific primer designing, VP2 and VP7 gene cloning and expression, multiplex RT-PCR for BTV and PPRV, RNA-PAGE and nucleotide sequence were standardized. Confirmation of BT virus isolates was done by RT-PCR using VP7 gene specific primers. Inactivated BTV vaccines gave promising results in local and Bharat Merino sheep. Samples of midges from Uttar Pradesh, Uttarakhand, Gujarat, West Bengal, Haryana, and Rajasthan were identified as *C. oxystoma, C. clavipalpis, C. actoni, C. anophelis, C. orientalis*, *C. similis* and *C. imicola.*

of Vanaraja chicken during first 6 weeks of age was estimated to be 2,600 kcal/kg metabolizable energy, 20% crude protein, 1% lysine, 0.4% methionine, 0.8% Ca and 0.4% non-phytate phosphorus, respectively, for optimum performance.

Protein and energy requirements of Krishibro, a multicoloured broiler, showed that high dietary energy (3,000 kcal ME/kg in starter diets and 3,100 kcal ME/kg in finisher diets)) and low dietary protein levels (20% in starter and 18% in finisher phases) could support optimum performance and immune response. **Feed deprivation** up to 48 hr post-hatch reduced the yolk-sac utilization, gastrointestinal tract development, body weight gain, dressed weight and breast meat yield in broiler chickens. Feed deprivation for initial 24 hr after hatch had no adverse effect on performance of broiler chickens. Feeding crude gum from rice bran oil was a useful **energy supplement** in broiler diets and could be safely used in commercial broiler chicken diet with some positive effects on performance. **Crude lysolecithin** (LL) improved broiler performance.

Hormonal modulation of egg production: Prolactin levels above the normal physiological ranges in the circulation showed negative effects on egg production and increased the pause days in PB3 birds. Through endocrinological manipulation of prolactin hormone and its secretory hormone vasoactive intestinal peptide (VIP), higher levels of egg production was obtained in birds immunized against prolactin or VIP or birds fed bromocriptine by 8.9, 10.98, and 5.38, respectively, in dual purpose birds (PB3). Field testing of the protocol developed for improving egg production indicated that egg production could be improved with available resources under normal feeding practices.

Cloacal gland foam: The effect of surgical removal of cloacal gland showed that this gland and its secretion do not play any role in the fertility of quails. The actual function of this gland needs to be explored.

Rural poultry production: Vanaraja, a dual type chicken is the most popular rural variety and is a cross of two pure coloured lines VML and VFL, improved genetically through selective breeding. In VML, the shank length showed an improvement of 2.81 mm over previous generation. The genetic and phenotypic correlations between shank length (primary trait) and body weight at 6 weeks were high and positive. The 40-week egg production showed an improvement of 1.87 eggs in the present generation over the last generation. In VFL, the age at sexual maturity decreased by 3.2 days and 40 week egg production showed an improvement of 4.18 eggs over previous generation. The shank length and antibody response to SRBC improved, which is desirable for better survival in the harsh environment of rural areas. In addition, genetic improvement and evaluation of a tinted egg female line of **Gramapriya** was undertaken. In S3 generation, age at sexual maturity, body weight at 20 weeks of age and egg weight at 28 weeks of age were 164 days, 1,189 g, 49.2 eggs, respectively.

The Vanaraja bird is popular among rural masses as it is better adapted to harsh conditions of rural areas

SUCCESS STORY

Vanaraja birds in Kashmir Valley

Vanaraja chicks, 5-week-old were distributed to farmers in Kashmir valley. The performance of birds under backyard condition was highly satisfactory. Body weight of birds at 12 and 27 weeks of age was 726 and 2,850 g respectively. The hens matured between 177 and 182 days of age and the mortality between 5 and 11 weeks of age ranged from 3 to 7%. The Vanaraja chicken was very well accepted in the valley. Vanaraja chicken, which is being successfully reared in most parts of the country was also found suitable for temperate climate of Kashmir valley.

A proud Kashmiri woman farmer with a flock of Vanaraja chicken

LIVESTOCK PROTECTION

Cattle

Isolation of *Campylobacter jejuni* from semen and preputial washings of breeding cattle and buffalo bulls as well as vaginal secretions of infertile and repeat breeder cows and buffaloes, and *Arcobacter* (aerotolerant *Campylobacter*) from cattle faeces were attempted. A recombinant 41

Bacteriocin based preparation for treatment of bovine mastitis

Attempts were made to develop a formulation containing natural food-grade antimicrobials of lactic acid bacteria, i.e. bacteriocins for the treatment of mastitis in lactating animals. Biochemical characterization of the pathogens revealed the predominance of coagulase positive *Staphylococcus aureus* (35%), followed by *Streptococcus agalactiae* (12%), coagulase negative staphylococci (7%), *S. dysgalactiae* (3%), *S. uberis* (4%), *B. cereus* (5%), Gram-negative organisms such as *E. coli* (11%), *Ent. aerogenes* (4%), *Klebsiella* sp. (4%), citrobacter (1%), pseudomonas (4%), proteus (1%) and yeast (1%). Incidence of mastitis was highest in the crossbred cows (57%), followed by indigenous cows (27%) and least in buffaloes (17%). Antibiogram of selected gram-positive pathogens revealed that 95% of the isolates were MAR (multiple antibiotic resistant) variants.

Among the 53 bacteriocinogenic strains, 11 had broad spectrum of activity against several spoilage and pathogenic organisms including mastitis pathogens. The bacteriocin of potent *Lactococcus lactis* M386 was optimally produced. The bacteriocin was extremely thermostable (100°C/60 min) and active over a wide pH range (1–12).

Bacteriocin based preparation was quite effective against both gram-positive and gram-negative pathogens under *in vitro* and *in vivo* conditions. *In vivo* application of formulation through intra-mammary infusions for 6 consecutive days in clinical mastitis cases resulted in cure rate of 66.6%. The formulation was well tolerated in udder and was non-irritating to animals. It was stable for more than 3 months at refrigeration temperature.

kDa OMP protein of *Leptospira interrogans* was identified as an important antigen for serodiagnosis of leptospirosis in animals. Aqueous extract of *Phyllanthus emblica* showed *in vitro* antimicrobial activity against *Staphylococcus aureus* and *Streptococcus agalactiae* isolated from clinical cases of mastitis.

Buffalo

Bacteriological examination of fecal samples from neonatal buffalo calves led to isolation of *Escherichia coli* belonging to serogroups, viz. O139, O37, O9, O106 and O143, while parasitological screening of samples was suggestive of coccidiosis with single/mixed infection with *Eimeria* spp.

Ultrasonography of mastitis affected udder indicated fibrosis, accumulation of particulate matter, calcification and abscess in lactiferous ducts, gland cistern, glandular parenchyma and teat cistern. Teat cistern was almost obliterated with fibrosis and teat wall thickness also increased in comparison to normal teat of the same animal.

Goat

A saponified sonicated vaccine against caprine pleuropneumonia proved safe and conferred immunity in goats. Enrofloxacin could effectively be used in combination with nimesulide for treating

SUCCESS STORY

Goat-pox vaccine

Research for development of a live attenuated goat-pox vaccine was initiated in 2001. Initially, a controlled experimental trial was carried out in experimental goats to determine the virus safety, potency and protection against virulent virus challenge. The experimental vaccine provided complete protection against high dose of virulent challenge virus. It produced no adverse reaction even at 10^5 $TCID_{50}$, while it conferred protection at a dose as low as 10^1 $TCID_{50}$. Upon vaccination, goats react initially by local hyperemia at the site of inoculation with a marginal rise in temperature from 5–7 days post vaccination. These reactions are generally transient.

The protection was confirmed by virulent challenge and by determining of humoral immune response. The longevity of protection was for more than 2 years, the maximum period studied so for. Preliminary studies carried out in pregnant goats that were in different stages of gestation showed that the vaccine is safe.

The goat-pox vaccine has been widely used across the country with no adverse reports

The experimental goat-pox vaccine has passed all in-house quality control studies. A large-scale field validation of the vaccine has been going on for the past 24 months. Till date, more than a lakh doses of vaccine have been used across the country with no adverse reports. The performance of the vaccine has been satisfactory as evident from the growing demand for supply of the vaccine and also the feedback received from the end-users.

Gastrointestinal parasitism

Epizootiological studies were conducted in different agro-climatic zones of country. In Madhya Pradesh *Haemonchus* was the most predominant (44.4%) species followed by *Oesophagostomum* spp. (22.4%) and *Cooperia* spp. (6%). Amphistome infection was more common than *Fasciola gigantica* and *Schistosoma indicum*. In West Bengal strongyles constituted the major nematode of which haemonchus was the predominant species in all the animal species surveyed. In Uttarakhand, prevalence of infection was higher in sheep and goats compared to cattle and buffaloes. In Tamil Nadu, overall prevalence of 47.45% of helminth infection was recorded. In Rajasthan bioclimatograph was prepared for semi-arid and arid zones of Rajasthan for future prediction of haemonchosis and trichostrongylosis in farms. Forecasting system FROGIN was evaluated for performance in semi-arid and arid zones. In Sikkim, goats were highly susceptible to G–I helminths with 62% prevalence as compared to yak and cattle having 22 and 25% prevalence respectively. Higher helminthic infection was recorded during autumn (September–November) with 78.57% infection in goats and 33.33% in cattle, whereas, in yaks it was 25.75% in summer. Least infection could be recorded during winter. In Sikkim, *H. contortus* was predominant followed by *Oesophagostomum* spp, *Bunostomum* spp and *Nematodirus* spp. These infections were prevalent in yaks also.

ES antigen of *H. contortus* was purified by immunoaffinity chromatography. In the bound fraction 26, 32, 60 and 120 kDa polypeptides were fractionated by SDS-PAGE; and 120 kDa polypeptide was recognized as early as 4 day PI, showing promise for diagnosis of preclinical haemonchosis in western blotting. In 60 and 120 kDa polypeptide L3 larvae, were also recognized in western blotting by 4-day preclinical sera of sheep. In dot-ELISA affinity purified fraction of ES antigen could detect anti-*H. contortus* antibodies in 4-day experimental sera of sheep. In western blotting 120 kDa polypeptide of ES antigen did not show cross-antigenicity to *Oesophagostomum columbianum, Paramphistomum epiclitum* and *Fasciola gigantica*. Revalidation of dot-ELISA based diagnostic kit for *Oesophagostomum* and *Bunostomum* was initiated in goats, cattle, yaks and mithuns. In a sequel of immunoprophylactic studies H-gal-GP antigen of *H. contortus* has given promising results. Egg count reduction was 54.15% and worm count reduction 92.15% for female worms and 87.1% for male worms with absence of lesions in immunized animals. H-gal-GP antigen was purified through peanut lectin agrose column chromatography. Molecular biology technique for detection of benzimidazole resistance allele-specific PCR was standardized. Application of the technique has revealed higher proportion of homozygous resistant larvae in farmer's flock as compared to farm flock. Selected isolates of nematophagous fungi *Arthrobotyrus oligospora* from field flocks from arid and semi-arid zones reduced the number of GI nematodes. Attempts to get wild isolates of hypomycete on trematode egg from organic environment of Durg, Chhattisgarh, were successful.

susceptible bacterial infections associated with inflammatory disease conditions in goats.

Surgical and clinical interventions: Techniques for application of acrylic external skeletal fixators for management of compound fractures of small animals and circular external skeletal fixation for large animals were standardized.

Technique for dissolution of cystic and urethral calculi was developed using oral and (or) cystic irrigation of ammonium chloride or hemiacidrin in goats and buffalo calves suffering from obstructive urolithiasis/uraemia. Calcium carbonate (80%) and potassium iodide (15%) were cost-effective alternative radiographic contrast to barium sulphate to delineate stomach and large intestine and gastrointestinal and urinary tract in small animals.

Diagnostics: *Toxoplasma gondii* SAG1 gene was cloned and expressed in eukaryotic system, and the recombinant protein was successfully tested with good immunoreactivity for detection of antibodies in goats.

Field validation of cathepsin-L cysteine proteinase of *Fasciola gigantica* confirmed that this protein was specific with no cross-reactivity with *Paramphistomum epiclitum*, *Gastrothylax crumenifer*, *Gigantocotyle explanatum*, hydatid (metacestode) and *Strongyloides stercoralis*. The ELISA sensitivity recorded with this protein was 95%.

The Bm86 homologue of *Hyalomma anatolicum anatolicum* was cloned and expressed in both prokaryotic and eukaryotic systems.

Sheep

A sterile and safe inactivated pentavalent vaccine against bluetongue in sheep was developed. The combined HS+FMD vaccine passed the safety tests with no adverse reactions. The protective titre 1.5 (SN titre) indicated the need for boosting of the vaccine every 6 months. An indirect immuno-peroxidase monolayer assay (IPMA) was developed for detecting pestivirus antigen and neutralizing antibodies in small ruminants.

Pig

A PK-15 adapted cell culture swine fever virus vaccine developed at sixth passage having $10^5 TCID_{50}$ titre was found potent in pigs. Twenty-one days vaccinated pigs were protected against

Diagnostic kits developed by PD_ADMAS

virulent challenge infection. PD50 of this vaccine contained ≥ 200 PD50/dose.

RT-PCR was optimized to detect classical swine fever virus (CSFV) in 1:10,000 diluted infected cell culture fluids and to screen clinical samples.

Equines

Surveillance and monitoring of equine diseases: Unique programme of nation-wide active equine disease surveillance facilitated poor equine owners in saving the precious indigenous equine germplasm through timely diagnosis and management of diseases. An outbreak of glanders was reported during July-August 2006 in Maharashtra. Subsequently, cases of glanders were also reported from Punjab, Uttar Pradesh and Uttarakhand. Nation-wide testing on 4,395 serum samples revealed 97 samples to be positive for glanders during the year. The disease was confirmed to be glanders serologically and subsequently by isolation of the causative agent, *Burkholderia mallei* from the suspected cases. The follow-up surveillance of the area revealed no new cases from Maharashtra, indicating control of the outbreak in that state. It is being monitored continuously to assess the situation in the entire country, with particular emphasis on the equines of Uttar Pradesh and Uttarakhand. Equine infectious anaemia, African horse sickness, equine influenza and *Salmonella* Abortus equi, were not detected in the samples. Equine rotavirus strains exhibited G10, G3, G6 and G1 type specificities that accounted for 19.0, 42.9, 14.3 and 9.5% of the isolates, respectively.

Diagnostics: Haemagglutination inhibition (HAI) assay was standardized for serodiagnosis of Japanese encephalitis (JE). On testing equine serum samples, from different states, for antibodies to JE serocomplex by HAI, 14.32% samples were detected positive. An RT-PCR was also developed for detecting the virus in infected tissues. A recombinant protein-based ELISA was standardized for differentiation of EHV-1 and EHV-4. A recombinant-protein based ELISA was developed for detection of *Babesia equi* antibodies in equine sera. This assay could detect *B. equi* antibodies in equines as early as 6 days post-infection till 90 days of observation period.

Validation of EHV-1 vaccine: An equine herpes virus-1 (EHV-1) killed vaccine incorporating indigenous strain of EHV-1 was evaluated in experimental pregnant indigenous mares. Challenge studies did not reveal any fever or virus shedding. Three of the vaccinated mares gave birth to healthy foals and only one mare aborted due to EHV-1 infection after challenge. Hyperthermia and virus shedding was observed in non-vaccinated mares after challenge. On challenge, one non-vaccinated mare aborted due to EHV-1, while one gave birth to a weak foal that died within 24 hr of birth. Virus could be isolated from the lungs and liver tissues of both the foals. The vaccine provided satisfactory level of protection against EHV-1 associated abortion but before commercialization further immune response studies need to be undertaken in selected organized equine farms.

Equine health camps and farmer meets (*Ashwa Palak Goshties*)

The equine owners were enlightened on various aspects of disease control and management. In addition to the treatment of major equine ailments in these camps, deworming and tetanus vaccination were done in equines. Feedback from farmers was obtained for further research and development in equine health and production.

Camel

To popularize the knowledge of our age-old scholarly system of medicine against one of the most common skin disease sarcopticosis in camel, an indigenous medicine, M-Cure has been developed, evaluated and made available for use at the NRCC. Five to seven local applications are required to cure the disease without any sign of relapse.

In camels intra-mammary infections cause health problems of diarrhoea etc. in suckling calves. *Staphylococcus*, Streptococcus, *Corynebacterium* and *Bacillus* were the commonly encountered intramammary infections in camels. Characterization of 55 isolates of staphylococci revealed that *Staphylococcus aureus, Staph. hyicus, Staph. intermedius, Staph. haemolyticus, Staph. auricularis, Staph. sciuri, Staph. hominis, Staph. epidermidis, Staph. capitis, Staph. warneri* were associated with camels. Mean pH of quarter milk samples was within the normal range in all the non-clinically infected quarters whereas in clinically infected quarters there was a significant rise in mean pH. Increase in sodium concentration in milk of clinically infected quarters compared to

milk of healthy quarters showed increased permeability of sodium due to inflammation of the secretary tissue. There was significant variation in mean Co concentrations among negative, sub clinical, non-specific and clinical groups. However Cu varied significantly with somatic cell count of milk. Daily feeding of Cu, Zn and Se for 30 days resulted in almost 40% lower infections.

Mithun

The overall seroprevalence of antibodies to BTV in mithun was 86%. Highest seroprevalence was observed in mithuns above 4 years of age and the lowest in 1–2-year-old. The likelihood of BTV infection was almost six-times more in mithuns in the age group of 2–4 years than that of > 4 years. Seroprevalence was higher in mithuns from free-ranging system in comparison to mithuns kept in semi-intensive system of management. Likewise mithuns from free-ranging system were almost seven -times more seropositive to BTV in comparison to mithuns kept in semi-intensive system of management.

The overall prevalence of antibodies to *Neospora caninum* in mithun was 10%. Highest seroprevalence was in mithuns above 3 years of age and lowest in mithuns of 2- to 12-month-old. No statistically significant difference was observed in seroprevalence between males and females. An overall seroprevalence of antibodies to *A. marginale* in mithuns was 63% and it increased with the increase in age of animals. In both the cases the seroprevalence was higher in mithuns in free-ranging condition in comparison to mithuns kept in semi-intensive system.

The distribution of *Escherichia coli* serogroups isolated from faecal samples of mithun calves with diarrhoea revealed 72 *E. coli* strains belonging to 38 different serogroups (based on "O" antigen). Of the 72 strains isolated, 10 were not typeable and four were rough. The virulence gene profile of different *E. coli* serogroup **(**isolated from faecal samples of mithun calves with diarrhoea) was studied — *stx1* genotype was prevalent in serogroups O4 (4 strains) and O32 (3 strains); *stx2* genotype in serogroups O55 (2 strains), O2 (2 strains) and O49 (2 strains); and *hlyA* genotype in serogroup O55, O2 and O49 (2 strains in each serogroup).

Yak

Epidemiology: Infectious diseases like foot-and-mouth disease, brucellosis, infectious bovine rhinotracheitis, haemorrhagic septicaemia, tuberculosis, babesiosis and non-infectious diseases (like keratoconjunctivitis, diarrhoea, tympany) were prevalent in different yak tracts. *Staphylococci*, *Pseudomonas aeruginosa* and *Escherichia coli*, *Candida albicans* were found associated with the chronic haemorrhagic diarrhoea in yaks with prolonged antibiotic therapy. *Mannheimia haemolytica* was found in yaks for the first time in respiratory complications. Survey at Nyukmadung revealed that 19% of the yaks (27 out of 140) bear this opportunistic organism in respiratory tract. *Haemophilus somus* and *P. aeruginosa* were the common associates with this pathogen. Most of the isolates of these pathogens were muti-drug resistant. Survey revealed that 12.42% yaks were positive reactors. Incidence of gastrointestinal disorders in yaks was highly correlated with rainfall and temperature. A fast and reliable PCR was standardized for molecular diagnosis of *Babesia bigemina* in yak and its hybrids.

FMD: The antibody titre level in yaks following application of trivalent oil adjuvant FMD vaccine, sharply increased to the protective titre within one month but tended to fall from third month onwards. Protective antibody level was present up to 90 days of vaccination only. However, following booster administration, protective antibody response was rejuvenated within a short period of time.

***Senecio* induced oxidative injury in murine macrophage cell line J774:** *Senecio* poisoning in yaks is very common in Arunachal Pradesh and other

Haemorrhagic septicaemia

A low volume saponified HS vaccine was prepared and tested in dairy animals and 100% protection was observed on direct challenge at one year duration. The vaccine was also inoculated in animals at Izatnagar, Himachal Pradesh, Tamil Nadu and Orissa. No untoward reactions or any clinical signs were observed in any vaccinated animal. Apart from that, a vaccine trial of combined HS and FMD vaccine was also carried out and a booster dose was given at 6 months post vaccination. At 7 months challenge, 100, 75 and 75% protection were observed, respectively, against FMD virus type A, O and Asia 1.

Major outer membrane proteins (OMPs), OmpA and OmpH, were identified and characterized in *Pasteuralla multocida* serotype B:2 that originated from sheep, goats, cattle and buffaloes. The tbpA gene of *P. multocida* serotypes D and F were cloned and sequenced. The nucleotide amino acid sequences of *P. multocida* D:1 showed 98.5 and 96.9% homology, whereas F:3 serotype showed 97.7 and 95.2% similarities with tbpA of *P. multocida* serotype A. Apart from that 77 isolates of *P. multocida* from various animal species and birds were identified and characterized using morphological, cultural and molecular techniques. A patent for low volume saponified haemorrhagic septicaemia (HS) vaccine was submitted.

sub-Himalayan areas of India. The plant contains seneciophylline that induces severe hepato-toxicity. Ethanol extract of *Senecio* increased severe oxidative burden in murine macrophage cell line J774. Following incubation with *Senecio* DNA laddering and single stranded DNA breakage were evident.

Herbs: Indigenous medicinal plants were collected from the West Kameng and Tawang districts of Arunachal Pradesh especially in the high altitude areas of Indo-Tibetan borders. The indigenous knowledge of the local tribal people was taken into account in many cases for collection of the plants. The anti-bacterial, anti-fungal, anti-inflammatory and wound healing properties of *Saussurea costus* and *Rubus idaeus* were found out through experimental trial.

Wild life

A bicistronic DNA vaccine was developed to induce virus neutralizing antibody response against rabies and canine parvovirus in dogs. A recombinant RNA replicon – based vaccine vector with immunogenic gene from canine parvovirus was constructed.

Local application of combination of oils of *Jatropha curcas* + *Phyllanthus emblica* + *Commiphora mukul* was highly effective in mitigating immuno suppression and oxidative stress in canine demodicosis.

Poultry

A PCR was developed and applied for detection and differentiation of avian tumours and determining the prevalence of MD and ALVs in various flocks. The results were confirmed by using real time PCR, which proved that the PCR is a useful technique for detection and differentiation of tumours caused by multiple viral infections such as MDV and ALVs. The incidence of MD detected in pureline layers was 7.5, 4.1, 2.6 and 3.7% in IWK, Anand, IWH and IWI respectively. Sporadic cases of MD were recorded in PB-2, Dahlem Red and naked neck populations.

The inactivated chicken infectious anaemia virus (CIAV) vaccine protected the SPF chicks against CIAV when vaccinated at day-old age, whereas layer *Gallus* chicken vaccinated at 18 weeks of age showed induction of antibodies up to 20 weeks post-vaccination and transferred protective maternal antibodies to their progeny. The chicken embryo origin turkey pox vaccine provided 90–95% protection under field trial, whereas cell culture origin turkey pox vaccine provided 72–72% protection. The formalin inactivated Newcastle disease (ND) virus (field isolate), adjuvanted and emulsified induced humoral and cell-mediated immunity, which was comparable to that induced by inactivated commercial ND vaccine. The experimental vaccine afforded protection up to 66.6% against challenge infection.

Quality control and production of Veterinary biologicals

RD 'F' strain vaccine, lapinized swine fever vaccine, tissue culture sheep pox vaccine, HS oil adjuvant vaccine, *Brucella abortus* strain-19 (live) vaccine, enterotoxaemia vaccine, Johnin PPD, Mallein PPD, *Brucella* agglutination test antigen, *Brucella abortus* Bang Ring antigen, Rose Bengal Plate Test antigen, *Brucella* positive serum, *Salmonella* Abortus-equi 'H' antigen, *S.* Pullorum plain antigen, *S.* Pullorum coloured antigen, *S.* Pullorum positive serum, and *Salmonella* poly 'O' sera were produced and quality tested. PPR vaccine, PPR c-ELISA kits and PPR s-ELISA kits were produced and supplied by Mukteswar campus, as per demand. Monovalent FMD vaccine comprising doses of type 'O', type 'A' and type 'Asia 1' were produced at the IVRI, Bangalore campus.

A rapid and simple recombinant antigen based user-friendly ELISA test kit was developed for serodiagnosis of infectious bursal disease. A sensitive, specific and accurate recombinant haemagglutinin neuraminidase antigen-based ELISA was developed to measure the specific antibody in sera of chickens against Newcastle disease virus.

Six strains of *B. stearothermophilus* were used for antibiotic disc assay. In all, 17 antibiotics from different groups were used for disc assay. Pencillin G, ampicillin and amoxicillin depicted sensitivity at MRL dose of 0.004 µg/ml. Cloxacillin, cefalexin, tetracycline, doxycyclin, gentamycin, streptomycin and lincomycin exhibited sensitivity close to MRL concentrations, i.e 0.5, 0.5, 1.0, 10.0, 0.1, 1.0,10.0 and 1.0 µg/ml, respectively.

Animal disease monitoring and surveillance

The databank was developed on animal disease trends, disease prevalence, meteorological data, land use data, animal and human demography, soil pattern data and crop production data. Integrating these factors an interactive website—National Animal Disease Referral Expert System (NADRES) — was developed, which can predict the probable occurrence of 10 major livestock diseases in any particular district of the country. This is a user friendly programme for general public, and can be accessed through internet (www.nadres.org).

An offline version ***India.AdmasEpitrak*** was also developed for collaborating units of PD_ADMAS. This programme provides data on ecopathozones, disease prevalence studies and

frequency of disease occurrence. It helps to estimate the spatial and temporal specific disease prevalence profiles of economically important diseases.

Latex based agglutination test for detection of *Brucella* antibodies in cattle, sheep and goat was standardized using heat killed sLPS antigen. An indirect ELISA protocol for *Brucella* screening in small ruminants was standardized. Seropositivity for *Brucella* antibodies in sheep and goat was found highest by RBPT (9.95%) followed by iELISA (7.36%) and least in STAT (5.67%). The PCR protocol to detect *B. abortus* and *B. melitensis* from the aborted material, foetal contents and vaginal discharges, was standardized. It is advantageous over serological tests, and avoids risk of laboratory-acquired infections. This protocol can be used to screen suspected herds for confirmatory diagnosis. Leptospiral abortions were scarcely reported and no systematic study has been carried out in our country. Clinical cases from various species of livestock and human samples were screened for the leptospira organisms, and in 119 cases out of 1,120 samples the organism could be isolated. The advantage of this study is that it would be possible to establish not only leptospiral etiology, but also *Brucella*, IBR and other infectious causes.

A study on molecular epidemiology of BHV-1 was initiated as the long term serological studies have shown serological evidence of the disease (35–40% sero-positive) all over the country, although there are limited reports of isolation of virus from Karnataka, Punjab and Uttar Pradesh. BHV-1 infection in bulls is epidemiologically important as the virus excreted intermittently in the semen may spread infection to cattle receiving semen from them. Identification and elimination of the bulls positive for BHV-1 antibodies and genome sequences by serological tests and PCR assays, respectively, would help in formulating the control strategies. Hence, the Directorate has taken up detection of BHV-1 genome/antigen in the semen samples of all bulls in the breeding farms on regular basis. Semen samples from bull mother centers were tested for the presence of the BHV-1 antigen/genome and all were found negative.Genome sequencing of IBR-1-ADMAS isolate was compared with those of reference sequences (one from Switzerland and two from Brazil). There was 100% homology with the sequence of AJ 004801 (Switzerland), 98.3% with AY 58382, and 98.7% with AY 330349 (both from Brazil). In clustering, the Indian isolate was closer to the sequence from Switzerland.

A survey showed the apparent prevalence of *Neospora caninum*—a cyst forming coccidian parasite—infection in dairy cattle which is now recognized as a major cause of abortion and economic losses to producers worldwide. Screening of sera samples from apparently healthy goats from different geographic zones of India suggested an overall countrywide seroprevalence of 7.93%.The carrier animals of trypanosomiasis become nuclei for its propagation in a particular area, and its detection is very important to control and eradicate the disease. The PCR technique was standardized and its field validation is in progress.Serum Bank facility, **the first of its kind in India** having more than 170,000 serum samples from all over the country was developed, and is being used for long-term national surveys on IBR, brucellosis, yersiniosis, RP, PPR,BT and other diseases. **Diagnostic kits for bovine brucellosis** were developed and standardized, and the state-of-the-art software based Avidin-biotin enzyme linked immunosorbent assay (Ab-ELISA) for bovine brucellosis can be used on serum samples and milk samples containing too little cream, colostrum, clotted milk or frozen milk.

Computer interface based BHV-1 whole antigen Ab-ELISA was developed as per the standards of IAEA, and standardized and validated.

CAPTURE FISHERIES

Marine fisheries

Marine fish landings and catch structure: Analysis of the marine fish landings in India during the year 2006 indicated an increase in total fish landings and a change in catch structure. The total marine fish catch, estimated at 2.71 million tonnes,

Successful pen culture in Bihar

Pen culture of fish in pens was demonstrated in the *maun*s (floodplain lakes) in Bihar for augmenting fish production and creating opportunities for employment and income generation. Pens of 0.1 ha size, installed in 3 *maun*s, viz. Kaithkola, Rajoura and Bahuara, were stocked with fish @ 15,000–20,000/ha. The grass carp *Ctenopharyngodon idella* recorded the highest survival rate followed by *Catla catla*. Overall survival rate ranged between 40 and 65% at an average of 50%. Highest fish growth both in terms of length and weight was recorded in Bahuara followed by Kaithkola and Rajoura. Among the fish species stocked, average maximum growth in length was recorded for *C. mrigala* (72%) and in weight for *C. catla* (567%). The maximum fish harvest was from the Bahuara (5,047 kg/ha). With a total cost of inputs of Rs 164,080, the gross and net returns per pen area were estimated at Rs 227,510 and net at Rs 63,430/ha respectively. The average B:C ratio for the *maun*s was 1.39. The demonstrations motivated the local communities to adopt pen culture technology.

registered an increase of about 4.1 lakh tonnes compared to the previous year. Pelagic finfishes constituted the majority (55%), followed by demersal fishes (24%), crustaceans (16%) and molluscs (5%). While mechanized sector accounted for 71% of marine fish landings in the country, motorized and artisanal landings contributed 24 and 5% respectively. Oil sardine, ribbon fishes, lesser sardines, cephalopods, seer fishes and croakers recorded increase, while there was a marginal decrease in the landings of Bombay duck and penaeid prawns. West coast accounted for more than 68% of marine fish landings. While the south-west region comprising Kerala, Karnataka and Goa coasts recorded 34.6%, the north-west region comprising Maharashtra and Gujarat coasts accounted for 33.5% of the national marine fish production. In the east coast, the south-east region consisting of Andhra Pradesh, Tamil Nadu and Pondicherry coasts contributed 21.8%, while the north-east region, comprising the West Bengal and Orissa coasts contributed 10% to the total marine catches.

Impact of climate change on marine fisheries: Oil sardine, the most abundant marine fish in India, showed signs of adaptation to climate change as per the interim findings of the National Network Project on Impact, Adaptation and Vulnerability of Indian Fisheries to Climate Change.

Inland fisheries

Changing catch structure in Ganga fisheries: Decline in catches and a shift in the species spectrum, observed in 3 different stretches of the river Ganga between Deoprayag and Farakka, were attributable to deteriorating fish habitats. Small and economically unimportant fish species dominated upper (Rishikesh to Haridwar), middle (Kannauj to Varanasi) and lower (Varanasi to Farakka) Ganga contributing 42–100% to the total catch. In the upper stretch, the contribution of major carps was negligible, but a good fishery of *Tor* spp. was recorded below Haridwar. In the middle stretch (Kannauj - Varanasi) contribution of major carps ranged from 7.5 to 15.5%, while in the lower stretch landing of major carps *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, was still lower, with the exception of Farakka, where these fishes formed up to 14.1% of the catch. Presence of exotic species *Cyprinus carpio* in the middle stretch (maximum recorded at Allahabad) suggested an impact on natural food web and ecological balance in the river ecosystem. Decline of major carps in the middle stretch is attributable primarily to man-made environmental changes and the resultant loss of fish habitats for breeding and feeding. Based on these findings, necessary packages for restoration of habitat and fishery are being formulated.

Impact of regulated river flows on the estuarine fisheries: A study was undertaken at Devi estuary in Orissa to assess the impact of Narauj barrage on Devi river, 70 km upstream of its confluence with the Bay of Bengal. At present, 4–5% of the total regulated river discharge at the barrage is released during the lean season, which was reasonably adequate to sustain the biotic communities. The salinity amplitude in the estuary was in the range of traces to >18.0 ppt and tidal regimes comprised marine (12%), gradient (55%) and freshwater (23%), which were favorable for fish productivity. During monsoons, estuarine fish fauna was dominated by freshwater forms like Indian major carps, minor carps and large catfishes, which migrated downstream of the estuary for breeding and nursing. During post-monsoon, as salinity increased, brackishwater fishes such as mullets, sciaenid, perches, threadfins, anchovies and shellfishes moved upwards in the estuary. In commercial landings of Devi estuary, 97 species of fishes were identified. The freshwater fishes contributed significantly (> 20%) to the fisheries of estuarine zone.

In contrast, drastic control of river water discharge in upstream of the river Krishna negatively impacted the estuarine salinity regime turning it into hypersaline. As a result, oligohaline and freshwater species such as carps, catfishes, murrels adapted to riverine environment, and featherbacks disappeared from the estuarine zone. This changed salinity regime contributed to domination of mullets mainly represented by *Mugil cephalus* and *Liza parsia*. Results emanating from these two case studies paved the way for setting the key parameters for assessing the environmental flows in rivers and estuaries.

Culture fisheries

Freshwater aquaculture

Cage culture: As part of developing a cage culture technology for the upland lakes,

Cages installed in lake Bhimtal registered an increase in biomass

experiments were conducted in Bhimtal lake, Uttarakhand. Four sets of rectangular cages made of HDPE (3 m × 3 m × 3 m) with 4–15 mm mesh size were installed at Bhimtal lake. Golden mahseer (*Tor putitora*) and snow-trout (*Schizothorax richardsonii*) of varied sizes were stocked in the cages. Fry of golden mahseer, reared in cages registered an increase in biomass of about 1.73 kg/cage in 3 months and the growth was 2.4 kg/cage in fingerlings for the same period. Growth of snow-trout, was slower –- the increase in fry biomass being about 300 g/cage in 3 months; and fingerlings registered a growth of 334 g/cage in 3 months, suggesting the potential of cage culture in upland lakes.

Pen culture: An alternative material to replace split bamboo screens was developed to construct pens in wetlands to raise stocking material. HDPE net material was cost effective and could be used as a substitute for split bamboo screens. Initial estimates indicate that HDPE net material reduces pen construction cost by one-third.

A haul of fish after 136 days rearing in pen

Coastal aquaculture

Organic shrimp farming: Success has been achieved in producing shrimp, *Penaeus monodon* using organic inputs. The organic shrimp farming being developed is based on use of natural nutrients, probiotics and bioremedial measures and avoiding artificial chemical fertilizers and pesticides, chemotherapeutic medicines including antibiotics in the culture process. Yeast (*Sachharomyces cerevisae*)-based organic preparations induced significantly higher growth in tiger shrimp *P. monodon*. These organic extracts have a greater role to play in organic farming when use of chemicals and antibiotics are to be restricted or prohibited. Organic manures including vermicompost were used for fertilization in organic shrimp culture. Under organic shrimp farming, stocking density of 6.5 nos./sq. m. yielded a higher growth rate of quality shrimps of more than 30 g in 110 days of culture with an average production level of 1,305 kg/ha/crop with a feed conversion ratio (FCR) of 0.95. The organically grown shrimps maintained a higher growth rate and health status (including coloration and texture) as compared to the other shrimps during the culture.

Culture of banana shrimp *Fenneropenaeus merguiensis*: Culture practice for the banana shrimp, *Fenneropenaeus merguiensis* was successfully developed through a public-private partnership in Bilimora, Navasari, Gujarat. The shrimps attained on average weight of 22 g in 120 days of culture. The pond was harvested after 166 days with the final average size of shrimp being 26.5 g with 78% survival and a production of 806 kg/ha. Apart from mitigating disease and price risks, diversification in shrimp culture is needed to accelerate the growth of *P. monodon* during winter in Gujarat, where the pond water temperatures falls below 20°C. Successful demonstration of the culture of banana shrimp indicated high potential of this species as an alternative to tiger shrimp especially during winter in Gujarat.

Indigenous shrimp feed technology: A shrimp feed was developed using indigenous ingredients to meet the dietary requirements of tiger shrimp, *Penaeus monodon* and Indian white shrimp, *Fenneropenaeus indicus*. The feed technology has been transferred to two entrepreneurs.

Fish harvest

Copper chrome arsenic (CCA) wood preservative for protection against borers: Painted and FRP sheathed panels accorded total protection against woodborers. Biodeterioration of rubber wood panels treated with CCA to three retentions, viz. 16 kg/m^3, 29 kg/m^3, 42 kg/m^3, dual preservative (16 kg/m^3 CCA followed by

Voluntary adoption of better management practices (BMPs)

Studies conducted to assess the 'adoption gaps' in BMPs of shrimp farming in Andhra Pradesh (AP) and Tamil Nadu (TN) indicated average adoption gaps of 32 and 31% respectively. About 68 and 69% shrimp farmers, respectively, in AP and TN had voluntarily adopted the BMPs. However, BMPs that address environmental and food safety issues like proper site selection, conversion of other land uses, overcrowding of farms and low stocking density were not fully adopted. Though these BMPs are not directly concerned with the productivity, they are essential for the long-term sustainability and marketability of the produce. This result highlighted the need for taking up suitable awareness programmes on BMPs to achieve in long-term sustainability of culture systems, food safety and marketability.

Construction of improved wooden canoes in Asom and Arunachal Pradesh

Improved fishing canoes were designed and fabricated at Guwahati, using locally available low cost wood such as *poma*, mango, *moje* and pine. These canoes were sheathed with fibre reinforced plastic (FRP) to increase the strength and durability. Canoes were handed over to the Department of Fisheries, Asom, which were eventually distributed to the Fishermen Cooperative Societies for use in rivers and *beel*s of Asom. The second set of canoes was handed over to the Department of Fisheries, Arunachal Pradesh, which will be used for fishing in Ganga lake, Itanagar, and Renganadi reservoir in Lower Subansiri district.

150 kg/m^3 creosote) and panels coated with paint and sheathed with FRP (fiberglass reinforced plastic) was studied under the estuarine conditions for 6, 12 and 18 months. On prolonged exposure for 12 to 18 months, the CCA treated panels at lower retention of CCA, showed susceptibility to borer attack especially to *Teredo* spp. Higher retentions of CCA preservative in wood imparted higher degree of protection. Dual treated panels performed equally well as CCA treated panels of 42 kg/m^3 retention. Painted and FRP sheathed panels accorded 100% protection against woodborers. The FRP sheath also ensured that there was no leaching of the constituent chemicals into the aquatic environment.

Development of monoclonal antibody: Production and characterization of monoclonal antibodies (MAbs) to serum immunoglobulins (Ig) from rohu,*Labeo rohita*, was achieved for the first time. Purified r-Ig was used as an antigen to develop MAbs to r-Ig. These MAbs were conjugated with horse radish peroxidase to produce anti-rohu Ig conjugate. This conjugate was used as a powerful tool for monitoring primary and secondary humoral responses by ELISA-based analysis.

Molecular fingerprinting of *Salmonella:* Enterobacterial repetitive intergenic consensus sequence (ERIC) PCR and PCR-ribotyping profile of two most prevalent serotypes in seafood (*Salmonella* Rissen and *Salmonell*a Weltevreden) were carried out to fingerprint the serotypes based on origin. PCR-ribotyping results showed 3 fingerprint pattern in *Salmonella* Rissen (n, 20) whereas, 4 different fingerprint profiles were observed in *Salmonella* Weltevreden (n, 24). ERIC-PCR fingerprinting pattern was more diverse as compared to PCR-ribotype as *S*. Rissen and *S*. Weltevreden serotypes have showed 14 and 16 different fingerprinting patterns respectively. ❑

Aquaculture development in NEH region

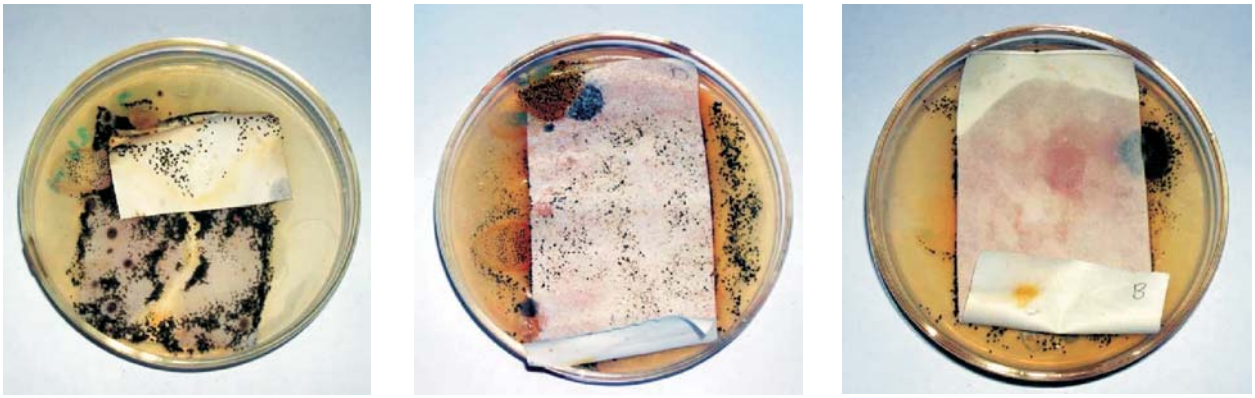
Fish culture technology packages was developed for carps and exotic trouts suitable for the northeastern region of the country. In Arunachal Pradesh, about 60% of culturable area is suitable for carp, where Chinese carps and Mahseer can be cultured together in ponds located at 600–1,800 m above sea level. Earthen/RCC ponds can be stocked at a density of 4–5 fish/m² during early March when water temperature is above 15°C. Common carp (25%), grass carp (35%), silver carp (20%), rohu (10%)

Carp farming in a fish pond of NEH region

and/or chocolate mahseer (10%) can be stocked with provisions of supplementary feed @ 2–4% of body weight. Organic fertilizers up to 9,000 kg/ha/year and liming 500–600 kg/ha need to be provided at suitable intervals. This technology has enabled the farmers to fish production of about 0.4–0.8 kg/m² in 8 months. Staggered stocking and harvesting can also be adopted.

9. Post-harvest Management and Value-addition

Nanotechnology for antifungal paper: A technology has been developed to produce zinc-oxide nanoparticles using microbial approach. CIRCOT in collaboration with the Central Pulp and Paper Research Institute, Saharanpur, has carried out studies for coating paper with zinc oxide, both in bulk as well as in nano form. Nano zinc oxide imparted antifungal property to paper. Besides, nano zinc oxide-coated paper performed better compared to normal coating in brightness, whiteness, smoothness, print density and uniformity, picking velocity and oil absorbency.



Antifungal property of control (*left*), 100% bulk nano (*middle*) and 100% nano-ZnO coated paper (*right*)

Jute extractor: Manually operated and portable CRIJAF jute extractor has been developed. The machine has an output of about 25 kg dry fibres per hr.

Batch-type steam-blancher for fresh vegetables: This blancher of 100 kg/hr capacity is made of stainless steel. The unit has 7 nozzles to eject steam under pressure (2.5 to 3.0 kg/cm^2) on a layer of cut-vegetables from top as well as from bottom for uniform blanching. The blanched vegetables are dropped in a larger tank of stainless-steel filled with water for immediate cooling of processed products.

Multiplier onion peeler: This consists of an aluminum drum seated over a rotating disc. Inner surface of the aluminum drum and top surface of the disc are covered with corrugated rubber sheets, which aid in peeling process. Capacity of the peeler is 60 kg/hr; peeling efficiency is 92%; unpeeled and damaged onions are 6% and 2%. Peeling cost is about Rs 1.20/kg as compared to Rs 4.00/kg for manual peeling, and cost of machine is Rs 15,000.

Banana-comb cutter: Its serrated cutting blade is attached to handle with a 150-mm round pipe of diameter 12.5 mm. The handle is about 100-mm long which provides easy grip during cutting. The semi-circular blade is made of stainless steel sheet having 75-mm length and 25-mm width to suit banana-bunch stem

Banana-comb cutter facilitates cutting and separation of banana comb with minimum damage

geometry. The hand-tool facilitates cutting as well as separation of banana-comb in a single push with minimum damage.

***Aloe vera* gel (Fillet) extractor:** *Aloe vera* gel is used for preparing medicines and cosmetics. Considering the importance of a small machine for taking out gel from the *Aloe vera* leaves an *Aloe vera* gel (fillet) extractor was designed and developed by providing tolerance in between the crushing rollers, so that only the gel is just extracted and over-crushing of the leaves is avoided. The capacity of extractor is 60–80 kg leaves/hr and its cost is Rs 4,000.

Crushing rollers are designed so that only gel is extracted

Assessment of losses during storage of rice in warehouses in Andhra Pradesh: Storage losses depend on the initial moisture content of rice, month of stacking and storage period. Higher initial moisture content resulted in more losses. Storage losses were higher due to driage in low humidity and high temperate conditions. The study has shown that average losses in raw rice storage over 12 months would be about 1.25%.

Post-harvest sugarcane quality under mechanical and manual harvesting: Effects of mechanical and manual harvesting of sugarcane variety Co 86032 on loss during staling were studied at sugar factories located in Pune and Kolhapur districts of Maharahstra. Sugarcane was harvested manually and mechanically at farmers' fields and analyzed in the laboratory. A gradual rise in reducing sugars and losses in cane weight due to staling of cane was observed up to 72 hr after harvest. Losses in cane weight were more in mechanically harvested cane (16.25±0.4%) as compared to manually harvested cane (6.08±1.7%). Increase in reducing sugars was 0.61±0.08% in manually harvested cane compared to 1.66 ±0.13% in mechanically harvested cane after 72 hr. Delay in transport of harvested cane from field to factory is a major contributing factor to losses of recoverable sugar. It is recommended that during late crushing season, the cane should be crushed within 24 hr of mechanical harvesting.

Reduction in post-harvest sucrose loss: In March, pre-harvest foliar spray of $ZnSO_4$ (Zn^{++} at 0.1%) on CoSe 92423 sugarcane showed reduction in post-harvest sucrose losses. Sucrose percentage and purity of juice were higher after 8 days of staling in Zn-treated cane covered with trash as compared to untreated trash-covered control. Spraying benzalkonium chloride at 2.5–4.0 g/litre + sodium lauryl sulphate at 0.2–0.5 g/litre on harvested cane followed by covering with trash reduced sucrose losses. This improved sucrose recovery between 0.3 and 0.5 units.

Accelerated retting technology: The NIRJAFT accelerated retting technology yielded better quality of fibre by one or two grades, and the yield was also higher by 10–20% over the traditional one. The accelerated retting technology has also been adopted by the Jute Corporation of India. The Jute Corporation of India has also procured 100 manual ribboners and chemicals from the institute for demonstration of improved retting technology to farmers through their centres.

Mobile agro-processing unit for foodgrains and spices: A mobile agro-processing unit for foodgrains and spices has been developed for demonstration in production catchments. The unit consists of a grain cleaner, two burr mills for grinding foodgrains and spices, a popcorn machine and a 7.5 kVA diesel-generator for operating the machines. It is suitable for the primary processing in rural areas. With an investment of Rs 200,000 an entrepreneur can generate a net income of approximately Rs 47,000 annually.

Mobile agro-processing unit, suitable for rural areas

Community-level evaporatively cooled storage: This storage structure could achieve up to 20°C lower air temperature and relative humidity as high as 70–99%, depending upon the outside temperature and relative humidity. Its cost is Rs 1.5–1.8 lakh. Shelf-life of fruits and vegetables stored in this are as follows: Potato: two months in summer (May–June); tomato: 5–7 days and kinnow: about 35 days in February–March.Weight loss of 12.17% was observed in Kufri Pukhraj potato tubers and 9.03% in Kufri Chandramukhi after 60 days. Reducing sugar content was less than 250 mg/100 g fresh weight.

Enhancing shelf-life of mango: Shelf-life of Alphonso and Banganapalli mangoes could be extended by 5 weeks at 8°C in unripe hard green condition without any chilling injury by bulk packing (4 kg box) in 100-gauge D-955 or PP film with 0.0125% micro-perforations.

Papaya: The storage life of papaya Taiwan Red Lady could be extended by 2 weeks at room temperatures (27–33°C and 32–44% RH) and 4 weeks (18°C, 70–75% RH) by bulk MA packing with micro-perforated D955 or PE film.

Osmo-convective dehydration of pineapple slices: A method for preparation of pineapple candy from fresh peeled cored pinapple has been standardized. Pineapple slices were osmotically dehydrated at room temperature using sucrose syrup. It was followed by convective drying in a tray dryer. The sensory evaluation of the product has established its acceptability. The dehydrated product has 15.6% moisture content (weight basis), 1.85% acidity, 18.8% reducing sugar, 3.88 mg/100 g ascorbic acid and 115.71 µg/100 g α-carotene.

Osmo-air drying in vegetables: In vegetables, osmo-air drying has been standardized in bitter gourd and cauliflower. Bittergourd slices were dried after osmotic diffusion treatment at 10% NaCl solution at 60°C for 90 min followed by drying at 65°C for 4–5 hr and 3–4 hr at 60°C. The blanching treatment in cauliflower was standardized with hot water blanching at 100°C/

Osmo-air drying was standardized in bittergourd and cauliflower

3–5 min followed by dipping into 0.2% potassium metabisulphite solution for 10 min. Osmotic diffusion in cauliflower was carried out at 10% NaCl solution at 60°C for 6 hr. The cauliflower slices were dried at 60°C for 2–4 hr and at 55°C for 3–5 hr with final moisture content. Okra pieces were effectively blanched at 100°C for 30 sec in 0.1% MgO and dipping 1% sodium sulphite solution for 10 min. The blanched okra pieces were dried at 65°C for 4–5 hr and dried okra pieces were packed in LDPE pouches.

Ragi in biscuit-making: Cooking quality of both brown and white ragi was found comparable. Seed coat a byproduct of decorticated ragi is a good source of calcium, phosphorus, micronutrients, dietary fibre, and phytochemicals, and it can be used as an ingredient up to 25% in biscuit-making.

Extruded products from millets: Different snack foods could be developed using sorghum and legumes combinations using (collate type) low-cost, single-screw food extruder (costing about Rs 2.0 lakh). Raw materials were subjected to pearling/decortication and size reduction for product development through food extrusion system. The extruded products could be ground to produce instant porridge.

White sorghum extrudates

Red sorghum extrudate

Fortified Bengal gram *sattu*: Fortified Bengal gram *sattu* was prepared following standardized *sattu*-making process, and was fortified as per the FDA standard of wheat flour for thiamin, riboflavin, niacin, calcium and iron and was stored at 25, 35°C and room temperature in low density polyethylene and laminated aluminium foil (LAF) pouches. No significant changes were observed during 6 months of storage in alcoholic acidity of these samples at 25°C. Protein digestibility, calcium and iron content in fortified samples were 80.58%, 170.10 and 12.55 mg/100 g against control samples (80.6%, 69.5 and 10.2 mg/100 g).

Fermented food products using *okara* and defatted soymeal: Technology for preparing fermented traditional '*Dhokla*' and '*Idli*' by fortifying batter with *okara* or defatted soymeal has been developed. Fortification up to 20% of *okara* and up to 25% of defatted meal has been found acceptable to consumers. Fortified *idli* could be stored for 24 hr under ambient conditions, and for three days in refrigeration.

Tobacco oil: Solanesol derivatives have been synthesized and found promising in anti-diabetic activity. An expert system for diagnosis of nutrient deficiencies in flue-cured tobacco has been developed.Oil content in tobacco seed is 35–39%, which is free from nicotine, is better than groundnut, mustard and cotton seed oil and is at

par with sunflower oil in terms of fatty acid composition. The potential of tobacco as an oilseed crop has been established with possibility of producing 1,171 kg seed/ha with a recovery potential of 433 kg oil/ha from a chewing tobacco cultivar A 145 with modified agro-techniques in addition to cured leaf yield.

"Green" towels from organic cotton: Organic cotton sourced from Maharashtra was converted into yarn and subjected to bioscouring using "pectinase" enzyme. Bioscoured, bleached yarn was converted into towels in a commercial factory. The organically processed "green" towel compared well with normally (chemical) processed terry towel as well as a commercial product for its water-holding capacity.

Kenaf/mesta fibres for making reinforced PP composites: The PP/mesta fibre compound has been prepared using grafting of Maleic anhydride (MAH) on polypropylene (PP) by melt-mixing technique in the presence of Dicumyl peroxide (DCP) initiator, lubricant and antioxidant at 180°C for 5 min at 60 rpm in a rheocord. The chopped mesta fibres were added during melt-mixing. PP/mesta fibre composite sheets were prepared by compression moulding at 200±5°C and maximum load of 20 T compression. Fibre loading of 40 phr was optimized for making composites. Performance of mesta fibre-PP composites vis-à-vis glass fibre-PP composites was found comparable with respect to various physico-mechanical properties.

Coffee from vilayati babool pods:Vilayati babool (*Prosopis juliflora*), an alien species, introduced in India in 1877 from Mexico. The species has now spread in entire arid and semi-arid parts of India except frost-prone areas and mountainous regions.

It profusely produces pods (15–30 kg/tree) and in general stray animals browse the fallen pods. At the CAZRI, Jodhpur, efforts were made to utilize pod flour for coffee, biscuits and syrup (sugary concentrate). In one cup of boiled water add ¼ tea spoon *Prosopis* coffee powder and enjoy the coffee without *caffeine*. The taste of *Prosopis* coffee is similar to original powder of coffee (*Coffea arabica*).

***Salvadora oleoides* fruits (peelu) for value-added products:** Peelu squash and peelu jam from the juicy pulp of fruits can successfully be prepared for use in off-season. Dried peelu fruits have also been prepared. Seeds (the squash and jam preparation residue) can be utilized cost effectively for extraction of inedible fat for soap industry and in candle making.

Jute-synthetic geotextiles in rural road construction: New woven fabric has been developed using jute and polyolefin fibres suitable for application in soil reinforcement and stabilization. Use of synthetic material enhances durability of fabric as geotextiles compared to 100% jute; with advantages of lightness, high productivity and low cost. An extensive field trial was conducted using geotextiles for separation and reinforcement function in construction of a low-medium traffic volume rural road, Deocha–Saranda village road, Birbhum district, West Bengal. After six months of full monsoon, physical observation of the road showed that the portion where fabric was underlaid had even surface without any significant mark of subsidence or canalization causing ruts, depression etc. And cracks were found on the top and no patch marks were seen. The marks of ruts and cuts were found and ruptures were seen in places with vibration sensations on road without using synthetic fabric.

Jute fibreglass reinforced shellac sheets: Jute fibreglass reinforced sheets were prepared using jute fabric and fibre glass mats using shellac-filled sheet moulding compound. The sheets were smooth and aesthetically appealing. These sheets can be used for partition wall (in place of plywood and particle board), for door and window panels, as these are resistant to water and termite attack. The sheets possess good mechanical properties. Technologies for jute fibreglass reinforced sheets and jute fibre glass plywood composite have been transferred to an entrepreneur for commercial production.

Mango products: Preparation of carbonated beverages and osmotic dehydrated slices from Totapuri and fruit-bar of pulp from Arka Anmol have been standardized. Fruits of Pulihora showed highest antioxidant capacity (80.73 mg/100 g), followed by Ratna (78.33 mg/100 g). Arka Puneet possess highest flavonoid content (12.69 mg/100 g).

Guava cider: A sweet, fermented nutritious and highly refreshing cider, having strong guava

Jute polyester blended fabric

The blended yarn has been produced using polyester (hollow) of 6 denier, 110 mm and raw jute of TD-3 grade in conventional jute-spinning system. Attempts have been made for developing winter fabric in handloom using jute-blended yarn and commercial cotton yarn alternately as weft and commercial cotton yarn of 5.9 tex (100s Ne) as warp for developing jacket fabric. Alternate use of cotton and jute-blended yarn in weft direction improves fabric appearance and other physical properties. Fabric is 7.5% lighter in weight compared to commercial acrylic, and 15% lighter than cotton-jacket fabrics. The fabric thickness of the jute based fabric was also lower compared to commercial acrylic fabric and cotton jacket fabric by 19 and 47%. Thermal insulation of the jacket is much superior compared to commercial jacket fabrics.

flavour could be prepared. The cider prepared from guava Lalit scored high for colour, clarity, aroma, taste and astringency, free from acetic acid, sugar and impression. This mildly fermented beverage has 13° Brix TSS, 3.0% alcohol, 0.45% acidity and 32.8 mg/100 ml ascorbic acid. The cider can be stored up to one year under ambient conditions and its taste improves with aging.

Sweet, nutritious and refreshing guava cider

Banana beverages: To increase nutritional quality and appeal of banana juice, it was blended with other fruit juices. Banana and tomato juice in a 1: 1 ratio has received the best organoleptic score (6.14) and has a shelf-life of 5 months.

Litchi wine: The technology for wine-making from litchi fruits by yeast fermentation method has been standardized with 6.5% alcohol recovery.

Aonla products: Aonla jelly has been prepared using aonla juice, pulp and other ingredients like mango pulp, papaya pulp sugar and pectin. Prepared aonla jelly has 72 mg/100 g vitamin C (ascorbic acid), 0.8% acidity (as citric acid), 0.3% total ash (mineral), 68% total soluble solids, 47% sugar (sucrose), and 2,552 gross calorific value.

Aonla leather has been processed by slow heating of aonla, mango and papaya pulps. At the time of heating prepared sugar syrup (50 ºB) was added. This mixture was heated slowly till it reached 35 TSS ºB. Potassium meta-bisulphite as preservative was added for increasing shelf-life. The product has 81 mg/100 g vitamin C (ascorbic acid), 1.3% acidity (as citric acid), 0.5% total ash (mineral), 80% total soluble solids, 27% sugar (sucrose), and 3,019 gross calorific value.

Aonla powder has been obtained using foam-mat drying. This drying of aonla pulp using foaming agent TCP: 1% with 5% egg albumin at 5 min foaming time and 60°C drying temperature gave the best results by retaining good colour, appearance and nutritional values of aonla powder. Nutritional quality of foam mat dried aonla powder was superior as compared to simple aonla powder. Nutritional value of foam mat dried powder is higher, vitamin C (135 mg/100 g) is higher than simple dried powder (96.5 mg/100 g) and the acidity was low (1.07%) and total soluble solids (8.5 ºB) were higher than sample power (TSS 6ºB).

Soft-type aonla toffee has been prepared by using shreds (10.4%), glucose, sugar and colouring


Aonla jelly prepared from aonla juice, pulp and other ingredients, contains vitamin C, citric acid, minerals, total soluble solids and sucrose

flowering agents. This toffee had higher acceptability and retained vitamin C. For making soft toffee, fat was used for softening as compared to hard toffee.

Processing and preservation of drumstick: They were without any fungal attack after on year of storage. Drumstick pulp was separated by steam blanching and gravy was prepared with onion and tomato, masala powder (3 different combinations as available commercially) and other spices used for cooking.

Jackfruit srikhand: Jackfruit srikhand from jackfruit bulbs has been developed and process was standardized.

Drying of onion in forced ventilated greenhouse type dryer: Thermal efficiency of greenhouse dryer is 21%. With dryer, onion slices could be dried from 86% to 5.8% moisture content (wb) in about 16 sunshine hr. Dehydration as well as rehydration ratios are 11.5:1 and 1:4.9. The dried samples can be stored safely for 6 months after 0.5% Potassium meta-bisulphate treatment.

Process for potato flour: Potato flour has been prepared by mechanical dewatering of potato-meal. The process requires 75% less energy compared to conventional drying.

Extraction of aromatic oil from patchouli: Its essential oil yield varied from 1.9 to 2.0%. And during storage, alcohol content of oil increased gradually. The refractive index values for oil samples distilled from shade-dried patchouli herbage, stored in different packaging materials for ageing, varied between 1.504 and 1.506, but refractive index values of distilled essential oils were insignificant with respect to packaging material used and the ageing period.

Banana-peel pickle: In banana-chip industry, for every tonne of fruits, 300– 400 kg banana

peels are generated. Peel pickle has an organoleptic score of 6.8 with a shelf-life of 8 months.

Natural resins and gums

Lac production technologies for Gujarat: On the basis of lac cultivation trials conducted at various places in Gujarat on the newly identified lac host, *Prosopis juliflora* (a serious weed available in abundance in Gujarat and neighbouring states), a pakage of practices for winter *kusmi* lac production (*aghani*) on this host has been developed. Utilizing summer broodlac produced on *kusum*, a good harvest of *kusmi* sticklac crop to the tune of 1.2 tonnes of sticklac can be made in a plantation of this host with 1,000 plants/ha. An annual profit of Rs 0.1 million/ha will be generated from plant-biomass and lac. Sale of lac produce as broodlac would lead to much higher returns (up to Rs 0.25 million).

Since limited resource in the form of *kusum* plant for production summer broodlac (*jethwi*) is available in Gujarat, alternative host was needed for cultivation of summer broodlac on plantation scale. *Flemingia semialata*, a quick-growing bushy host plant, is normally recommended for winter *kusumi* lac production under rainfed condition. Earlier experiment at the Institute has shown summer sustainability of lac crop on this plant under irrigation. Therefore, field trials were undertaken in Gujarat for summer *kusmi* broodlac production on *F. semialata*. The crop matured during the first week of July and 90 kg broodlac was obtained with the use of 9 kg broodlac, which is equivalent to 3–6 tonnes/ha.

Lac insect-host plant relationship: *Kusmi* and *rangeeni* strains of Indian lac insect, *Kerria lacca* were evaluated on five host plants [*Acacia auriculiformis* (*akashmani*), *Albizia lucida* (*galwang*), *Butea monosperma* (*palas*), *Schleichera oleosa* (*kusum*) and *Ziziphus mauritiana* (*ber*)] for productivity-linked parameters. Host-suitability index was calculated for all the five hosts for both seasons.

Acacia auriculiformis was least suitable and *Butea monosperma* most suitable host during summer (*baisakhi*) crop for *rangeeni* strain. Differences in relative suitability of host plants were very high. Host suitability in order of lac yield was: *Acacia auriculiformis*<*Albizia lucida*<*Flemingia semialata*<*Butea monosperma.* Host-plant suitability changed with season. Maximum yield of lac was obtained on *Ziziphus mauritiana* and least on *Albizia lucida* during rainy-season crop than summer crop. Host-suitability index in order of lac yield was: *Albizia lucida* < *Acacia auriculiformis*<*Flemingia semialata*< *Butea monosperma*< *Ziziphus mauritiana.*

For *kusmi* strain host plants were more suited to lac insects in winter than summer season crop. Inter-host plant variability was also lesser. Host-suitability index in order of lac yield was: *Flemingia semialata*< *Acacia auriculiformis*< *Albizia lucida*< *Ziziphus mauritiana*< *Schleichera oleosa.* And during summer season (*jethwi*) crop, *Flemingia semialata* was the lowest yielder of lac and *Schleichera oleosa* the best yielder. Variability observed in host-suitability index among the different hosts was very high in this season. Host-suitability index in order of lac yield was: *Flemingia semialata*< *Acacia auriculiformis*< *Ziziphus mauritiana*< *Albizia lucida*< *Schleichera oleosa.*

Resin-dye content of lac when grown on different hosts showed significant differences and other industrial parameters, viz. life, flow, m.p. of lac, did not differ significantly when lac insects are grown on different hostplants for one generation. An endosymbiont *Wollbachia* sp. was found associated with lac insect for the first time.

Detection of adulteration of ghee: A rapid colour-based test has been developed to detect adulteration of ghee with vegetable oils/fats. The test gave appearance of orange-brownish colour/ tint in ghee samples adulterated with vegetable oils/fats. Adulteration to the tune of 5–7% could be detected with the newly developed test. Efficiency of the method remained unaffected as the result of storage of ghee for test period of 12 months.

Detection of adulteration of milk: The colour-based test for this is simple and reproducible. It can detect detergent up to 12.5 mg/100 ml milk. The result can be obtained in 5–10 minutes.

Goat milk products for additional income generation

In arid Rajasthan, the higher number of goats reared indicate its role as a saviour of drought-prone rural economy and human livelihood. The goat milk produced is organic in nature and is mostly obtained from the animals browsing on local bushes and tree fodder. Besides, its limited home use in the tea making and/or infant feeding in rural areas it has not been considered for making any value-added products. Goatee odour from the milk could successfully be removed to make the value-added products. The goat milk products like paneer, kulfi and paneer whey drink are now popular for additional income generation and livelihood security in the region. The benefit:cost ratio of kulfee and paneer is 1:1.69 to 1.70.

Continuous *chhana*-ball forming system: A prototype for continuous *chhana*-ball forming system has been developed. This system is an integrated device consisting of a kneading unit and a ball-making unit working in perfect synchrony to convert *chhana* mass into smooth balls of uniform size. The same unit can produce *chhana* balls of different desirable diameters from 15 mm to 25 mm. It does not involve any contact of human hand during the process. The system is easy to operate, saves labour and gives smooth hygienic balls required for preparation of high quality rasogolla.The prototype has a capacity of preparing 3,000 rasogolla balls from 18 kg *chhana*/ hr. It can be scaled up to any desired capacity as per the production plan of the company. It can save up to 80% on labour cost.

Continuous *chhana* ball making machine—it does not involve any contact of human hand during process

Milk: A substantial rise in phagocytic activity of macrophages was observed in probiotic *dahi* group on 2, 5 or 8 days of supplementation and it was found highest on the fifth day. Activities of β-glucuronidase and ß galactosidase enzymes were highest in probiotic *dahi*, group followed by normal *dahi* and milk groups. The augmentation in activities of these enzymes was highest after 2 days of dietary treatment.

Consumer response to dairy products: A consumer response study was conducted for evaluating a newly developed ready-to-reconstitute *basundi mix* (RTR-BM). The average consumer response on RTR-BM was between 'very good' and 'excellent'. A sizeable number of consumers (79%) rated product as 'very good' or better, indicating a high acceptability of the new RTR-BM. Most of the respondents (97%) expressed their willingness to buy this product as and when it would be available in the market.

A new shelf stable product formulation, ready-to reconstitute rasmalai mix, was also subjected to consumer-response study. Their opinion was also sought for willingness to purchase new formulation. More than 80% of the consumers rated product as very good or even better, the average consumer ranking for the product was more than 4.0 on 9.5 point scale. The respondents were segregated according to age and sex to evaluate demographic pattern of their responses. More than 90% of the respondents expressed their willingness to buy this product if produced commercially.

Multi-nutrient feed block: boon for livestock and self employment for farmers

The multi-nutrient feed block (MNFB) and nutrient mixture are prepared by using locally available ingredients, viz. molasses, urea, guar *churi*, salts, mineral mixture, dolomite, wheat bran, pearl millet husk, neem leaves and guar gum. Feeding of block/moisture to the livestock meet their requirement for balance feed by supplying fat, mineral and salts. To popularize this technology farmers' training programmes through KVK were organized. One of the trainees Shri Dada Ram Patel, resident of Kharda Ki Dhani village established his own unit for commercial production of MNFB with initial investment of Rs 9,800 and his product became popular in the area. Shri Patel has registered his enterprise and earning monthly income of around Rs 6,000 successfully by self employment.

Meat products: Designer **pork sausages** with low salt and fat, with high fibre, and shelf-life of 35 days in vacuum packaged in multi-layered nylon pouches, were developed. The processes for designer **chicken patties** with better consumer acceptability and **chevon and mutton sandwich spread**, well-acceptable variety products, were developed. Calcium chloride proved to be most effective in improving tenderness and other sensory attributes of mutton curry. Capsicum addition in mutton and chicken formulations improved flavour and acceptability of the products.

Designer pork sausages with low salt and fat with high fibre and shelf-life

Post-harvest cooling of fish: Cooling of Indian major carp catla (*Catla catla*) and rohu (*Labeo rohita*) fish under ice has been studied. Exponential and logarithmic models adequately represented cooling behaviour of catla and rohu. Average surface heat transfer coefficient of catla ranged

Technology of flavoured milk transferred for commercialization

from 11.68 to 34.41 W/m/C for weight range of 1.378 to 0.195 kg, respectively and that of rohu ranged from 19.84 to 33.01W/m/C for the weight range of 1.165 to 0.215 kg. Thermal diffusivity ranged from 6.6012 to 3.2475 × 10^{-8} m^2/sec and from 6.6481 to 5.4267 × 10^{-8} m^2/sec for catla and rohu. Thermal diffusivity decreases with increase in weight of fish. The study has indicated that for each 10°C reduction of fish temperature, approximately 0.110 kg ice/kg fish is required to lower temperature up to 0°C.

Fish products: New fish products developed include coated trout fillets, cutlet from filleting waste; cured product from freshwater fish; canning of trout; prawn soup powder; smoked fish products; tuna biriyani; ready-to-serve mahaseer (*Tor khudree*) curry in mughlai and Punjabi style. ❑

Technologies assessed and transferred

Probiotic dahi

- Continuous *chhana* ball forming system
- Probiotic dahi
- Gulabjamun mix
- Hansa test serum (HTS) to detect admixing of buffalo milk in cow milk
- Technologies of urea treatment of paddy straw,preparation of balanced concentrate mixture
- Technology of flavoured milk for commercial use

10. Agricultural Mechanization and Energy Management

The machines developed for seeding and planting, interculture, plant protection, harvesting and threshing and transport are discussed here.

Animal-drawn tool carrier: Animal-drawn wheeled tool-carrier has been developed with attachment of tools for tillage, seeding and interculture. The unit consists of main-frame, tool-bar and wheels (pneumatic/iron wheels) with provisions for attachment of tools and lifting of tools on turns. This tool-carrier showed advantage in terms of higher command area (2.0–2.5 times) over conventional implements. The unit with attachments may cost Rs 20,000. Its performance as work rate (ha/hr) for sowing, weeding and seed bed preparation is 0.10, 0.15, 0.10 compared to 0.03, 0.07, 0.10 by MB plough, seed drill, cultivar blade hoe respectively. The tool-carrier permitted higher command area per season (4–5 ha).

Animal-drawn tool carrier with attachment for tillage, seeding and weeding operations

Tractor-operated, 7-row seed-cum-fertilizer attachment for rotavator: The attachment has seven sets of plastics rotors for metering different seeds. It has a provision for varying seed and fertilizer rates also. The machine was used for planting six rows of soybean and chickpea and seven rows of wheat. Average capacity of the unit varied between 0.4 and 0.45 ha/hr.

Tractor-operated zero-till drill with rotary slit-opener: This is useful for zero till-drilling of wheat after combine-harvesting of rice. In this, seven rotary disk-type openers with trapezoidal-shaped blades are mounted on a shaft powered by a tractor, 45 hp or above, from PTO through gear from and side-chain drive for cutting surface straw and opening narrow slits in soil. Secondary furrow openers with small shoe and delivery boots for seed and fertilizer are positioned right behind the rotary slit-openers. Average field capacity and field efficiency of the drill are 0.41 ha/hr and 85% on controlled path operations. An additional toolbar on the main-frame is provided for mounting furrow openers in staggered manner for improving functional performance and smooth flow of straw.

Animal-drawn inter-row crop seeder: Animal-drawn inter-row crop seeder for rice and sesbania has been developed for row seeding of rice intercropped with sesbania. For biasi operation, seeding unit was removed and same equipment with two-row biasi tool was operated in row spaces where sesbania got chopped and mixed into the soil. The inter-row crop seeder serves tripple

Animal-drawn inter-row crop seeder for rice and sesbania

purpose of seeding of rice and sesbania, placement of fertilizer and biasi operation with chopping of sesbania. The cost of the inter-row crop seeder is Rs 3,500.

Barrow-type seed-cum-fertilizer spreader: Implement has spreaders with trapezoidal and bucket hopper for urea and diammonium phosphate (DAP) spreading with adjustable orifice for rate up to 100 kg/ha. Effective swath for urea is 6 m, having uniformity coefficient of 75.25%. Effective swath for DAP is 5 m with uniformity coefficient of 81.43%.

Tractor-mounted inclined-plate planter with raised-bed forming attachment for intercrop: For sowing bold seeds of groundnut, cotton, maize, a six-row machine has been developed. On the rear tool bar of the frame, shoe-type furrow openers with modular units of seed-boxes are clamped. Each seed box (15 kg capacity) is provided with inclined-plate (120-mm diameter)-type seed-metering mechanism. The provision has been made for different crops by selecting seed plates and by changing transmission ratio. Row spacing (225–450 mm) between furrow openers can be changed by sliding furrow openers on the rear tool bar of the main-frame. Depth of planter is controlled by tractor hydraulic system. Field capacity of the machine varies from 0.45 to 0.60 ha/hr with 65–75% field efficiency at about 3 km/hr.

Tractor-mounted inclined-plate planter with raised-bed forming attachment for intercrop

Single/two-row inclined-plate planters for sowing cotton and other crops: These planters are suitable for small and medium-size pair of bullocks. They can be used for sowing soybean, pigeonpea, cotton, chickpea, peas, groundnut at row spacing varying from 250 to 900 mm. The field capacity of 2-row animal-drawn planter is 0.11 ha/hr for row-to-row spacing of 450 mm.

Four-row vegetable transplanter: A tractor-mounted vegetable transplanter has been developed. With this, minimum percentage of seedlings in lying-down position was 3.86% for 450 mm row spacing for rolling type design with open press wheel on the straight shaft. For 330 mm row spacing for cauliflower, the minimum percentage of seedlings in lying-down position was 5.26 for rolling-type design 2 on the straight shaft.

Tractor-operated vegetable transplanter: Two-row vegetable transplanter is provided with opening type finger with flappers. Power from the wheel is supplied to planting mechanism through shaft, chain and sprockets. Plant spacing in the machine is kept at 300 mm and can be varied by changing sprockets or number of fingers. Two persons (one for each row) are required to place seedlings in the flappers when there are open. To increase planting speed, number of persons for seedling feeding are increased to two per tow. After seedling is dropped, the soil is compacted with two moving inclined wheels. The machine is operated at forward speed of 1 km/hr. The capacity of machine is 0.07 – 0.08 ha/hr for two-row model. Cost of operation is Rs 2,200/ha.

Tractor-operated vegetable transplanter

Tractor-operated multipurpose implement for sugarcane: This facilitates interculture and earthing up operations in addition to planting of sugarcane-setts. In three-row machine, operator lifts cane from seed-tray and puts it on the slanting chute. Cane slides down and cutter cuts canes into setts automatically, and in interculture mode implement

Tractor-operated multipurpose implement for sugarcane

has 6 standard tynes with reversible shovels, which provide soil cover in three rows of cane placed in opened furrows.

Animal-drawn single-row and 2-row inclined-plate planter: The planter consists of modular seed boxes, main-frame, ground drive wheel, power transmission system, furrow opener, beam and handle. The seed box-furrow opener assembly may be adjusted on the tool bar of the main-frame for row spacing varying from 25 to 90 cm. The ground drive wheel has spring loaded for slip-free rotation. The fertilizer unit is optional. The 2-row planter has a field capacity of 0.1 ha/hr at draught value of 50 kg for planting of cotton at 90 cm row spacing.

Power-tiller-mounted earthing-cum-fertilizer applicator: The earthing-up unit for sugarcane consists of single ridger body (20 kg weight), which also performs shaping of ridges. Field capacity of the machine is 0.15 ha/hr and the cost of operation is Rs 750/ha.

Power tiller-mounted earthing-cum-fertilizer applicator

Tractor-operated aero blast sprayer: This consists of a tank of 400 litres capacity, pump, fan, control value, filling unit, spout adjustable handle and spraying nozzles, its air blast is produced by centrifugal blower. The air blast distributes chemical in the form of very fine particles throughout its swath width, which is on one side of the tractor. Machine can cover about 1.7 ha/hr at a speed of 1.5 km/hr. Application rate can be varied from 100 to 400 litres/ha. Effective width of sprayer is 13 m distance. The cost of machine is Rs 80,000 and of operation is Rs 500/ha compared to Rs 700/ha by conventional method.

Bullock-drawn sprayer for field crops: The commercially available bullock-drawn sprayer (length × width × height 3.90 m × 1.80 m × 1.85 m) having 6 nozzles and boom (length 5.4 m) was modified in respect of orientation of beam and hitch system, operator seat and clutching system for the pump. The unit having 90 cm ground clearance was operated at the speed ratio (wheel: pump) of 1: 4. The hollow cone nozzles at 45-cm spacing gave swath of 3 m. The field test results have indicated average discharge of 440 ml/min/nozzle at average pressure of 324 kPa, giving draught value of 95 kg. The height of the boom is made variable from 30 to 100 cm. A manufacturer of cotton sprayer has adopted modifications. Cost of the sprayer is Rs 25,000.

Tractor-mounted turmeric harvester: This was evaluated to harvest turmeric rhizomes on raised bed, and indicated reduction in soil load by 30–35%. The harvester was tested in farmers' fields also at Thondamuthur in Coimbatore district. Its harvesting efficiency was 98% at forward speed of 2.5 km/hr, and damaged and undug rhizome were 4% and 2–3% respectively.

Self-propelled fodder harvester: It consists of 1,450-mm cutter bar. Power to wheel is provided through extension with chains and sprockets with the chassis suitably strengthened. The field capacity of machine is 0.1 ha/hr, and cost of operation is Rs 900/ha.

Self-propelled fodder harvester

Curry-leaf stripper: Two operators can strip approximately 40–50 kg leaflets per hour, and the cost of stripper is approximately Rs 15,000. It saves to a tune of 80% in labour and 60% in cost over conventional method.

Power-operated maize dehusker-cum-sheller: Maize dehuskers-cum-threshers, spike-tooth type (modified version of wheat thresher) and axial-flow type (modified version of sunflower thresher) have been developed. Recovery of grain with these is 97%. The cost of the machine is Rs 45,000 and of operation is Rs 5,000/tonnes.

Tractor-mounted banana shredder: The shredding unit consists of 4 blades placed perpendicular to each other at 225 cm distance. Additionally, 12 spikes with flat-cutting edge are fitted with a gap of 120 mm between rows. The blades are driven by PTO of tractor with a bevel gear-box and the hopper is trapezoidal with a height of 800 mm. It takes 1.2 min to shred stem having average height of 2,400 mm. The cost of operation is Rs 300/hr.

Tractor-mounted banana shredder

Tree climber: A tree climber has been developed for harvesting coconut and arecanut. Climber has two components. The upper component is provided with a seating arrangement and lower component is having provision for holding foot, the upper component can be moved up or down over the tree. The operator can safely climb a tree of 10 m height in 1.5 min. Its cost is Rs 2,000.

Tree climber helps operator to climb 10 m in 1.5 minutes

Tractor-mounted banana-clump remover: A nine-tyne cultivator frame has been adopted for development of the equipment. Two numbers of 100 mm × 15 mm × 1,000 mm sub-soiler shanks with shares of 190 mm × 40 mm × 5 mm were fitted in the frame at 225 mm spacing. These two sub soilers perform as a fork while removing banana clump. A deflector has been provided to push soil sideways. Cost of the components is Rs 6,000. The field capacity and cost of operation are 0.5 ha/hr and Rs 500/ha, respectively.

Two-wheel donkey cart: Two-wheel steel cart was developed for large white Kathiawad breed donkeys (body weight, 150–170 kg) matching their draught capacity (25% of body weight). With the help of the steel cart a pair of donkeys could transport 500 kg load compared to 40–50 kg carrying on back load. The unit cost of the cart is Rs 6,000.

Two-wheel steel cart for donkeys

Two-wheel bullock cart: A standard chassis of 2-tonne payload capacity with options for interchangeability of pneumatic wheels by iron wheels and hitch arrangement for single and a pair of bullocks has been developed. The chassis has the provision for mounting of different sizes of platforms for operations such as platform for transportation of crop, straw, grain bags, platform for transport of materials/passengers and tankers for transport of oil/water. The pneumatic wheel cart is recommended for transport of 2 tonnes payload on the tar road, 1.5 tonne payload on earthen road and 1 tonne payload under field conditions. The developed cart is superior to conventional wooden wheel cart in load carrying capacity, draught and power requirements. The unit cost of the cart is Rs 15,000.

ERGONOMICS AND SAFETY

Survey of agricultural accidents: Development of safer equipment and minimization of accidents are important links in enhancing farm mechanization strategies. An agricultural accidents survey was carried out with large sample size of villages for a period of one year. The results indicated that of the total accidents, 63.4% were due to farm machines and hand tools, whereas 36.6% accidents were due to snake bites, animal bites, fall in well, lightening, heat stroke etc. Of the total accidents, 5.5% were fatal and 94.5% were non-fatal. The overall annual accident incidence rate was 334 accidents per lakh workers, whereas the annual fatality rate was 18.3 per lakh workers.

Anthropometric and strength data of agricultural workers: Data on 79 body dimensions from 12 states and strength data on 16 parameters from 6 states were collected. The mean stature and weight of Indian agricultural workers on the basis of data worked out to be 163.0 cm and 53.8 kg for male-workers and 151.2 cm and 45.9 kg for female-workers. The mean values for strength

Agricultural accidents data

State	No. of villages surveyed	Data collection period	No. of accidents reported			Accident incidence rate/lakh workers/year	Fatality rate/lakh workers/ year
			Farm machinery and hand tools	Others	Total		
Tamil Nadu	240 from 6 districts	July 04–June 05	265 (46.2%)	308 (53.7%)	573 (100%)	245	10.0
Orissa	240 from 6 districts	July 04–June 05	412 (83.3%)	104 (16.7%)	516 (100%)	1520	17.7
Madhya Pradesh	360 from 9 districts	July 04–June 05	120 (63.5%)	69 (36.5%)	189 (100%)	294	18.7
Punjab	200 from 5 districts	Jan 05–Dec 05	32 (78.0%)	9 (22.0%)	41 (100%)	66	12.8
Rajasthan	280 from 7 districts	July 05–June 06	218 (48.1%)	235 (51.8%)	453 (100%)	373	42.8
Arunachal Pradesh	160 from 4 districts	July 05–June 06	61 (71.8%)	24 (28.2%)	85 (100%)	558	6.5
West Bengal	120 from 3 districts	Sep 06–Aug 07	352 (79.1%)	93 (20.9%)	445 (100%)	294	15.2
Total			1,460 (63.4%)	842 (36.6%)	2,302 (100%)		
Weighted mean						334	18.3

Severity-wise data of victims of agricultural accidents

States	Agricultural accidents		
	Fatal	Non-fatal	Total
Tamil Nadu	24 (4.2)*	549 (95.8)	573 (100)
Orissa	6 (1.2)	510 (98.8)	516 (100)
Madhya Pradesh	12 (6.3)	177 (93.6)	189 (100)
Punjab	8 (19.5)	33 (80.5)	41 (100)
Rajasthan	52 (11.5)	401 (88.5)	453 (100)
Arunachal Pradesh	1 (1.2)	84 (98.8)	85 (100)
West Bengal	23 (5.2)	422 (94.8)	445 (100)
Total	126	2176	2302
% of total accidents	5.5	94.5	100

*Figures in parentheses indicate per cent of total accidents

data in pushing and pulling by both hands in standing posture are 226 N and 223 N for male-workers 151 N and 169 N and for female-workers respectively.

Safety gadgets for power-operated chaff cutter: An automatic belt conveyor system for powered chaff cutter has been developed to ensure that operator's hands shall not reach cutting machine to cause an accident. The top of the conveyor trough near feed roller is covered to distance of 40 cm to prevent insertion of hand. A guard for the idler pulley of conveyor at outer end is provided to prevent accidental contact of persons or parts of clothing being caught in the transmission system. Guard for cutter head, guard

Safety gadgets ensure that operator's hands do not reach cutting machines

for belt transmission system, cover for electric motor, guard for idle roller conveyor, guard for feed rollers are provided to prevent accidental contact of persons or parts of clothing being caught in transmission system. The unit also includes feed reversing mechanism for the safety of operator, as feeding can be instantly stopped or reversed as required without stopping machine.

Ergonomical evaluation of power tiller: A 6.7 kW power tiller was evaluated with 10 male subjects. The salient findings are:

- Rota-puddling in wet soil is more energy-intensive operation than rota-tilling in dry soil. However, muscular load on forearm is higher during rota-tilling than rota-puddling operation. Transportation is more comfortable operation as compared to rota-tilling and rota-puddling operation.

- The frequency-weighted vibration acceleration (rms) is highest during transportation followed by rota-tilling and rota-puddling. The most detrimental frequency of vibration in hand-tractor operation is 31.5 Hz, which exceeds 1 hr exposure limit.
- Isolator with high stiffness (16.3 kN/mm) and high damping coefficient (0.51 N s/mm) is better for reduction of vibration during field operation of power tiller. Engine mounting and handle isolator reduced frequency un-weighted and frequency-weighted vibration acceleration (rms). The average reduction of frequency weighted vibration acceleration (rms) by handle grip was 11.31%.
- Designed glove from elastomeric material is most preferred by hand-tractor operators. It reduces about 14% frequency-weighted vibration acceleration (rms) below 50 Hz and above 160 Hz frequencies.
- Mounting of isolators reduces heart rate of the operator to 23.9, 18.4 and 15.4% during transportation, rota-tilling and rota-puddling operations. The corresponding reduction in energy expenditure rate is 1.41, 0.35 and 1.52 kJ/min. In these operations, about 54.5, 53.0 and 43.65% work related body parts discomfort in hands, arms, shoulders and neck was reduced.

Ergonomically designed sugarcane harvesting knife: A sugarcane harvesting knife has been ergonomically designed. The weight of the knife is 486 g. Performance of this knife was compared with existing Dharmapuri sugarcane harvesting tool weighing 585 g. The harvesting capacity of

Equipment for women workers

The following improved equipment were evaluated and their brief performance is given here.

Equipment for women workers and performance

Equipment	Centre	Brief results
4-row rice seeder	CIAE	• Twelve female subjects participated in the study • Mean HR during work - 144 beats/min • Mean ΔHR – 61 beats/min • Output – 917 m^2/hr
4-row rice transplanter	CIAE	• Twelve female subjects participated in the study • Mean HR during work - 148 beats/min • Mean ΔHR - 62 beats/min • Force required - 251 N • Output – 245 m^2/hr
Single-row-finger-type rotary weeder	TNAU	• Twelve female subjects participated in the study • Mean HR during work - 125 beats/min • Mean ΔHR - 43 beats/min • Energy expenditure – 25.1 kJ/min • ODR – 5.4 on 10 point scale • Force required - 91 N • Output – 0.016 ha/hr
Sugarcane detrasher	TNAU	• Twelve female subjects participated in the study • Mean HR during work - 113 beats/min • Mean ΔHR - 44 beats/min • Energy expenditure - 16.5 kJ/min • ODR - 5.0 on 10 point scale • Output - 119.8 kg/hr
Vaibhav sickle	NERIST	• Eleven female subjects participated in the study • Mean HR during work - 129 beats/min • Mean ΔHR - 42 beats/min • Energy expenditure - 16.7 kJ/min • Output – 61.9 m^2/hr
Naveen sickle	NERIST	• Mean HR during work - 126 beats/min • Mean ΔHR - 38 beats/min • Energy expenditure - 15.9 kJ/min • Output – 61.9 m^2/hr

Ergo refined sugarcane harvesting knife in operation

the improved knife was 9.8 m^2/hr against 9.4 m^2/hr of traditional tool. However the mean heart rate (HR) during work with the improved knife was lower, i.e. 115 beats/min, as against 132 beats/min for the traditional tool. The corresponding HR (increase in HR over rest) were 41 and 54 beats/min. Thus, operation with newly developed knife involves less drudgery.

ENERGY

Concentrator for solar photovoltaic panel (SPV): The most important constraint in the widespread adoption of SPV panels is its very high initial cost. The cost of panel per unit output has been reduced by developing solar concentrators which increase solar energy incident on SPV panels. Stationary solar concentrator and tracking solar concentrator designs are being studied. A stationary concentrator has been fabricated. Its Fill factor has been found to be 0.7. The output of the SPV panel with stationary concentrator has been 56% higher compared to output of SPV panel without concentrator, with 16% estimated increase in cost of SPV panel.

Triple-purpose integrated solar device: An improved 3-in-1 compact integrated device has been designed and developed, which can be used as solar water heater during winter, solar cooker during clear days and solar dryer on availability of fruit or

Concentrator for solar photovoltaic panel

vegetables. The device has 25% enhanced capacity of water and 13.4% less area of window but having 35% more effective utilization of energy compared to earlier developed model. As a water heater, 50 litres hot water of 50–60°C could be obtained in winter afternoon while as a cooker food for a family could be boiled within 2–3 hr in summer (loading time 10 AM). As a dryer, fruit and vegetables like *ber*, grated carrot, spinach, watermelon flakes, tomato slices etc. could be dehydrated efficiently with regulation of temperature during day-time and continuation of the drying process even in the night through the heated water. The device can save about 230 kWh during winter as a water heater and 70 kWh as a solar cooker when used in the forenoon of 210 days in a year. In addition, 50 kg fruit and vegetables can be dehydrated from the same device saving additional 30 kWh and providing the dried material for its subsequent use. Year-round utility makes it a useful domestic appliance.

Year-round utility makes triple-purpose integrated solar device a useful domestic appliance

Fixed-dome type biogas plants: Two non-functional 60 m^3 capacity KVIC type biogas plants were converted into fixed-dome type biogas plants at a Gurudwara near Ludhiana. All brick construction for the dome of the biogas plant has been done. Both the plants were commissioned using cattle dung, water and fresh digested slurry available from a running biogas plant. The gas available is being used for routine cooking of meals (*Langar*) in the Gurudwara.

Biogas plant slurry dewatering machine: A rotating-cylinder type machine for partial removal of water from digested slurry discharged from

large-capacity cattle dung-based biogas plants has been developed. The machine handles fresh digested slurry at around 4,800 litres/hr. The total solids content of the input slurry varied between 6.0 and 6.5%, of dewatered slurry between 10.5 and 11.0%, and that of filtered water between 2.4 and 2.5%. The filtered water can be recycled in the plant for dilution of input cattle dung. The machine can handle digested slurry available from a battery of 4 or 5 plants each of 85 m^3 capacity. At Palampur (Himachal Pradesh), the input slurry was fed into machine under gravity. However, in plains, a slurry pump may be used for feeding the input slurry into the machine. The estimated cost of the machine is Rs 40,000, excluding prime mover.

Biogas plant slurry dewatering machine

Durable improved biomass cook stoves: Durable improved biomass cook stoves for agro-industrial and community applications have been developed. Single pot stove for agro-industrial applications has a power rating of 9.9 kW at fuel-wood (*Acacia nilotica*) burning rate of 8 kg/hr. This stove has thermal efficiency of about 35%. Cost of single pot cook stove is around Rs 1,200, and double pot cook stove Rs 1,800.

Biomass briquetting: A briquetting facility consisting of a piston press-type briquetting machine, a rotary die-type pelleting machine, flash dryer with cyclone separator, a 62.5 kVA genset, a hammer mill for size reduction of the biomass and water softening plant-cum-boiler for heating of the biomass has been installed. The rated capacity of the piston-press type machine is 500 kg/hr of briquettes of 50 mm diameter. The machine was used for briquetting of saw-dust, sugarcane-bagasse, cotton-stalk, pearl millet stalk, rice-straw, wheat-straw, groundnut-shell and *Jatropha*-shell, in powder and granular forms. Good-quality briquettes were obtained in all cases. The estimated cost of the briquettes was Rs 2,100/tonne for saw-dust and around Rs 3,000/tonne for sugarcane bagasse, cotton stalk, pearl millet stalk and wheat straw. The cost of briquetting was lower with saw-dust, primarily because of lower requirements of pre-treatment of feedstock and higher output.

Good-quality pellets of 22 mm and 10 mm size could be made in rotary die-type machine when feedstock was mixed with 50% de-oiled cake on volume basis. The briquettes prepared from the feedstock having low ash content could be used in gasifiers without any difficulty. Briquettes and pellets of all the feedstock studied could be used in improved portable metallic stoves and inverted downdraft gasifiers for thermal applications.

Agro-industrial application of biomass gasifier: A throatless downdraft gasifier of SPRERI design was installed in a commercial bakery at Udaipur. The industry has two ovens, each consuming approximately 6.5 kg of lpg/hr. One of the ovens, which normally operated up to 16 hr/day, has been provided with producer gas supply. One batch of the product takes around 20 min at a temperature of 230–250°C. The gasifier consumes 40 kg/hr of biomass and operates for 15–16 hr everyday.

Efficient process for biodiesel extraction from *Pongamia* and *Jatropha*: Higher oil recovery from seeds of pongamia and jatropha was obtained with CRIDA modified oil expeller. Pretreatment of the seed enhanced the oil recovery from 24 to 28% in pongamia and from 26 to 30% in jatropha over conventional steaming process. Oil quality also improved with seed pretreatment. With seed pretreatment, viscosity of oil decreased by 2.7 to 3.7 centistrokes, which is close to BIS specifications, thus contributing to higher oil recovery. More than 94% of the biodiesel was recovered in the case of jatropha oil when CRIDA process was used, which reduced the catalyst requirement when compared to the two-stage process for high free fatty acid oils with biodiesel recovery of 88%. The recovery of biodiesel was around 91% in case of pongamia using CRIDA process as against 86% with normal process.The flash point of the CRIDA biodiesel was around 127°C while that of normal biodiesel was 135°C.

Jatropha biodiesel with CRIDA process

Pongamia biodiesel with CRIDA process

This is useful in burning the fuel at lower operating temperature.Performance of a 5 HP water cooled engine coupled with eddy current dynamometer was tested using the B20, B40, B80, B100 biodiesel.

Testing of tractor with fuel blends of *jatropha* ethyl ester and diesel: A 35 HP tractor was tested in laboratory at varying loads using blends of jatropha ethyl ester (JEE) and diesel. The jatropha ethyl ester was produced in batches by single stage trans-esterification method using KOH and ethanol; and on an average ester recovery of 90% was observed using optimized parameters. The engine efficiency of the tractor increased with increase in load on the tractor and increase in JEE blending percentage in diesel. The thermal efficiency ranged from 25 to 27% at maximum power of tractor. Similarly, NO_2 levels increased with increase in JEE blending in diesel from B-30 to B-50. The smoke emission from tractor increased considerably with increase in brake power.

Mechanical fish harvesting devices for fish ponds

Bycatch reduction devices (BRD) for selective shrimp trawling: Field experiments with horizontally oriented fish eye BRD (10 cm × 30 cm)

Operation of radial escapement device

installed in the upper half of the cod end of shrimp trawl, showed 100% efficiency in excluding seven species of fin fishes, viz. *Parastromateus niger, Leiognathus equulus, Pampus argenteus, Thryssa mystax, Alepes djedaba, Encrassicholina devisi* and *Stolephorous waitei.* Above 50% escapement was observed in 25 other species. Semi-circular fish eye BRD (20 cm × 30 cm) showed 100% efficiency excluding *Caranx semifasciatus* and *Secutor ruconius,* and 8 species showed escapement of more than 50%. Loss of target catch shrimp and squid [*Uroteuthis* (*Photololigo*) *duvauceli*] was minimal in these two designs. Field experiments with vertically orientated oval fish eye BRD (20 cm × 30 cm) showed 100% efficiency in excluding 12 species of finfishes and 1 lobster species; and 37 species showed escapement above 50%, while catch loss of cephalopods and shrimp was higher in this design.

Radial escapement device with 150 mm mesh netting (covered codend method) showed 100% efficiency in excluding fin fishes. *Uroconger lepturus, Nibea maculata, Scatophagus argus, Selar crumenophthalmus, Trypauchen vagina, Leiognathus brevirostris, Penaeus semisulcatus;* and 8 species showed escapement above 50%. Among 68 species, 19 species showed 0% escapement that consisted of 8 species of finfishes, 3 species of shrimps, 1 species of cephalopod, 2 species of crabs, and 5 species of other molluscan shells. Shrimp loss was about 8.32%.

Development of traps: Collapsible traps for crab, lobster and fish were designed and fabricated. Fishing trials were conducted with collapsible crab traps in Kochi backwaters using different baits. Of the different baits used, chicken waste showed higher catches of *Scylla serreta* than other baits. A design of collapsible fish trap for inland fishing was developed and the same was tried in the inland waters of Kerala mainly for *Eutroplus* spp. The catch rates of fish were better with these traps than with traditional fish traps; and that is also being patented.

Operation of fish traps

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11. Agricultural Human Resource Development

Education Division undertakes planning, development, coordination and quality assurance in higher agricultural education in the country and, thus, strives for maintaining and upgrading quality and relevance of higher agricultural education through partnership and efforts of the components of the ICAR—Agricultural Universities (AUs) System, comprising State Agricultural Universities (SAUs), Deemed-to-be universities (DUs), Central Agricultural University (CAU) and Central Universities (CUs) with agriculture faculty. The Division has a National Academy of Agricultural Research Management (NAARM) at Hyderabad that facilitates capacity-building of the National Agricultural Research System (NARS) in research and education policy, planning and management.

STRENGTHENING AND DEVELOPMENT OF AGRICULTURAL UNIVERSITIES

For development and strengthening of undergraduate and postgraduate programmes financial and professional support of Rs 10,345.00 lakh was allocated to SAUs, DUs, CUs. This included special grant of Rs 2,500.00 lakh (out of Rs100 crore special grant to PAU, Ludhiana).

Niche Area of Excellence: There are 28 niche areas of excellence functioning in the country. Fourteen have been added during the year. Significant achievements include arsenic toxicity management, resource conservation technologies, management of acidic soils, organic agriculture, integrated pest management, biofuel production and improvement, quality fish production, hi-tech horticulture, genetic engineering for drought resistance, production of medicinal and aromatic plants/products, immuno-diagnostics, buffalo genomics, protected floriculture, neutraceuticals, functional fermented dairy products including biotics, improving water productivity and production of bioagents.

Experiential Learning: Experience-based or "experiential" programmes seek behavioral change in students/learners. Experiential learning is "learning from experience" which is learner-centered and allows participants to manage and share responsibilities. With this objective including skill-oriented hands-on-training, 45 units in 43 universities have been established under experiential learning programme. At present, 183 experiential learning units are functional in 43 AUs with a total allocation of Rs 7,406 lakh. They provide a broad spectrum of skill- and experience-oriented exposures to undergraduate students in particular and trainings to clientele including para-professionals and farmers in general.

Emeritus Scientist Scheme: Twenty-one Emeritus Scientists have been selected in 2007. Significant achievements are: developing package and standards for commercial tulips production in Kashmir Valley, development of biopesticide formulations, management of mildew diseases in maize, generation of phytopathological database for central India, development of molecular protocols for clearing wheat grains under sanitary and phytosanitary regulations for Karnal Bunt, phyto-remediation of heavy metal accumulation in rhizosphere, identification of new markers for protein synthesis in ruminants and induced breeding in major carps.

CAPACITY DEVELOPMENT

State Agricultural Universities

Banaras Hindu University, Varanasi: Four post graduate diploma courses have been added at the south campus of the university. Also new facility with construction for Mushroom Production

and Economic Pest Management Centre has been created.

Indira Gandhi Krishi Vishwa Vidyalaya, Raipur: Faculty of Veterinary Sciences and Animal Husbandry, Durg, has started Ph.D. programme in Animal Nutrition and Livestock Production and Management. Establishment of two new colleges one in Agriculture at Kawardha and the other in Agricultural Engineering at Mungeli has been initiated. Two new girls hostels, one at CARS, Bilaspur, and another at CARS, Jagdalpur, have been established.

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur: Its Jabalpur college is ideal for focusing research on domestication, cultivation, processing and quality evaluation of medicinal and aromatic plants. Its herbal garden comprises 1,100 plant species belonging to 450 genera. This garden is serving as center for education, demonstration, reference for entrepreneurs engaged in the pharmaceutical preparations and trade in the Indian System of Medicine. Commercial cultivation programme of more than twenty medicinal and aromatic plants has been undertaken in 75 hectares. The Post Graduate Programmes in Medicinal and Aromatic Plants and Crop and Herbal Physiology have been started in the university. A resource book on Medicinal and aromatic plants has also been compiled and published. Several varieties have been developed/released including Jawahar Kapas 35 in cotton; JKM-189 in pigeon pea; JGK-2; JAKI 9218, Jawahar Gram Kabuli 3 (JGK 19) and JGK 2 in chickpea.

Teaching Veterinary Clinical Service Complex has empowered the veterinarians at JNKVV, Jabalpur

The University is empowering veterinarians with modern diagnostic and farming skills through Teaching Veterinary Clinical Service Complex (TVCSC).

Maharana Pratap University of Agriculture and Technology, Udaipur: This is the first University in the country in adopting revised curriculum for Under Graduate education based on IV Deans Committee Report. This has resulted in better filling of all seats in Home Science where earlier seats used to remain vacant.

Girls' hostel Ganga constructed at MPUAT, Udaipur

Its Textile and Apparel Designing facility has won appreciation. Apparel Production Management Laboratory has started providing industrial training in software and garment designing using automatic machines for cutting-and-stitching.

Industrial training in software and garment designing using automatic machines has been started at MPUAT, Udaipur

A modern girls' hostel named 'Ganga' has been constructed. The hostel has internet and semi-automatic laundry facility.

The university has latest infrastructure in the

areas of Hi-tech Horticulture, Biotechnology, Food and Processing Engineering, IPM, and that has renewed interest of students from Kuwait and other Middle-East and African countries.

This university is also the first in the country to introduce scheme of Adjunct Professor under which eminent educationist is honoured and invited to be the Professor in the University. The University has upgraded its connectivity from 512 kbps to 2 Mbps and Video Conferencing facilities linking its KVKs to main campus at Udaipur have been established. The university has also created models for technology and economic empowerment of farming community.

Marathwada Agricultural University, Parbhani: Five colleges, one Agricultural Biotechnology College at Latur and four non-grant private colleges (one for agriculture, two for horticulture and one for food technology at Aurangabad)—have been started. Niche Area of Excellence project "Development of Agro-based Nutraceuticals for Health Security" is being implemented and under Experiential Learning, facilities have been set up for hands-on-training on preparation of ice-cream, paneer and shrikhand.

Navsari Agricultural University, Navsari: Two new courses/programmes, Masters in Plant Biotechnology and Ph.D. in Agro-forestry and Ecology, have been started. The programmes under Niche Area of Excellence include tomato ketchup processing plant and a fruit juice processing and packaging each of 5 MT capacity, have been commissioned. Under Experiential learning programmes High-tech Horticulture unit and Commercial biofertilizer production unit have been developed for experiential learning.

Orissa University of Agriculture and Technology, Orissa: An advanced Analytical Laboratory and a Central Laboratory have been developed and made operational at the university. Management of acidic soil for sustainable crop production – Niche Area of Excellence project has been completed successfully. Extensive field studies were conducted at seven acidic areas of Orissa and increase in productivity of both *kharif* and *rabi* crops was observed. Two 50-seated Girls' Hostels have been constructed and that are fully occupied.

Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut: Under the Niche Area of Excellence scheme, Isolation, characterization, production and dissemination of bio-agents scheme, regular collection of pests from the field and isolation of bio-agents were carried out. Experiential Learning Projects and setting-up of hands-on-training have been accomplished on 'Model agro processing system for horticultural produce' and 'Doorstep Clinical Services on Demand'.

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu: In Agriculture stream, 2 Masters and 3 Doctoral degree programmes and in veterinary stream 10 Masters and 5 Doctoral programmes have been introduced.

Major facilities developed include Library building, Veterinary referral hospital-cum-clinic complex, Class Rooms and Examination Hall complex and also new girls' hostel at R.S. Pura. Under Niche Area of Excellence, new varieties of Basmati Rice, Toria and Raya have been submitted for release and for E-learning, a studio has been established.

Tamil Nadu Agricultural University, Coimbatore: Undergraduate syllabus has been improvised to include nanotechnology, electronics bioinformatics, mathematics, agribusiness management and IPR management.

The Directorate of Students' Welfare, provides career-counseling and Overseas Employment Unit through which students get overseas employment and also directed for higher education abroad. TNAU graduates excel in All-India Competitive Examinations like JRF/SRF, ARS, Civil Services. The university has well developed latest infrastructure for internet browsing, library, video conferencing etc.

Tamil Nadu Veterinary and Animal Sciences University, Chennai: Some of the highlights of the university are as follows:

- Bachelor of Technology (B.Tech), Food Processing Programme with 4 years duration with intake capacity of 20 students has been introduced.
- Two Post Graduate Diploma courses, viz. Companion Animal Practice and Veterinary Laboratory Diagnosis for one year duration with admission strength of six students each have been introduced for B.V.Sc. graduates.
- Niche Area of Excellence in Animal Biotechnology was supported by the ICAR on "Molecular diagnostics for emerging avian viral diseases and their immunopathogenesis". Under the project, fourteen nucleotide sequences of ICP4 and repeat sequence genes for MDV field isolates have been submitted to GenBank.
- In Experiential learning the following schemes have been implemented: Model Turkey Post Harvest Technology Unit at Poultry Research Station, Nandanam, Feed Manufacturing Technology at VC&RI, Namakkal, Commercial Pig Rearing at VC&RI, Namakkal and Unit on Seafood Processing and Value Addition at FC&RI, Thoothukudi.

University of Agricultural Sciences, Bangalore: Its College of Agriculture, Hassan,

has started functioning from its new campus and the university has started Diploma in Baking Technology from academic year 2006–07. Under Experiential learning project two polyhouses have been established for production of high value crops and under the Niche Area of Excellence, the integrated centre for drought research has undertaken genetic engineering for developing crop plants resistant to abiotic stresses.

Sugarcane variety 'CoVC 2003-165', resistant to wolly aphid, has been identified and registered. IPM strategies for management of Red Headed Caterpillar in groundnut have been developed and field-validated. Biofuel Park has been established at Hassan centre. Sports and Games team has bagged Team Championship Trophy in Athletics and Overall Champions Trophy in the 8th All-India inter Agricultural University, Ludhiana, for the second time.

PROMOTION OF EXCELLENCE AND HRD

ICAR National Professor Scheme: There are ten positions of such chairs. Out of these five have been filled up till date, 2 National Professors have been selected this year. Major achievements under the scheme are as follows.

- "Pant– ICAR Subsoiler-cum-Differential Rate Fertilizer Applicator" was designed and developed. The patent application for the machine has already been filed and it is to be evaluated under different agroclimates, crops and soil types.
- In rice and wheat, real time synchronization of nitrogen (N) applications with crop demand has been achieved through a combination of preventive and corrective N-management strategies. In-season estimated yield (INSEY) defined as NDVI divided by number of days after transplanting or sowing for wheat was highly correlated with actual grain yield, thereby suggesting that 'Green Seeker', that assesses extent of greenness, can be usefully employed to work out need-based fertilizer N doses.
- Design of single factor and multi-factor experiments have led to identification of fractional factorial designs for asymmetrical factorials and supersaturated designs (SSDs). Software has been developed for generation of Hadamard matrices. The software also describes the method by which a Hadamard matrix is generated. This software is an on-line generation of the Hadamard matrix and is the first of its kind. A Statistical Package for Repeated Measurements Designs (SPRMD) and an input data management module have also been developed.
- Impact of agriculture policy, technology, institutions and trade on agriculture growth, farm income, sustainability and rural poverty has been studied. During early 1980s, magnitude of public investment was 3.51% of GDP of agricultural sector and slightly more investment came from private sources, primarily farmers themselves. Level of public investment has declined year after year and recent level of public investment is less than three-fourth of the level attained during 1980–81. After 1995, level of public investment remained below 2% of GDP of agriculture. There has been a decline in public sector investments after 1981–85 that coincided with increase in subsidies. During 1985–86 to 1989–90, magnitude of public investments declined to 2.96% and level of subsidies increased to 4.96%. This trend is continuing since then. Subsidies provided by Central government like fertilizer have been highly skewed as the use of such inputs is very low in low productivity states and high in the high productivity states.

ICAR National Fellow Scheme: There are presently 20 ICAR National Fellows working on a variety of research projects in the country. Their projects include (i) enhancement of efficiency of *Trichogramma* spp. (ii) developing regional plans for managing poor quality irrigation waters, (iii) quantitative trait loci and marker assisted selection in indigenous breeds of cattle and buffaloes, (iv) development of Elisa-based immuno-diagnostics for classical swine fever, (v) exploitation of metabolic diversity for isolation of genes involved in lipid biosynthesis, (vi) technologies for using modified atmosphere gases to extend shelf-life of tropical fruits and vegetables for export, (vii) sustainability of watersheds in rainfed regions of peninsular India using GIS and remote sensing, (viii) senescence: mechanism in crops in relation to abiotic stresses, sink strength and their interaction, (ix) effect of rising atmospheric CO_2 on photosynthesis and productivity of crop plants, (x) molecular characterization of Indian maize landraces and allele mining for argonomically important traits, (xi) improvement of strain of *Chaetomium globosum*, a potential antagonist of fungal plant pathogens and developing molecular markers for its identification, (xii) textile articles through processing of wool with silk waste and cotton to create entrepreneurial skills in rural women, (xiii) Genome analysis of indigenous breeds of cattle, buffalo and goats, (xiv) Study of gene interactions in developing *Drosophila* embryo, (xv) Identification and quantification of phosphotase hydrolysable organic Phosphorus sources for plant nutrition and refinement of a

non-destructive technique for phosphatase estimation, (xvi) Decontamination of pesticide residues from edible commodities, (xvii) Returns to livestock research and development in India: implications for growth, equity and sustainability, (xviii) Assessing soil quality key indicators for development of soil quality index using latest approaches under predominant management practices in rainfed agro-ecology, (xix) 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 (*xx*) Efficient design of experiments for quality agricultural research.

MANPOWER DEVELOPMENT

All-India Admissions and Fellowships

All-India Competitive Examinations for Admissions to UG: For admissions to 15% seats in eleven subjects of Under Graduate Programmes, 12th All-India Competitive Examinations including award of National Talent Scholarships (NTS) were conducted on 21 April, 2007. In this examination, 20,267 candidates appeared and 1,332 were finally admitted in 45 Universities through counseling. All the candidates who joined any university falling outside their state of domicile were awarded National Talent Scholarship (NTS) of Rs 1,000 month.

All-India Competitive Examinations for Admissions to PG: For admissions to 25% seats in P.G. programmes at 51 Universities, including award of Junior Research Fellowships, examinations were held on 19 May, 2007. A total of 11,257 candidates appeared in the examination and admissions were granted to 1,552 candidates. Also, 470 Junior Research Fellowships (JRF) were awarded to meritorious candidates.

Merit-cum-Means Scholarship (MCM): This scholarship is granted to students of economically weaker sections of the society to undertake U.G. studies in agriculture and allied science subjects in SAUs, ICAR DUs, CAU and CUs with agricultural faculty. Maximum 7% students from one University are awarded the Scholarship. The amount has been increased from Rs 170/month to Rs 500/month.

Internship Assistance: This assistance is being given to all final year students of B.V.Sc & A.H. programme during their Internship at Rs 400/month besides Rs 400 for undertaking to-and-fro journey to place of internship for 6 months.

Junior Research Fellowships (JRFs): There are in total 475 Fellowships in 19 subject groups (90 subjects). The amount is Rs 5,760/month for non-veterinary and Rs 8,000/month for veterinary students to pursue PG degree programme. Besides, a contingency grant of Rs 6,000/year is payable to all awardees

All-India Competitive Examination for award of Senior Research Fellowship for Ph.D.: ICAR SRF examination was held on 28 October, 2007 at 7 centres in the country. Based on the results, a total of 202 fellowships in 13 major subject groups and 56 sub-subjects have been awarded.

Admission of Foreign Students: During the first-half of the year 2007–2008, 147 students from 17 countries have been granted admissions. Students came from Nepal, Afghanistan, Bhutan, Kenya, Ethiopia, Libya, Guyana, Sri Lanka, Iran, Oman, Mozambique, Egypt, Namibia, Vietnam, Bangladesh, Mauritius and Fiji. Maximum candidates came from Ethiopia (43 nos.).

Summer/Winter Schools and Short Courses: To provide continuing education and training in highly specialized subjects to teaching faculty, 82 Summer and Winter Schools and Short Courses of 10 to 21 day duration were supported for organization at ICAR Institutes and State Agricultural Universities.

Centres of Advanced Studies: The 31 Centres of Advanced Studies (CAS), offer facilities for continuing capacity-building of faculty engaged in teaching at UG and PG levels. Total of 65 training programmes have been approved for 2,000 scientists/faculty.

QUALITY ASSURANCE AND REFORMS

Norms, Course Curricula and Syllabi Revision for UG & PG: The Norms, Standards, Academic Regulations and UG Curricula and Syllabi report submitted by the Fourth Deans' Committee on Agricultural Education in India, has been approved for implementation in all Agricultural Universities. For improving quality and ensuring uniformity, the committee has recommended norms and standards of departments, faculty positions and minimum infrastructure for UG and academic regulations for UG and PG programmes. It has also suggested examination reforms at UG and PG level for improving quality of research work, and restructuring of Under Graduate programmes for increased practical and practice contents. Experiential learning has been recommended in the new curriculum. Several agricultural Universities have already adopted the revised curricula and syllabi. Also, a National Core Group appointed by the ICAR, has initiated the revision of Masters and doctoral course curricula and syllabi.

Accreditation: Fourteen agricultural universities have so far been accredited. During the year, Peer Review Teams (PRTs) constituted by the ICAR for accreditation submitted their reports after visiting four agricultural universities, viz. RAU-

Bikaner, OUAT- Bhubaneshwar, NDRI- Karnal and IARI- New Delhi. Another PRT visited and submitted its reports for extension of accreditation period of four agricultural universities: CCSHAU-Hisar, ANGRAU- Hyderabad, TANUVAS–Chennai and TNAU- Coimbatore.

INDO-US AGRICULTURAL KNOWLEDGE INITIATIVE (AKI)

AKI intends to promote agricultural education, research, service and linkages in the areas of *(i)* Education, learning resources, curriculum development and training; *(ii)* Food processing and use of byproducts and biofuels; *(iii)* Biotechnology, and *(iv)* Water management.

Thirteen Borlaug Fellows were selected from National Agricultural Research System for training, and their host institutions in the USA have been identified. Also, nominations for Cochran Fellowship Programme have been communicated to the USDA and two joint workshops were organized in India. As an outcome of Borlaug Fellow visit, a laboratory model for ethanol production from cellulosic biomass (e.g. paddy straw) is being established at the Central Institute of Post-Harvest Engineering and Technology, Ludhiana. The Fifth Meeting of Indo-US AKI Board was held in Washington DC on June 14-15, 2007 in which the progress was reviewed and joint deliverables were identified.

Collaborative projects in function under the AKI

- Water Harvesting for Groundwater Recharge and Bio-drainage for Salinity Control
- Sustainable Water Resource Management: US-India Collaborative Research and Education
- On Farm Water Management for Rainfed Agriculture on Benchmark Watersheds in Five Diverse Eco-regions of India
- Information and Communications Technologies for Capacity Building in Water Management: US-India Collaborative Extension/Outreach and Distance Education
- Pigeonpea Genomics Initiative
- Capacity Building for Risk Analysis and Modeling to Promote Trade
- Capacity Building for Intellectual Property Protection and Technology Licensing in Agriculture

NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT

Various types of programmes are organized by the Academy.

Various programmes organized by the academy

Type of programme	Programmes (Nos.)	Participants (Nos.)
Foundation Course for Agricultural Research Service (FOCARS)	1	78
Foundation Course for AOs and FAOs	1	21
Refresher Courses/ Summer/Winter Schools (21 days)	13	251
Senior Programmes Workshops	21 9	340 368
Executive Development Programmes	2	36
Off-campus programmes	14	386
International Programmes	1	67
Total	62	1547

Training: Major emphasis during the year was on need-based twenty-one days programmes. Thirteen programmes were organized to cater to career advancement requirement of 251 NARS scientists, in addition to equipping them with knowledge and skills in a wide range of topics. The details are as follows.

The Foundation Course for Agricultural Research Service (FOCARS), which is basic induction training for newly recruited scientists to agricultural research service, with four months duration was organized in three phases. The other programmes conducted by NAARM were:

- Advances in Educational Technology
- Computer-based Multimedia Presentation (Sponsored by NICHE Area of Excellence in Educational Technology (ICAR)
- FDP on Advances in Educational Technology (Sponsored by NICHE Area of Excellence in Educational Technology (ICAR)
- GIS Based Decision Support Systems for Sustainable Agriculture
- Summer School on Advances in Agricultural Research Project Management
- Summer School on Participatory Video Production for Decision and Empowerment
- Summer School on Optimizing Learning Teaching in SAU System
- Summer School on GIS Based Decision Support Systems for Sustainable Agriculture
- Summer School on Advances in Agribusiness and Information Technology
- Winter School on Team Building and Interpersonal Relationship for Agricultural Research Scientists and Teachers
- Information Technology in Agriculture for Effective Decision Support

- The Academy helped the National Biodiversity Authority in developing the guidelines for International Collaborative Research Projects involving transfer or exchange of biological resources. The guidelines, with suitable modifications, were eventually notified. A book on "Regulatory and Operational Mechanisms Related to Agro-biodiversity" has also been brought out that is being used as a resource material.
- A book on "Developing Winning Proposals in Agricultural Research" was published, and is being used as resource material for capacity building of NARS scientists in these areas.
- Application of GRAM GIS in micro-level planning and development for sustainable agriculture has been streamlined.
- Methodological protocol was finalized for assessing the impact of fisheries research in India under the Network Project on Impact Assessment of Fisheries Research in India.
- Issues and implications pertaining to agricultural higher education in India under GATTS have been identified.
- Appropriate strategy for promotion of bio-fuels in Andhra Pradesh has been developed.
- An on-line Delphi process has been developed to seek experts' opinions on issues of topical interest.

- Winter School on Personality Development and Self-Motivation for Enhanced Performance of Agricultural Scientists and Teachers

Research and consultancy: The NAARM is also mandated to undertake research studies on management problems faced by agricultural research and educational institutions in the NARS. These studies are generally of short duration in nature and are meant not only to serve as technical backstopping for different training programmes organized by the Academy but also to provide policy support to NARS in specialized areas of agricultural research and education management. At present, the Academy has 13 on-going research projects, ten of which are institute (NAARM) funded and remaining three are external funded projects. During this period, nine projects were successfully completed.

On competitive grounds, the United Nations Conference on Trade and Development (UNCTAD) has sanctioned a project on "Study on Socio-economic Implications of GI Registration for Agricultural and Non-agricultural Commodities/ Products" to the Academy. Under this project, the geographical indications would be identified in three geographical regions covering twelve states of India.

Policy support: The NAARM is recognized as the focal point for initiating activities under NAIP. A Help Desk has been created at the NAARM for facilitating concept note and proposal writing under the key components of the NAIP.

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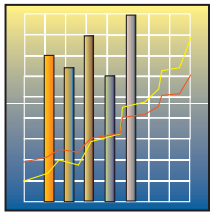


12. Agricultural Economics, Marketing and Statistics

AGRICULTURAL ECONOMICS

Impact of vegetable production on income and employment of small farms

The impact of diversification of agriculture towards vegetables was assessed on farm income and employment using household level information from the western Uttar Pradesh. The results clearly revealed that vegetable production is more profitable and labour-intensive as compared to cereals and it fits well in the small farm production systems. The small farms are relatively more efficient in production and own more family labour in contrast to large farms. Women are also benefited as the vegetable production engages relatively higher women labour in various operations.

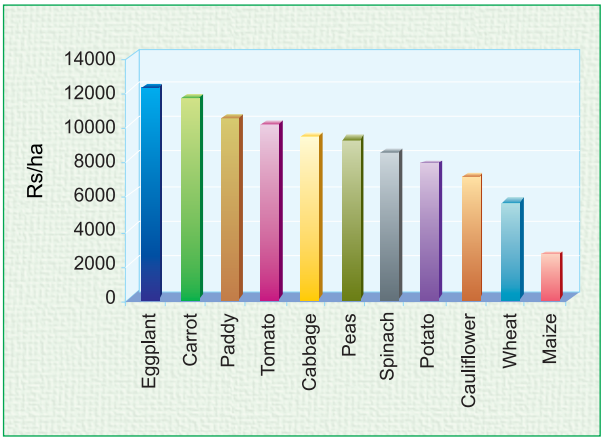
Labour use in vegetable production (man days/ha)

Vegetable production is an important source of income for small farms. It accounts for 66% share in the value of crops output. Among vegetables, potato, cauliflower and tomato contribute 57% to the total farm income. Large farmers also gain much from vegetable cultivation. With nearly 28% of the area under vegetable cultivation, they realize about 46% in terms of value. Potato, cabbage and tomato account for about 66% of the total value of vegetable production in the production portfolio of large farmers.

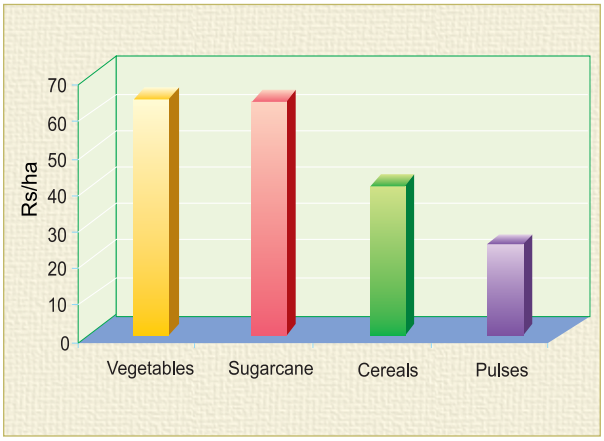
Linking smallholders to markets for high-value crops: Role of farmers' organizations

Institutions such as farmers' cooperatives, producers' associations and contract farming are considered efficient means of linking smallholders to markets. Integration of vegetable producers with village level associations of fruit and vegetable growers has been examined along with costs and profits of the producers.

The impact of association on farmer members was studied through a survey conducted in Haryana. Study revealed that transaction costs are higher in wet markets and the institution-linked sales



Net return from vegetables and cereals production



Labour use in vegetable production (man days)

Production costs, transaction costs and net returns from spinach (base 2002)

(Rs/tonne)

Particulars	Producer members	Independent producers	Per cent difference
Crop yield (tonne/ha)	8.6	8.3	4.0
Cost of production	1,485	1,171	–12.9
Transaction cost	35	437	–92.0
Total cost (production + transaction)	1,520	2,067	–26.5
Output price	3,311	3,074	7.7
Net revenue	1,791	1,007	77.9

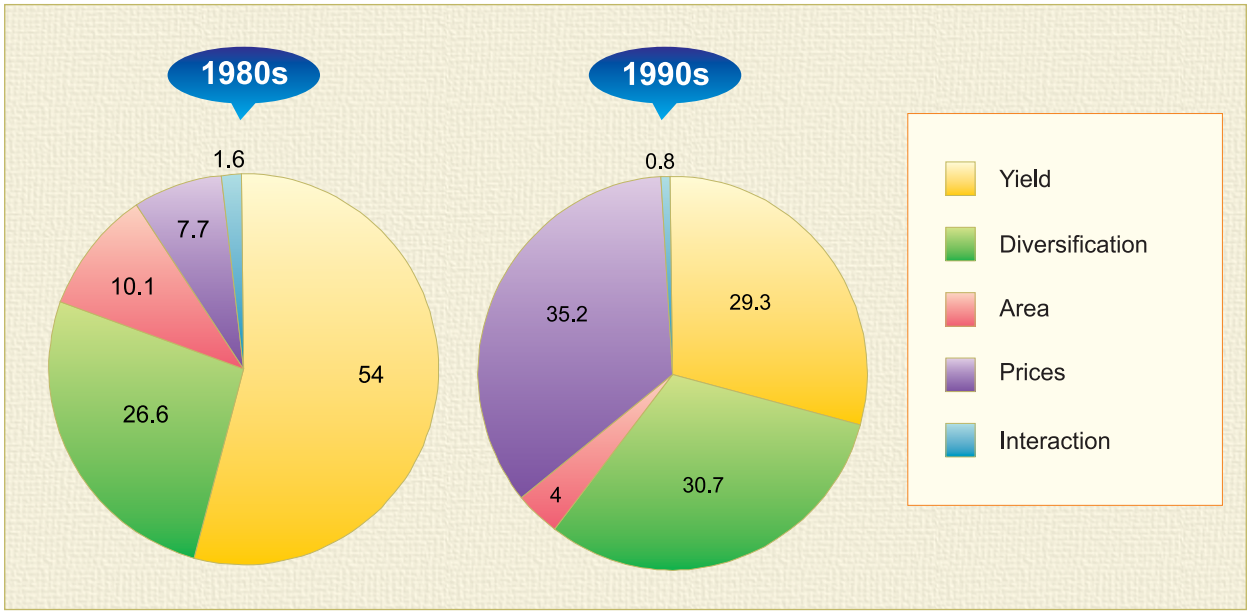
reduce these costs by 92%. The smallholders benefited most from this arrangement despite having low marketed surplus and higher transaction costs. Price realization was also higher in institution-linked sales; this shows producers' collective bargaining power and no extraction of monopsonisic rent in the output market. Post-stratification of sample vegetable producers consist 50% members of small holding size indicating large involvement of smallholders in growers' associations.

Sources of agricultural growth in India

The sources of agricultural growth in India have been decomposed during pre-reform (decade of 1980s) and reform (decade of 1990s) periods. A clear trend has emerged at the national level that during the pre-reform period technology (crop yields as proxy) dominated the different sources of growth, and output prices became the important sources of growth in agriculture during the reform period. Share of agricultural diversification towards fruits and vegetables has consistently increased in agricultural growth during the past two decades, with much faster rate during the reform period. Some important policy implications have emerged from this study.

First, the contribution of technology to future agricultural growth should be viewed seriously. The present agricultural scenario and current stagnated or decelerated growth of major commodities are due to various ailments. It may be recognized that contribution of technology must be stepped-up for sustaining agricultural growth and meeting the global challenges. This would require (i) higher efficiency of investment on agricultural R&D, (ii) matching R&D agenda, keeping in view the ever changing and emerging challenges in different regions, and (iii) strengthening of public-private partnership in research, extension and input-delivery system. Higher allocation of research resources would be necessary for developing technologies to enhance yield potential of all commodities. Additional research resources would also be required to promote agricultural diversification in the non-traditional areas. New high-value crops in non-traditional areas would require greater research on production, marketing and processing to sustain their technical feasibility and economic viability.

Second, the contribution of agricultural diversification to agricultural growth must be viewed as an opportunity in the rainfed areas, which were by-passed during the 'green revolution'



Sources of agricultural growth

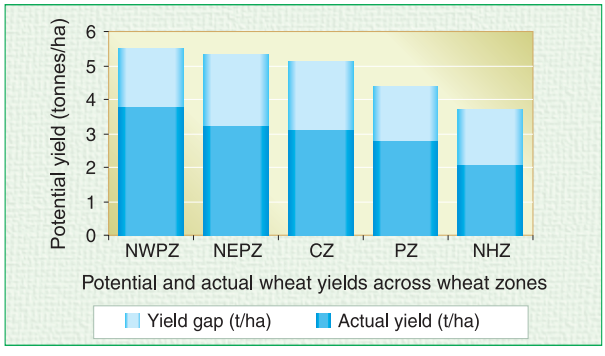
period. Promoting agricultural diversification towards high-value commodities and creating their appropriate markets and processing technologies can be used as effective tools to alleviate poverty and conserve natural resources in the niche areas. It may require investment on development of infrastructure and institutional arrangements, which suit the needs of high-value commodities. The study has suggested that better market integration, effective vertical coordination and value addition would be the pre-requisites for promoting agricultural diversification towards high-value commodities.

Third, output prices have emerged as an important source of agricultural growth in all the regions during the reform period. Price-led agricultural growth may not be sustained unless supported by the government, as has been practised for rice and wheat. During the reform period, prices of rice and wheat were raised to protect the interests of farmers. On the other hand, rising demand for fruits and vegetables led to a rise in their prices. These high prices may not continue in the event of globalization when demand-induced cheaper import would suppress their prices. The other problem with the price-led growth is that it would benefit only those farmers, who have sufficient marketable surpluses. The smallholders, who have tiny marketable surplus, will be deprived of the benefits of rising prices. Such a phenomenon may lead to growth with wider inequality.

Fourth, area expansion may not continue as a future source of growth in the land-scarce regions. The growth in such regions will come from agricultural diversification towards more remunerative commodities and technological breakthroughs. It is, therefore, important that these growth sources are targeted for sustainable and equitable growth in agriculture.

Wheat production in India: Opportunities and challenges

Wheat is the staple food crop accounting for about 40 % of total cereals production in India. Its production is constrained by a number of problems, and a huge yield loss of 30 % is estimated at all India level. The loss in yield occurs due to a number of abiotic, biotic and socio-economic constraints. If these could be minimized, the actual production and yield levels can be increased considerably.



A study conducted across major wheat zones during 2004, has revealed nearly 2 tonnes/ha of yield gap between the actual yields on farmers' field and frontline demonstration yield. It varies across different wheat zones. The yield difference is high (2 tonnes/ha) in the north-eastern plains zone (covering wheat areas of eastern parts of Uttar Pradesh, Bihar, Orissa, and West Bengal), and central zone (covering areas of Madhya Pradesh and Gujarat). There is also a considerable scope to increase wheat yield and bridge the yield gap of 1.7 tonnes/ha in north western plain zone covering states of Punjab, Haryana, Rajasthan and western parts of Uttar Pradesh, despite high yield levels.

AGRICULTURAL STATISTICS AND COMPUTER APPLICATION

National information system on agricultural education network in India (NISAGENET)

NISAGENET has been developed and implemented on the recommendations of National Statistics Commission (NSC) for providing information for policy and planning of agricultural education in the country. The project is being executed by the Indian Agricultural Statistics Research Institute (IASRI), New Delhi, as the Lead Center having collaboration with 42 participating organizations that includes SAUs - 34, ICAR Deemed Universities - 4, AAIDU - 1, Central Universities – 2 (AMU and BHU) and the Central Agricultural University, Imphal.

The Central Server Application Software website has been implemented on internet at the web address http://www.iasri.res.in/NISAGENET having the facilities like:

- Agrikhoj – a Search Engine for agricultural education
- Directory – Classified information from NISAGENET
- Discussion Forum – for sharing information
- Reports/Queries – Dynamic Reports for user's
- Reports/Queries on other public funded and/or private aided and unaided colleges affiliated to central and other universities are also available on the web site.

The network architecture of the system ensures that NISAGENET acts as an independent information system at the organization level and would be useful for the agricultural education data management of the university and its affiliated/constituent colleges as well as from the Central Server at the IASRI. It will act as a decision

support system and would be quite useful to academicians, planners, policy makers, scientists and technologists, and the students pursuing higher education in agriculture.

Expert system on wheat crop management

Expert system on wheat crop management is a Web-based system developed at the IASRI in collaboration with the DWR, Karnal, and IARI, New Delhi.

The system provides the users with recommendations and advice concerning wheat production. This system is subdivided into four modules: Variety selection, Plant protection, Cultural practices and Harvesting technology and one module for knowledge management. Variety selection module specifies the variety from the farmer's point of view. Plant protection module is subdivided into pathological aspects, entomological aspects and weed management. In pathology, the system identifies micro diseases such as leaf rusts, blights and bunts etc. In entomology, the system identifies pest/insects affecting plants and recommends control measures. The cultural practices module specifies the process of cultivation of the crop. The harvesting technology module helps in advising the right method, right machinery and right time for the harvest.

A user can interact directly with any module as per his requirements. These modules extend information to the user through his queries or through a click of the button. The developed system can be utilized in making similar systems on other crops. It may be used as an effective tool for agricultural research and planning.

Design resources server

A design resource server (www.iasri.res.in/design/) was created to popularize the research in design of experiments and analysis of data among the stakeholders, experimenters and research statisticians. This server is strengthened and uploaded regularly.

- Square lattice designs are resolvable block designs and are quite useful for agricultural field experiments. For the benefit of the experimenters an online software for generation of square lattice design with 3 replications has been prepared and uploaded on Design Resources Server.
- Supersaturated designs are fractional factorial designs. Definition of supersaturated designs, experimental situations in which supersaturated designs are useful, efficiency criteria for evaluation of supersaturated designs, catalogue of supersaturated designs for asymmetrical factorial experiments and bibliography on supersaturated designs has been uploaded on Design Resources Server. The complete details of the design can be obtained by clicking on the design parameters in the catalogue.
- Designs for biological assays help in the estimation of the *relative potency* of the *test preparation* with respect to *standard* one. Material on contrasts of interest in parallel line assays and slope ratio assays has been uploaded on Design Resources Server.
- Hadamard matrices have a tremendous potential for application in many fields particularly in generating fractional factorial designs. An online software has been developed. The software also describes the method by which a Hadamard matrix is generated.
- A B-version of the software for generation of efficient nested block designs is prepared.

Web page developed

Lattice designs: This web page contains list of Lattice designs along with the layout for easy accessibility of the experimenters.

Circular designs: This web page generates layout plan of circular designs that form an important class of incomplete block designs and is available for all number of treatments with smaller number of replications. The randomized layout of these designs can also be generated. These designs offer more flexibility in terms of their availability for any block size.

The Agricultural Research Data Book 2007

This is eleventh in the series, and is an attempt to put together main components/indicators of such

Outlier in designed experiments

A dissemination Workshop was held on 26 July 2007. Some salient achievements of the project are:

- A test statistics for detecting the multiple outliers in the presence of masking was developed.
- Some M-estimation procedures are appropriately modified for application in designed experiments. A new objective function is also developed.
- Least Median of Squares (LMS) has been modified for application into the designed experiments.
- A robustness criterion for identifying robust design that is robust against the presence of two outliers is developed. It was found that binary variance balanced designs are robust against the presence of two outliers.
- Software for analyzing experimental data in the presence of outliers is developed.

information. The Data Book comprising 261 tables, is organized into 11 sections.

Developing remote sensing based methodology for collection of agricultural statistics in Meghalaya

The project entitled "Developing Remote Sensing Based Methodology for Collecting Agricultural Statistics in Meghalaya" was initiated in 2003 in collaboration with Space Application Centre (SAC), Ahmedabad and North East Space Application Centre (NE-SAC), Shillong. Its main objective was to develop a suitable methodology for generation of crop statistics through integration of remote sensing digital data and field survey. The study was initially carried out in Ri-Bhoi district for estimation of area under paddy crop. To validate this methodology, it was repeated in the next year in two districts of Ri-Bhoi and Jantia Hills. Methodology was also found to be flexible to take care of the problems of North Eastern region i.e. non-availability of land record system, non-accessibility of vast area, undulating topography, hilly terrain, etc. Accordingly, SAC has decided to implement this methodology for estimation of area under paddy crop in the entire state. Meanwhile, attempt was also made to develop suitable methodology for estimation of area under potato, ginger, pineapple, banana and maize in East Khasi Hills and West Garo Hills. Suitable integrated sampling designs were adopted to collect the data for above crops through field survey. The data related to production statistics, consumption pattern, disposal and seed rate from the selected farmers from the Ri-Bhoi, East Garo Hills were collected through scientifically designed survey schedules. This methodology needs to be further validated for extending it to other crops and in the entire state, which is the future course of action under this project.

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13. Information, Communication and Publicity Services

Mission has been set to market, showcase and popularize agricultural technology developed by National Agricultural Research System (NARS) through Information, Communication Technologies and Publicity Services. The functioning of the Directorate of Information and Publications of Agriculture (DIPA) has been streamlined by appointing Project Director (DIPA) with additional charge of ADG (ARIS). This has added the strength in the Directorate, and major gap in the implementation of Mandate of Directorate has been streamlined. The ARIS Unit, Library, Media and Information Unit, Press and Publicity services were integrated as knowledge center for optimum utilization of resources for efficient, responsive and value added products of information under single umbrella. The Directorate is a Media-window of the ICAR (Hq). In DARE/ICAR Annual Report thematic concept has been introduced as a quality improvement programme on the basis of recommendations of the committee. Open access of General Provident Fund subscription has been introduced by the Finance Division and DIPA.

DIPA plays a significant role in dissemination of agricultural research information. The user community largely comprise scientists, extension workers, progressive farmers, nurserymen, entrepreneurs, students etc. Information remains the first purpose of the media, DIPA believes in public service rather than a bureaucratic office, its purpose is to gather, print; and provide electronic information; and make global visibility through electronic media and web-based services.

The Directorate has submitted 1 project on 'Enhanced Communication and Public Awareness—Development of on-line Electronic publishing system with on-line hosting of ICAR publications and integrated e-commerce, e-marketing and DIPA portal'. Scrolling news on ICAR web page has been launched on 16 July 2007 in which English Editorial, and Press and Publicity act as a content inventory units. Above 5,000 visitors per month from across the world are using the service. ICAR web page has been reorganized and process is on to rewrite the ICAR web page for making better delivery on technology through electronic media. The DIPA officers (10) were provided opportunity to participate in National thematic event for capacity building.

COMMUNICATION RESOURCES

Editorial Committees of journals and periodicals have been reconstituted as new dimensions. Editorial Units (English and Hindi) play a pivotal role in DIPA and have co-ordination with all units. They brought out internationally reputed research journals, viz. *Indian Journal of Agricultural Sciences* and *Indian Journal of Animal Sciences* (English, monthly): the semi-technical periodicals, viz. *Indian Farming* (English, monthly) and *Kheti* (Hindi, monthly), and *Indian Horticulture* (English, bimonthly) and *Phal-phool* (Hindi, bimonthly), *Krishi Chayanika* (Hindi, quarterly), *ICAR Reporter* and *ICAR News* (English, quarterly) on time. The value addition was made by covering the primary information / news in the *ICAR Reporter*. The *ICAR Reporter* (an in-house journal and brand product of DIPA, ICAR) was improved by adding volume of news /reports etc, digital photos, and quality of paper. As a policy decision inclusion of 2-4 pages of Hindi news for farmers belonging to Hindi speaking states will upgrade the standard of the *ICAR Reporter,* as well as *ARIS News* is to be merged with the *ICAR News*.

During the reported period DIPA brought out 40 titles in English and 15 in Hindi. In English 10 proposals pertaining to WTO/GATT books, 40 Agri-pop series, 8 general books are in process. Besides this Unit has also brought out time-bound

Dr Mangala Rai, Secretary (DARE) and DG (ICAR) inaugurated scrolling news on ICAR web page on 16 July 2007

urgent publications, viz. *DARE/ICAR Annual Report 2007-08, ICAR –At a Glance, State-Specific Technological Interventions for Enhanced Growth* etc. All honoraria payment to contributors have been updated.

The Production unit has produced Council's publications maintaining high standard of production quality by using computerized print control (CPC) and Computer to Plate (CtP) technologies. The unit has conceptualized and designed new layout for magazines and books. The production unit has provided technical support to the other divisions of ICAR Hqrs., ICAR Institutes and State Agricultural Universities for production of publications and for framing technical and financial bid tender document for printing. Art Unit is well reflected in form of attractive and elegantly designed publications/ publicity materials which include special posters brought out on various occasions, viz. *Hindi Chetna Mas*, Vigilance Awareness Week, etc. Designed logos for ICAR and its Institutes. Cover designs pertaining to books, magazines, reports have been developed on thematic mode. Photo unit has adopted digitizing database and covered all important conferences of the ICAR (Hq) in Delhi as well as out side Delhi and provided photographs of visiting dignitaries for the *ICAR Reporter*, press releases etc. Business Unit of Directorate has fetched more than Rs 4 million (by the end of 2007) through sale of the journals, periodicals, books, e-books (CD) and advertisement procurements. The participation of this Unit in book exhibitions (11) has educated ICAR readers and our farmers, and to those interested in our books. Advertisements of new information products have been regularly done through leading newspapers. Thematic information display- and sale-stalls have been put in Chennai, Hyderabad, Nagpur, New Delhi, Pondicherry, Udaipur, for dissemination of knowledge and publicity.

Agricultural Research Information Centre has compiled *ICAR Telephone Directory 2008* and it was also published simultaneously on the ICAR web site (*www.icar.org.in*). This Unit is maintaining the Local Area Network (LAN) of Krishi Anusandhan Bhavan-I/II and providing support/ trouble-shooting services to the internet/e-mail users of these two buildings. A survey of ICAR-ERNET Connectivity in ICAR set up was conducted. A database on ARIS Nodal Officers was developed by ARIC services in National Agricultural Research System. A committee was also approved to improve the funding of Agricultural Research Information Centre and report is being submitted for implementation. Database management services have been accelerated.

INFORMATION TECHNOLOGY

The web services include updation of ICAR web site in respect of latest achievements and developments in National Agricultural Research System, weather advisories, online scrolling news, hosting publications with free text search facilities for books, journals, and *ad hoc* schemes. All the issues of the *ICAR News*, *ICAR Reporter* since 2000 onwards, annual report and various directories are available in PDF format. This Directorate also coordinated internet connectivity at ICAR (Hq) as well as at ICAR Institutes/Centres through liaisoning with different ISPs, including NIC, ERNET, MTNL, SIFY etc. Since September, 2007 there have been 15,856 visitors on 38,193pages world-wide. *ARIS News* (English, half-yearly) was brought out on time.

PUBLICITY SERVICES

Publicity material for important National events, organized by ICAR (Hq), has been designed and documents were published by the Directorate. Policy decisions have been taken for providing ICAR video-films to various means and utilization of scientific knowledge by media. Benchmark has also been developed for utilization of agriculture and technological resources by any private firm and ICAR web page. Miscellaneous services on development, publicity have been extended to all the divisions of ICAR (Hq). *Vichar Manch* and cultural programmes, organized by ICAR (Hq), have been provided wider publicity.

Certain measures have been taken for reviewers of article by the development of database of reviewers for two research journals and three magazines. Interview and features have been added for reader/audience. Interactive meetings have been organized at Bangalore, Delhi, Hyderabad, Kolkata, Lucknow, Ludhiana, Nagpur, Udaipur, and more

than 35 ICAR Institutes have been directly approached to streamline the activities of Information Services. Advisory Committee for Information, publication and publicity have been constituted under the chairmanship of Director-General, ICAR for the improvement of communication services in National Agricultural Research System.

ERNET has been entrusted to establish IP Video Conferencing and IP Telephony facility at 23 selected ICAR Institutes connected on ICAR-ERNET network.

The facility is being managed and monitored centrally from National Agricultural Science Centre (NASC), New Delhi.

The National Agricultural Sciences Museum was visited by more than 10,000 farmers, general public, scientists and various delegations from the country and abroad.

On average 1,000 publications and bound journals were added to the ICAR (Hq) library every year. Besides the ICAR staff, several outside readers used the library services. The library also extended information support for consulting database of the Centre for Agricultural and Biosciences International. The document delivery service was also extended to individuals and libraries against specific requests for supply of documents for the AGRIS database. DELNET services have also been provided to readers as reference service. Library services are being reorganized in electronic mode at Krishi Bhavan and Krishi Anusandhan Bhavan I for the development of state-of-art facility.

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14. Technology Assessment, Refinement and Transfer

The Council has created a vast network of Krishi Vigyan Kendras (KVK) aiming at assessment, refinement and demonstration of technology/ product. At present, there are 558 Krishi Vigyan Kendras (KVK) which include 376 under Agricultural Universities, 40 under ICAR Institutes, 90 under NGOs, 33 under State Governments and the remaining 19 under various other organizations.

KRISHI VIGYAN KENDRAS

Technology assessment

During the year, 893 technologies were taken up for assessment related to cereal, oilseed, pulse, commercial, vegetable, fruit, flower, plantation, tuber crops including varietal evaluation (193), nutrient management (200), cropping system (106), resource conservation (25), small-scale income generation enterprise (39), value-addition (15), integrated farming system (17), seed and plant production (16), weed management (33), insect/ disease management (217), drudgery reduction (7), storage technique (4) and farm implement and tool (21).

Similarly, 122 technologies related to animal enterprises (cattle, poultry, piggery and goatery) and fishery were taken up for assessment in thematic areas of disease management (19), evaluation of breeds (15), feed and fodder management (22), nutrition (37) and production practices (29).

Technology refinement

A total of 143 technologies related to cereal, oilseed, pulse, commercial, vegetable, fruit, flower, plantation and tuber crops were taken up for refinement including nutrient management (71), pest management (34), disease management (31) and weed management (7); besides technologies related to cropping system/farming system (26), resource-conservation technology (7) and drudgery reduction (3).

As far as livestock (cattle, poultry, piggery, goatery) and fishery is concerned, 22 technologies were taken up for refinement including disease management (4), evaluation of breeds/strains (2), feed and fodder management (6), nutrition (2) and production practices (8).

Frontline demonstration

Frontline demonstrations were conducted to demonstrate the production potential of newly released technologies on the farmers' fields in a given farming system, and organize training and extension activities for farmers and the extension workers for dissemination of technologies. A total of 71,640 frontline demonstrations were organized including oilseeds (18,306), pulses (13,042), cotton (6,206) and other important crops (31,248), covering an area of 25,000 ha. Besides, 2,838 demonstrations on various enterprises were also conducted.

Demonstrations on hybrids

Out of 71,640 demonstrations, 2,473 were conducted on hybrids of different crops including cereals, oilseeds, cotton, vegetables and fodder.

The hybrids of different crops showing maximum increase in their yields in demonstration plots over their local checks are:Hy 93330 pearlmillet (80.43%), COSS sorghum (26.87 %), COH (M) 5 maize (105.15 %), RH 10 rice (105.95%), TMVCH 1 castor (94.13%), HNG 10 groundnut (15.79%), Mahyco mustard (47.06%), DSH 129 (19.46%), TCSH 2 sesame (21.80%), MFSH 8 sunflower (62.67%), AAH cotton (27.48%),NDBGH bottel gourd (21.88%), Pooja brinjal (179.38%), Megha cauliflower (16.67%), Sonali tomato (143.88%), Malini cucumber (135.88), Hy 2/16 cashew (195.38%) and Taiwan papaya (42.86%).

Oilseeds: During the year, 18,306 demonstrations were conducted covering 6,283.98 ha on different oilseed crops including castor, groundnut, niger, sesame, soybean, sunflower, linseed, mustard, safflower and toria. The increase in yield varied from 28.2% in groundnut to 77.9% in niger and on an average, oilseed crops under demonstration gave 34.8% more yield than farmers' practice.

Pulses: A total of 13,042 demonstrations were conducted, covering 4,285.79 ha on various pulse crops including blackgram, greengram, Frenchbean, *rajmash*, mothbean, pigeonpea, gram, lentil and pea. The percentage increase in yield varied from 5.4 in lentil to 89.1 in Frenchbean and on an average, pulse crops under demonstration gave 37.6% more yield than farmers' practice.

Frontline demonstration on foliar spray in greengram

Cotton: The frontline demonstrations on production technology of cotton were conducted in nine major cotton-growing states, viz. Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and Tamil Nadu, besides West Bengal. The number of districts covered were 7, 5, 5, 15, 5, 15, 5, 3, 9 and 2 and villages were 12, 17, 53, 17, 8, 25, 39, 27, 13 and 3, respectively, in these states.

The demonstrations were given on production technology, integrated pest management and farm implements. There were 6,206 demonstrations covering an area of 4,281.3 ha. In production technology, 2,495 farmers were benefited directly covering an area of 1,012.3 ha. The demonstrations on integrated pest management were also conducted, including 1,261 farmers, covering an

Demonstrations on production technology in cotton

State	No. of farmers	Area (ha)	Demo yield (q/ha)	Local yield (q/ha)	Increase (%)	Demo cost (Rs/ha)	Local cost (Rs/ha)	Demo benefit:cost ratio
Andhra Pradesh	321	142.4	23.40	18.74	24.87	14,990	15,582	2.99
Gujarat	180	72.0	23.35	23.12	1.01	11,516	11,351	4.43
Haryana	190	76.0	20.38	17.49	16.51	10,325	9,607	3.78
Karnataka	457	176.8	15.04	12.32	22.00	12,047	12,100	3.06
Madhya Pradesh	180	72.0	17.59	12.24	43.64	11,786	10,592	3.43
Maharashtra	512	204.8	17.86	13.69	30.46	13,373	11,274	2.67
Punjab	147	68.8	23.66	25.15	–5.92	15,505	15,875	3.09
Rajasthan	120	48.0	20.90	17.64	18.46	12,755	11,689	2.95
Tamil Nadu	320	128.5	18.26	11.59	57.55	12,411	11,458	3.64
West Bengal	68	23.0	11.20	10.07	11.23	8,738	8,981	2.31
Total/average	2,495	1,012.3	19.14	15.63	22.46	12,345	11,850	3.24

Performance of Bt hybrids, *desi* hybrids, non-Bt hybrids and other varieties in frontline demonstrations on cotton

Type of hybrid/ variety	No. of farmers	Area (ha)	Demo yield (q/ha)	Local yield (q/ha)	Increase (%)	Demo cost (Rs/ha)	Local cost (Rs/ha)	Demo benefit:cost ratio
Bt hybrids	1,500	602.4	22.69	18.72	21.22	11,873	11,596	3.51
Desi hybrids (A×A)	60	24.0	20.29	16.64	21.97	9,692	9,322	3.78
H×B hybrids	152	68.0	13.50	10.43	29.53	9,791	10,236	3.02
H×H hybrids	155	62.0	13.21	10.98	20.31	13,140	12,284	2.13
herbacium varieties	75	30.0	5.91	4.65	27.24	8,069	6,903	1.66
hirsutum varieties	409	153.9	13.76	10.84	26.90	8,210	7,705	2.56
arboreum varieties	144	72.0	14.25	11.05	29.02	8,858	8,616	2.92
Total/average	2,495	10,12.3	19.14	15.63	22.46	12345	11,850	3.24

area of 925 ha, in 19 blocks spread over 6 states, majority of which were in Maharashtra and Karnataka. As far as the demonstrations on farm implements are concerned, 2,450 farmers were included, covering an area of 2,344 ha.

Production technology: Average seed-cotton yield in the demonstration plots varied from 11.20 q/ha to 23.66 q/ha, with the cost of production from Rs 8,738/ha to Rs 15,505/ha. Due to variation in cost of production, yield and market price, the benefit : cost ratio also varied from 2.31 to 4.43. There was negligible increase (1%) in yield in demonstration plots in Gujarat and negative increase (–5.92%) in Punjab because the local checks RCH 2 Bt and RCH 134 Bt hybrids, respectively, outyielded new hybrids (MRC 6301 and MRC 6304 in Punjab) and Vikram 5 in Gujarat.

Performance of hybrid: A number of demonstrations were conducted on Bt hybrids by involving 1,500 farmers. In hybrids other than Bt, demonstrations on H×H hybrids and H×B hybrids were conducted in 152 and 155 locations. The *desi* hybrids performed better than other non-Bt hybrids. Among varieties, *hirsutum* and *arboreum* varieties performed very well next to Bt and *desi* hybrids.

Integrated pest management: The IPM demonstrations were conducted in Amaravati, Jalna and Sriganganagar districts with 2 block demonstrations each (50 ha per block) and in other districts in one block each of 50 ha. In Vadodara district of Gujarat 91 demonstrations were conducted on IPM and the entire production was used for seed purpose. The maximum yield of 26.5 q/ha was reported from Dhule district of Maharashtra.

Demonstrations on IPM technology in cotton

State	District	No. of farmers	Seed-cotton yield (q/ha)		
			IPM	Non-IPM	Increase (%)
Andhra Pradesh	Karimnagar	50	17.40	16.00	8.75
Gujarat	Vadodara	91	10.10	8.38	20.53
Haryana	Sirsa	25	23.50	20.50	14.63
Karnataka	Mysore	125	13.72	11.54	18.89
	Bellary	50	24.90	21.60	15.28
	Raichur	50	24.80	19.58	26.66
	Chitra-durga	69	14.10	10.66	32.27
	Belgaum	149	22.16	20.40	8.63
Maharashtra	Dhule	50	26.50	22.80	16.23
	Buldana	70	16.37	13.05	25.44
	Akola	64	13.12	9.25	41.84
	Amaravati	81	11.75	8.85	32.77
	Nanded	125	24.95	14.45	72.66
	Jalna	132	26.14	20.90	25.07
	Nandurbar	30	13.56	11.50	17.91
Rajasthan	Sriganga-nagar	100	17.50	15.50	12.90
Total/average		1,261	18.79	15.31	22.73

Production of seed/planting material

During the year, the KVKs produced 111,164 q seeds of value Rs 84,852,506 including cereals, oilseeds, pulses, commercial crops, vegetables, flower crops, spices, fodder crops, fibre crops, forest species and others. In addition, production of planting material included, 91.29 lakh saplings/seedlings of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species amounting to Rs 28,962,204, besides 8.94 lakh kg bio-products of value Rs 6,583,128, and 40.08 lakh fingerlings and other livestock/poultry strains were produced for availability to the farmers.

Farm implements: Demonstrations on farm implements were spread over 2,344 ha area in which 2,450 farmers participated. In addition, 36.2 q seeds were delinted by using improved delinting machine. Rotavator, harrows and cotton stalk uprooter were demonstrated in 890 ha area, sprayers in 787 ha, weeders in 449 ha, and planters/seed drills in 218 ha.

Direct sowing is being demonstrated using paddy drum seeder

In order to create awareness on improved practices, a number of extension programmes (consultancy, conventions, demonstrations, diagnostic surveys, exhibition, farmer study tours, farmers field school, field-days, field visits, *gram sabha*, group discussions, *kisan gosthi*, *kisan mela*, training for extension functionaries, training for farmers, video show, newspaper coverage, popular articles, publication, radio talks, TV programmes) were organized with the participation of 68,645 farmers.

Other crops: During the year, 31,248 demonstrations were conducted covering 10,149 ha on different cereals, horticultural and other commercial crops, besides 2,838 demonstrations on different enterprises like dairy, piggery, poultry, rabbitary, sheep and goat, mushroom, sericulture and vermicompost.

Training programme

During the year, 43,285 training programmes were organized with the participation of 1,174,136 farmers including rural youth, and in-service extension personnel.

Farmers' training: A total of 33,589 training programmes were organized for the benefit of 9.42 lakh farmers and farmwomen on various technologies. Total number of beneficiaries including male and female in different programmes were 210,382 in productivity enhancement of crops; 64,697 in commercial production of vegetables; 57,997 in orchard management; 34,034 in production and value-addition of ornamental, plantation, tuber, spice crops and medicinal and aromatic plants; 12,483 in agro-forestry plants; 137,801 in plant protection; 74,662 in soil health and fertility management; 101,163 in livestock production and management; 50,226 in household nutritional security; 62,963 in economic empowerment of women; 6,795 in drudgery reduction of women; 6,761 in methods of protective cultivation; 200,19 in farm machinery, tools and implements; 7,966 in processing and value-addition; 17,371 in fisheries; 41,287 in production of inputs at site; and 34,942 in capacity building and group dynamics.

Women farmers are being trained for using *bhendi* plucker

Training for rural youth: As many as 6,323 skill-oriented training programmes were organized for 1.52 lakh rural youth. The beneficiaries (male and female) in different areas were 15,119 in productivity enhancement of crops; 3,197 in orchard management; 9,190 in fruit plants; 22,290 in livestock production and management; 13,233 in economic empowerment of women; 3,209 in methods of protective cultivation; 5,354 in farm machinery, tools and implements; 18,480 in processing and value-addition; 3,638 in fisheries; 33,402 in production of inputs at site; and 25,019 in capacity building and group dynamics.

On-campus training for rural youth for raising nursery

Training programmes for extension personnel: A total of 3,373 training programmes were conducted benefiting 80,416 participants. These training programmes were organized for extension

Training programmes for extension personnel

Thematic area	No. of courses	No. of participants		
		Male	Female	Total
Productivity enhancement of crops	1,391	29,207	5,303	34,510
Plant protection	525	10,890	1,139	12,029
Soil health and fertility management	263	5,775	574	6,349
Livestock production and management	293	5,443	1,403	6,846
Farm machinery, tools and implements	78	1,342	123	1,465
Economic empowerment of women	217	2,373	1,816	4,189
Capacity building and group dynamics	275	5,690	868	6,558
Household nutrition security	331	1,427	7,043	8,470
Total	3,373	62,147	18,269	80,416

Diagnostic support

A total of 111,303 samples including 94,647 samples of soil, 15,916 samples of water, 721 samples of plant material and 19 samples of manure were analyzed, generating a revenue of Rs 53.73 lakh, benefiting 96,207 farmers from 14,971 villages during the reporting period.

Extension activities

Activities	No. of programmes	Beneficiaries
Advisory services	75,393	139,188
Diagnostic visits	16,727	63,849
Field-days	3,038	168,201
Group discussions	12,712	353,027
Kisan ghosthi	2,731	164,907
Film show	4,609	151,540
Self-help groups	1,860	28,648
Kisan mela	835	1,477,838
Exhibition	1,277	1,539,773
Scientists' visit to farmers field	18,1175	491,606
Plant/animal health camps	6,838	36,045
Farm science clubs	797	41,414
Ex-trainees *sammelan*	842	10,855
Farmers' seminar/workshop	1,143	90,833
Method demonstrations	5,171	96,036
Celebration of important days	275	20,747
Special day celebration	877	55,872
Exposure visits	2,025	32,923
Total	318,325	4,963,302

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): Out of a total 43,285 training programmes (11.74 lakh participants) conducted by the KVKs for the farmers and farm women, rural youth, and in-service extension personnel; 5,265 training programmes were conducted on sponsorship by various organizations covering 1.52 lakh participants. The participants were from various government and non-governmental organizations associated directly or indirectly with the development of agriculture. The training was imparted to upgrade their knowledge and skills including productivity enhancement of crops; commercial production of vegetables; production and value-addition of fruit plants, ornamental plants and spices crops; soil health and fertility management; processing and value-addition; methods of protective cultivation; production of inputs at site; farm machinery; tools and implements; livestock production and management; fisheries; household nutritional security; economic empowerment of women; drudgery reduction of women; and capacity building and group dynamics.

Training programmes (vocational): Out of 6,323 training programmes conducted for rural youth, 1,886 programmes were specifically conducted for 44,847 persons, on various vocations including agricultural para-workers and para-veterinary training; capacity building and group dynamics; commercial floriculture; commercial fruit production; commercial vegetable production; composite fish culture; dairy farming; income generation activities; integrated crop management; mushroom cultivation; nursery; grafting etc.; organic farming; piggery; poultry farming; production of bio-agents; bio-pesticides; bio-fertilizers etc.; repair and maintenance of farm machinery and implements; rural crafts; seed production; sericulture; sheep and goat rearing; value-addition; vermi-composting; and tailoring; stitching; embroidery; dyeing etc.

Extension activities

The KVK organized 318,325 extension programmes, benefiting 49.63 lakh farmers and others to create awareness about improved agricultural technologies. The activities include field-days, *kisan mela*, *kisan gosthi*, exhibitions, ex-trainees *sammelan*, advisory services, film shows, diagnostic services, organizing farm science club, and formation of self-help groups (SHG).

In addition 13,074 newspaper coverages, publication of 2,685 extension literatures, 5,037 radio and TV talks etc., were taken up by the KVK.

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15. Gender Issues for Technological Empowerment of Women in Agriculture

The Mandate of the National Research Centre for Women in Agriculture is—to identify gender issues and test appropriateness of available farm-technologies/programmes/policies with women perspective for promoting gender mainstreaming in research and extension for empowerment of farmwomen and capacity building of scientists, planners and policy makers to respond to the needs of the farm women. Accordingly the research projects on broad areas of testing of technologies, gender mainstreaming and capacity building activities were taken up.

Testing of technology with women perspective

As women participation in rice and groundnut production is higher, and the drudgery is involved in weeding, studies were conducted to **identify the ecofriendly weed management practices of these crops**. Rice variety Khandagiri and groundnut variety TMV 2 recorded the highest yield under weedy check implying that these varieties had highest tolerance to the weed infestation. Lowest weed dry weight was recorded in rice variety Nilgiri and groundnut variety TG 3 indicating that these varieties had weed smothering character.

Rice and groundnut under the impact of *Perotis indica* weed recorded the lowest yields and weed population beyond 125 plants/m^2 was the critical limit for reducing grain yield of both rice and groundnut in *kharif* season. Spacing geometry also reduced the weed infestation and lowest weed population was recorded with a combination of 160 cm^2/plant area and 3: 1 row to plant spacing ratio. The findings could help in reducing the workload of farmwomen to a great extent.

Grand Naine variety of banana, and Farm Selection and Pusa Dwarf of Papaya could be grown in homestead gardens for **nutritional security** and **income generation**.

Invigoration or traditional pre-sowing methods practised by farmwomen in different crops were documented under the project **Refinement of invigoration techniques as suitable to farmwomen for enhancing planting value of finger millet (*Eluesine coracana*) seeds**. Farm-saved seed samples of ragi (*Eluesine coracana*) were collected. Germination was less in 6-month-old farm saved seeds than the minimum seed certification standards. The seeds were having normal vigour (vigour index 21%). The seed treated with NaCl (5%) and urea (1%) enhanced the planting value of ragi seeds.

Trials with zero energy cool chamber (ZECC) for post harvest storage of vegetables—It was found suitable for rural women for storage of fresh farm produce like vegetables and fruits for 7–10 days without any loss of quality. As the relative humidity in the chamber remained more than 80% the fresh produce did not show any shrinkage. The temperature variation between ZECC and open fields during summer was 14–16°C. During rainy season the chamber was not effective as the outside temperature and humidity was equal to ZECC.

Ergonomical evaluation of manually operated OUAT ESA pedal operated paddy thresher with farm women revealed that the throughout capacity of the equipment was 79 kg crop/hr and the paddy grain output was 24 kg/hr. The speed of operation

A farm woman operating OUATESA pedal operated paddy thresher—higher work pulse suggests rest pauses for worker

was 77 pedal strokes/min. The force required in pedal operation was 162 N. The working heart rate of farm women was 136 beats/min and the work pulse value was 53 beats/min. Higher work pulse value suggests that adequate rest pauses need to be given to the worker for day long work. Two workers may be engaged with the equipment and they can operate the equipment in shift continuously.

Similarly, **ergonomical evaluation of manually operated CRRI rice winnower** revealed that the output with this equipment was 242 kg clean grain/hr. The winnower was operated by hand cranking at a speed of 65 rpm and the torque required was 5.3 Nm. The working heart rate of farm women was 112 beats/min. The work pulse value was 31 beats/min, which was under acceptable limit (resting heart rate plus 40 beats/min) for daylong work with standard rest pauses. Two workers are required for the operation i.e. one for cranking and another for feeding the material, collection of grain etc.

Farm women working on CRRI rice winnower—work pulse value was under acceptable limit

Gender mainstreaming

Gender disaggregated data on participation in household chores and other productive activities revealed that the woman contributed on an average 7.2 hr/day, whereas man contributed 1.6 hr/day to household activities. Apart from cultural factors structure and size of the household also influenced their contribution. The burden of household activities falls heavily either on married young and middle-aged women or on unmarried young girls. Number of women in a family is also a determinant of the actual work burden on a woman.

For assessing the access of women to information, training and extension services in two situations namely irrigated and rainfed in Orissa and **to test an alternate gender sensitive extension model** a benchmark study was carried out**.** Pre-seasonal training was organized for Village Level Para Workers (men and women) on need-based

Training on women friendly improved farm tools and equipment to farm women in village

areas in farming and home management to promptly address the farming problems of men and women. The para workers were trained to organize extension activities and promote women's participation in farm enterprises, income generation and nutritional security in agriculture. To secure participation of women sensitization programmes and thirty nutritional gardens, two fish culture units, one ornamental fish production unit and three mushroom units were developed involving participatory approach.

Demonstrations were conducted on yield maximization of ginger and groundnut, preparation of seedbed, soil treatment, seed treatment, sowing of seeds, mulching, eco-friendly technologies for the management of brinjal shoot and fruit borer (*Leucinodes orbonalis*) and tomato fruit borer (*Heliothis armigera*) for **Technological empowerment of farmwomen for family sustenance.** Special training programmes were conducted on production of straw and oyster mushroom, value added products such as squash from ginger and lime, blended squash and pickle and preparation of *sagu papad* and *suji papad*.

The data on the **Entrepreneurial status of SHGs** revealed that majority of group members belonged to the agricultural families with marginal land holdings. Most of the SHGs, however, existed for a long time without involvement in any enterprise. Their interests and preferences for skill training were assessed and skill development training programmes were organized on vermi-composting and bee-keeping.

The study under **Mechanization of rice sector and impact on gender** indicated that most of the mechanization was adopted in man dominated tasks while in women related tasks mechanization was not found adopted. The extent of mechanization of activities varied with farm-specific factors such as number of draught animals, size of work force in family, size of farm, location of farm, availability of non-agricultural income and external factors

SUCCESS STORY

Ornamental fish production—a new avenue for supplementing farm income

The National Research Centre for Women in Agriculture, Bhubaneshwar, developed a simple and cost effective ornamental fish production technology for resource poor rural women using indigenously developed infrastructure. The primary aim was to enable women utilize their spare time productively to earn some income.

The technology consisted of locally available earthen tanks of 50–60 litres capacity that are commonly used by women in traditional method of rice parboiling. The tanks were slightly modified to make them suitable for ornamental fish culture.

Ornamental fish production units (12) were developed in a cluster in Nimapara block of Puri district of Orissa. Each unit had 10–12 earthen tanks and reared two species one each of guppys and mollys. Training programmes were conducted on fish rearing and aquarium setting. In the beginning, women faced marketing problems that created doubts about sustaining the production. To overcome an educated unemployed young man from a nearby village was associated with the programme to help in marketing of ornamental fishes. He was also trained in the fabrication of aquarium tanks and setting so that he can help in creating market in the nearby areas. The above strategy was successful. It not only enabled the youth earn a monthly income of Rs 3,000 but also ensured the rural women a better price and returns for the ornamental fish produced by them.With a total investment of Rs 2,000 in a year (including establishment and recurring cost) a unit could generate on an average income of Rs 560/month. Similarly, an investment of Rs 5,000 could generate a monthly average income of Rs 1,400.

The institutional arrangement encouraged women to expand their units by adding more number of tanks and has motivated the other women groups of the area to start similar ventures using the low cost technology.

Organization of ornamental fish production units at village level

such as availability of machines in village/locality, cost of hiring the machines and diversion of the equipment for non-farm work. The process has led to displacement of men workers, and an average number of working days lost for wage labourers due to mechanization of land preparation and threshing was 26.5 days and 18.6 days respectively. In Orissa mechanization of threshing generated additional employment to women displacing men.

Training of farmers and farm women

Farmwomen (286) were trained for skill development in (i) insect pest management of vegetables nursery, (ii) vermicomposting, (iii) value addition of lime and ginger into squash, blended squash and pickle, (iv) preparation of *sagu papad* and *suji papad*, (v) oyster and straw mushroom production, and (vi) bee-keeping.

Two hundred farm women from the villages of Nipania Jat, Adampur, Dobra and Sagoni Kala of Bhopal districts were trained on improved tools and equipment, viz. hand ridger, seed treatment drum, fertilizer broadcaster, seed drill, CIAE wheel hoe, PAU wheel hoe, grubber weeder, hanging type cleaner and sitting type decorticator, and one set of these equipment was kept in each village for their use. Training on repair and maintenance of these equipment has also been imparted to 14 farm women from these villages. The performance of the implements is being evaluated.

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16. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through its institutes located in North-west Himalayas, Islands and North-east Himalayas evolve 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, agroforetry, apiculture, sericulture, horticulture, animal husbandry, poultry and fisheries.

NORTH-WEST HIMALAYAS

The research work carried out at institute in North-west Himalayas led to:

Varietal release

Eleven varieties/hybrids of different crops were released for different agro-climatic regions of the country.

Seed production

A total of 21.9 tonnes breeder seed of 47 released varieties/inbred lines was produced. Organic seed (0.495 tonne) of wheat, pea, lentil, horsegram and French bean was also produced. In addition, around 1.2 tonnes nucleus seed of 33 released varieties was produced. Breeder seed (20.795 tonnes) was supplied to different seed-producing agencies to take up further multiplicaiton.

Nutritive biscuits from fingermillet

Fingermillet is an important foodgrain of Uttarakhand. Its grains are a rich source of mineral and dietary fibre. For increasing dietary fibre and micronutrient availability in biscuits, fingermillet flour was blended with gluten powder or wheat

New varieties released

Variety	Adaptation region/agro-ecology	Duration	Salient features
Vivek Maize Hybrid 21	Commercial cultivation in Zone I, II and IV	Extra-early (85–90 day)	Resistant to leaf blight

Vivek Maize Hybrid 21 is an extra-early maize, showing resistance to leaf blight (*left*). VL Arhar 1, suitable for cropping system in hills, possesses protein content 21.4% and 25.9% for whole seed and *dal* respectively (*right*)

New varieties released (contd...)

Variety	Adaptation region/agro-ecology	Duration	Salient features
Vivek Maize Hybrid 23	Cultivation in organic conditions of Uttarakhand	Extra-early (90–95 days)	Registered 9.9 and 27.3% yield superiority to Vivek Hybrid 9 and Vivek Sankul 11 respectively. Resistant to leaf blight
VL Masoor 126	Timely sown rainfed conditions of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and north-eastern hills	126–150 days (mid-hills), 195–205 days (high hills)	Small black-seeded variety, moderately resistant to wilt and rust; and resistant to grey mold
VL Matar 42	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal and Asom	Medium maturity (145–155 days)	Field pea genotype having higher protein content (25.8%) and superior in cooking quality parameters, possesses higher resistance to pea rust and powdery mildew
VL Gahat 10	Timely sown organic conditions of Uttarakhand hills	Medium maturity (113–117 days)	Horsegram variety resistant to stem rot and anthracnose
VL Arhar 1	Uttarakhand hills	Early maturity (120–125 days)	Dark brown, matures 24 days earlier to the checks, hence suitable for the cropping system in hills. Exhibits high degree of resistance against wilt and alternaria leaf blight. Protein content 21.4% and 25.9% for whole seed and *dal* respectively
VL Toria 3	Organic conditions of Uttarakhand hills	85–145 days	Resistant to pod and leaf blight. Total oil is higher by 21.6%/ha over best check PT 303
VL Barley 85	Organic conditions of Uttarakhand hills	155–160 days	High-yielding, rust resistant

SUCCESS STORY

Crop diversification for food, economic and nutritional security

Diversification towards vegetables and fruits by reducing allocated area under food crops may cause scarcity of food in adverse climates. Therefore, emphasis has been laid on crop diversification to enhance farm income as well as sufficient foodgrain production in Bhagartola village. The area under vegetables and fruits has been increased by 6 and 5%, respectively, while other farming components like protected cultivation and fisheries also occupied a notable area. This increase in vegetable area coupled with better production management techniques, resulted in Rs 8.60 lakh and Rs 14.60 lakh/ha income during 2005-06 and 2006-07. At the same time, area vacated from food crop did not reduce total food production because of introduction of high-yielding, improved varieties that gave 26% higher yield than the local varieties.

Harvesting of vegetable pea—diversification with vegetable

Improved varieties for ensuring higher yield

SUCCESS STORY

Protected cultivation – a boon to farmers

The structural cost of greenhouse is Rs 85/m^2 of floor area. Mr Girish Pandey, a farmer of Dhaspad village, was not earning adequately by producing vegetables in open due to erratic climatic conditions. Proper motivation led him to construct a polyhouse in which he planted tomato cv. Manisha and harvested 0.76 tonne tomato and marketed in small town of Danya. He earned a net income of Rs 8,000 from his 80 m polyhouse.

flour or both the products. This technology is ready for transfer to local entrepreneur for commercial exploitation.

ISLANDS

The research findings of the institute located in Islands are:

Integrated farming system models

Component analysis of developed integrated farming system (IFS) models under different resource conditions in humid tropics of Bay Islands indicated that cropping contributed more to net returns (69 to 83 %) in hilly and sloping hilly uplands, whereas livestock components (cattle, poultry and fish) contributed more to net returns (49 to 66 %) in medium upland valley and lowlying valley areas. On an average, net returns from IFS was Rs 1.0-2.5 lakh/ha under various resource situations. Bacterial load in fish-cum-poultry-cum-duck system revealed that *Samonella* sp. in the pond gets increased during monsoon and further increased during the summer, revealing unsuitability of pond water for household purpose.

Crop diversification through broad bed and furrow-based farming system

In valley areas of Bay Islands, cropping system on the beds and furrows of broad bed and furrow (BBF) revealed that 1 ha of BBF gave a net return of Rs 198,000 from radish – chilli on the beds and rice–ratoon (azolla + fish : singhi + magur) – groundnut in the furrows. Benefit : cost ratio of lowlying paddy land improved to 2.77 from <1 and cropping intensity increased from 100 % to 300 – 500 % on the beds and 300 % in the furrows.

Early flowering mango clones

Out of 32 local early flowering mango clones, 15 clones exhibiting higher qualitative characters were collected and were found free from post-harvest diseases like anthracnose. Polyembryonic characters were found in all these clones even in the seedling progeny. Identification of gene expression using RAPD and ISSR markers were also done. Fifty saplings were planted in the main field for evaluation.

Natural resource management through integrated farming system

SUCCESS STORY

Women and youth empowerment through quail rearing in bay islands

For promoting quail farming under 'Production to Consumption System', quail farming technology was started with 6 SHGs from South and North Andamans and a group of youth with an aim to develop hub system (Hatchery, Feed Mill, Parent Stock) to facilitate satellite units. They were provided with inputs of 200 quail chicks per unit. The quail shed, feeders and waters were made with the locally available materials like bamboo, palm, arecanut tree leaves and trunks. The eggs from farmers' stock were hatched in hatchery of institute, for its recycling which has become a constant source of income for SHGs. The quails were active with no mortality throughout the rearing period and quail rearing is gaining popularity owing to larger consumer acceptance of its egg, meat and pickle. It has become a very remunerative livelihood option with net income ranging from Rs 5,000 to 6,570 per month with a benefit : cost ratio of 2.8.

Conservation and characterization of indigenous goat

Two breeds of goat (Local Andaman and Teressa) belonging to Andaman and Nicobar islands were phenotypically characterized for the first time. The maximum body weight (kg) was in Teressa goat (male 34.92±4.26; female 32.36±1.47) followed by Malabari (male 30.44±7.09; female 27.68±1.69) and Local Andaman goat (male 28.21±0.95; female 23.45±0.70). Sexual dimorphism in Local Andaman goat was also found statistically significant ($p<0.05$) for circumference of abdomen, neck, chest and hoof and for length of horn and tail.

Coral diversity

The total species recorded from Andaman and Nicobar (2004 – 2006) islands were 192 under 57 genera in 15 families. Many species of corals of Diglipur area, North Andaman was exposed after Tsunami due to elevation of land mass and died. Corals bleaching was noticed due to increase of surface temperature; bleached corals died and partially bleached corals recovered slowly. Predation by crown of thorns, siltation of coastal waters, effluent discharge, unfavourable environmental conditions, human interference like coral mining, are some of the factors responsible for damage and destruction of corals

Broodstock development and breeding of damselfishes

Of the recorded 105 species of reef fishes, about 15 varieties of damselfishes species are harbouring in Andaman and Nicobar islands. *Amphiprion percula* could be successfully bred and reared in captivity.

NORTH-EAST HIMALAYAS

The research work conducted at institute located in North-East Himalayas led to:

New rice genotypes

Two cold-tolerant short-duration (~ 90 days) rice genotypes, viz. MC 34-10-6-1-26 and MC 34-1-22-64, with yield potential of 6.0 tonnes/ha were developed for post-flood cultivation in NEH region. Another rice genotype, RCPL 1-129, was also developed for shifting cultivation (*jhum*) areas, yielding 1.8 tonnes/ha at farmers' fields without any fertilizer or crop management input.

A rice genotype MC 34-10-6-1-26 of short duration, having cold tolerance, developed for post-flood cultivation in NEH region

Germplasm collection

Fiftysix accessions of maize were collected from so far unexplored areas of Ukhrul district of Manipur. Eighty accessions were also collected from Nagaland.

New genotypes of guava and strawberry

Three guava genotypes, viz. Hybrid 1, Hybrid 7 and Selection 11, were found to be quality genotypes for the north-eastern region. Fruit weight of these genotypes varied from 110 to 160 g/fruit, TSS from 11.0 to 11.8%, acidity from 0.31 to 0.40% and

Ofra variety of strawberry recommended for Meghalaya

ascorbic acid content from 205 to 255 mg. These genotypes are ready for multilocation trial.

Strawberry varieties recommended for different locations are: Ofra for Meghalaya and Sweet Charlie for Sikkim and Manipur.

Micropropagation technique for banana and strawberry

Micropropagation in banana (Giant Cavendish) and strawberry has been standardized for mass production and distribution of quality planting material.

Mushroom cultivation

Cultivation of various mushroom species, viz. *Agaricus bisporus, Pleurotus* spp., *Volvarella* spp., *Lentinus edodus* and *Calocybe indica,* in polypropylene bags (size 500 mm × 160 mm) using sawdust incorporated with paddy straw has been standardized with other locally available raw materials under local conditions. A quantity of 5–6 kg dried (weight) mixture yielded 3 kg *Lentinus edodus* within 6-8 months.

Botanicals in control of ginger soft rot

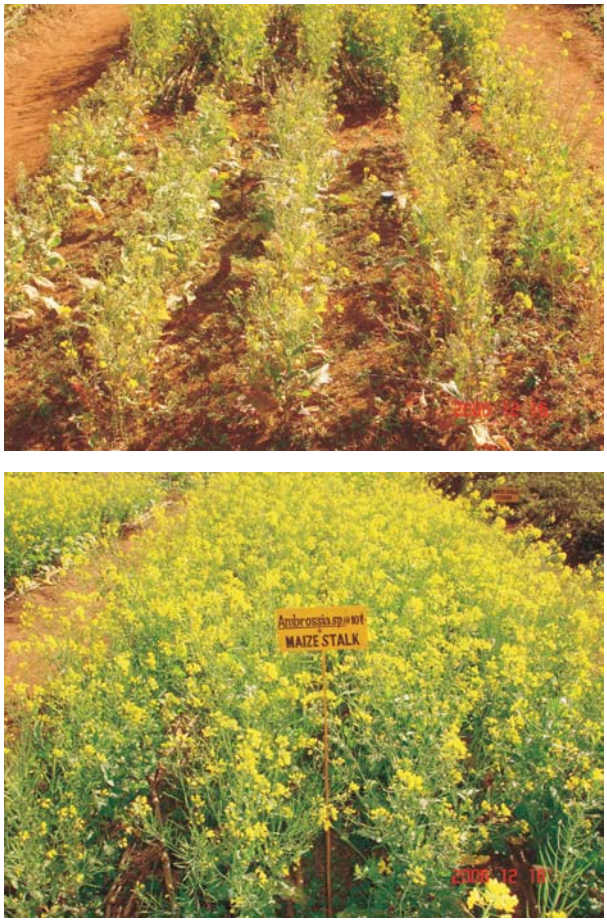
Soft rot of ginger accounts for 20-30% of yield loss, besides affecting the quality of seed. Mother rhizome treated with botanical extracts formulation (GF_1) at 4% concentration for 12 hr before planting completely managed the soft rot of ginger with nearly 30 % increase in ginger yield.

Entomopathogenic nematodes for bio-control of maize stem-borer

An entomopathogenic nematodes (EPNs), *Heterorhabditis* was isolated from soils and mass multiplied on laboratory hosts *Galleria mellonella* and *Corcyra cephalonica*. *Heterorhabditis* @ 5 million ijs/ha was found effective in controlling maize stem-borer 70% in the fields. The same was also used at farmers' fields for the control of the maize stem-borer.

New technique of *in-situ* soil-moisture conservation for terraced and slopy land

A simple and very low cost technique of *in-situ* moisture conservation was developed for *rabi* crop (mustard) using residue of preceding maize crop grown during rainy season and *Ambrossia,* a weed, as external input ensuring double cropping under both upland terrace and flat upland situations. Biomass of a local weed *Ambrossia* sp. was applied between rows of standing maize 20 days before its harvest in September to recharge *in-situ* soil-moisture profile by preventing run-off from the field at the later part of rainy season. Immediately after harvest of maize, its stalk was spread all over the field just above the applied *Ambrossia* and kept as such till sowing of mustard. This way *Ambrossia* sp. and maize stalk act as double mulch not only to provide optimum soil moisture for sowing of mustard in October but also to recharge the soil profile for support growth and development of mustard during the whole growing season. Mustard was sown in October between maize rows by removing maize stalk and put back between mustard rows on the same day immediately after sowing and kept till harvest of mustard. This ensured good germination of mustard, growth and 5-fold increase in mustard yield over control under terrace and flat upland situations.



Control plot without cover of mustard (*top*) and mustard plot under maize stalk cover + *Ambrossia* sp. (*bottom*)

Induced breeding of *pengba* (*Osteobrama belangeri*)

Osteobrama belangeri locally known as *pengba* is an endemic medium carp of Manipur. Induced breeding using Wova FH was standardized to propagate this endangered fish population.

Diagnostics

The polymerase chain reaction (PCR) protocols for rapid identification of *Brucella abortus, B. melitensis* and *B. suis* based on the repetitive genetic

SUCCESS STORY

On-farm trial with improved pig production technology

Developed germplasm (Hampshire × Khasi local) of pig along with improved package of practices was tested in 3 villages (Saiden, Upper Shillong and Mawkriah). The average daily body weight gain of indigenous and improved pigs was 62.56 and 114.95 g, respectively, under traditional production system, while it was 85.73 and 237.95 g under the improved production system. Thus, an advantage of 137 and 207% was achieved with the improved pig production system. Artificial insemination (AI) technology in pigs was refined to suit the local needs and tested at farmers' fields. The farrowing rate with AI was 65% and the litter size at birth was 8.5 under field conditions. Hormonal induction of estrus was also carried out in pigs under field conditions with follicle stimulating hormone and the success rate was 70%.

Improved pig at farmer's field

element IS*711* were standardized using the specific published primers. The overall seropositivity for brucellosis in cattle in north-east region was 17.5 %. A PCR-based method was standardized for the rapid detection of *Campylobacter jejuni*.

Region-specific mineral mixture

The extent of mineral deficiency in dairy cows in Mizoram was quantified and based on the data, a state-specific mineral mixture feed formula was evolved. Blood serum samples of cows and the soil and fodder samples were collected from different areas of Mizoram and analyzed for macro- and micro-minerals. Based on deficiency in blood a mineral mixture composition was developed for cattle of Mizoram.

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17. 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 1 of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India in the DARE functions as the Director-General of the ICAR. The 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 15 Group A, 13 Group B, 8 Group C, and 6 Group D employees. The recruitment to the post in the Groups A, B, C is being made centrally, either through the Department of Personnel and Training or through the Department of Agriculture and Co-operation, depending on the level of the post. The DARE makes direct recruitment only to Group D posts. Such recruitments are being made in accordance with the orders of the Government of India regarding reservations for scheduled-castes, scheduled-tribes, and other backward classes. Presently, DARE has 6 scheduled -caste employees.

A detailed break-up of the posts and names of the important functionaries is given in Appendix II of the DARE. The financial requirement (Grant No. 2) includes budget estimates (BE) and revised estimates (RE) of the DARE and ICAR (Plan and Non-Plan) 2006–2007, respectively, and BE

Hon'ble Shri Sharad Pawar (MoA) said that there is need for policies and programmes to invigorate agriculture productivity. (L-R) Shri A.K. Upadhyay (Secretary, ICAR), Dr Mangala Rai (DG, ICAR), Sh. Sharad Pawar (MoA), Sh. M.V. Rajasekaran (Minister for Planning, State) and Dr (Mrs) Rita Sharma (FA, ICAR).

Hon'ble Shri Sharad Pawar (Union Minister of Agriculture) is giving away award to First Prize Winner, Shri Chandresh Singh, from Barabanki (U.P.) for Essay Writing (Hindi) on 'Global Climate Change and its effects on Agriculture.' Prof. Yash Pal (*centre*) and Dr Mangala Rai (*right*) also congratulated him.

for 2007–08 (Plan and Non-Plan). The detailed-break up of these financial figures is given in Appendix III of the 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 under the Societies Registration Act 1860, on the recommendations of the Royal Commission of Agriculture. It was reorganized twice, in 1965 and 1973. The ICAR (Headquarters) is located at Krishi Bhavan, New Delhi, and its other buildings are Krishi Anusandhan Bhavans I and II, and NASC, 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 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, education institutes, scientific organizations and farmers (Appendix 1).

The Governing Body (Appendix 2) is the chief executive and decision-making authority of the ICAR. It is headed by the Director-General. It consists of eminent agricultural scientists, educationists, legislators and representatives of the farmers. It is assisted by the Standing Finance Committee, Accreditation Board, Regional Committee, Policy and Planning Committee, several Scientific Panels, and Publications 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 DDGs 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 of the ICAR.

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), 32 National Research Centres (Appendix 7), 75 All-India Co-Ordianted Research Projects, All India Network Projects, and Network Projects (Appendix 8).

The Project Directorate of Information and Publications of Agriculture is working independently with the approval of the Competent Authority. The Media and Publicity and Public 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' Training Centre along with Zonal Co-ordinating Units.

The total sanctioned as well as existing strength of the employees of the total number of employees in 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.

INTELLECTUAL PROPERTY RIGHTS, POLICY AND PERSPECTIVE PLANNING

Policy imperatives

Support for the implementation of the Protection of Plant Varieties and Farmers' Rights Act, 2001: The ICAR has been providing input for the development and implementation of plant variety protection law in the country since beginning. In this period, besides human resource

support to the Protection of Plant Varieties and Farmers' Rights Act (PPVFR) Authority in various capacities/platforms, the ICAR has extended support for the implementation of the PPVFR Act as follows:

- National Bureau of Plant Genetic Resources has documented and digitalized database of extant-notified varieties of various crops by using the software INDUS (Indian Information System). This database has significance in context of the global search for registration and protection of plant varieties under the plant variety protection law.
- ICAR has developed National Test Guidelines for examination of Distinctiveness, Uniformity and Stability (DUS) of the candidate varieties of 35 crops for their registration and protection abide by the Indian PPF and FR law. On the basis of these guidelines, 12 crop species were notified by the Central Government/Protection of Plant Varieties and Farmers' Rights Act Authority for the protection of their plant varieties in the First Phase.
- National Bureau of Plant Genetic Resources has entered into an agreement with the Protection of Plant Varieties and Farmers' Rights Act Authority through which dedicated space has been provided in the National Gene Bank for the storage of seed samples of the candidate and notified varieties under the Protection of Plant Varieties and Farmers' Rights Act.

Perspective Plan/Vision 2025 of the ICAR Institutes

Perspective Plans/Vision 2025 documents of all the ICAR Institutes were prepared and published for the research execution up to 2025.

Intellectual property management, Technology transfer/ Commercialization

The intellectual property (IP) management and related activities in ICAR have proliferated as a result of decentralization of IP management practices in the Council and the delegation of powers to Directors/Project Directors of the ICAR institutes to execute the related matters. The *ICAR Guidelines on Intellectual Property Management and Technology Transfer/Commercialization* have been implemented since 2 October 2006. As a result, the number of reporting institutes has more than doubled to 51 during this period. Seven patents have been granted to ICAR institutes (Table 17.1) and 53 patent applications are reported to have been filed by 16 institutes. The patent on *Bt* transgene detection kit has also been granted in

Table 17.1. Patents granted to ICAR since the implementation of Intellectual Property Management Guidelines

Patent granted	Area of research	Institute
Rapid detection of *Bt*-cry toxins	Transgenic detection kit	CICR, Nagpur
A process for isolating anaerobic microorganisms using a new apparatus	Micro-organisms	CIRCOT, Mumbai
Process for the purification of solanesol (95+%) from crude enriched extract of tobacco	Pharmaceutical (Drug intermediate)	CTRI, Rajahmundry
A process for preparing a novel herbal formulation for the treatment of mange in animals	Veterinary medicine	IVRI, Izatnagar
Cold process technology for preparation of urea molasses mineral block	Feed production	IVRI, Izatnagar
A simple and efficient micro-dialysis assembly for dialysis of samples in microlitre volumes	Research tool	NDRI, Karnal
A method for preparing a mushroom growth agent	Mushroom production	NRC on Mushroom, Chambaghat

Table 17.2. Some prominent ICAR technologies other than plant varieties transferred/ commercialized

Technology	Institute
Gene constructs of *Cry 1* genes *Bt*-detection kits	IARI CICR
Bt-based biopesticide KNOCK WP for control of semilooper pest in Castor and other crops	DOR
Trichoderma based biopesticide TRIVIR 1% WP for control of wilt and root rot diseases of castor, chilies, and other oilseed and pulse crops, and reniform nematodes	DOR
Vaccine for control of goat pox	IVRI
Diagnostic kits for PPR (Goat Plague)	IVRI
Diagnosis and vaccine for Avian Influenza	IVRI
Portable FRP Carp Hatchery	CIFA
Agricultural Machinery and Farm Implements	CIAE

South Africa. Further, applications via Patent Co-operation Treaty (PCT) route have also been filed in China, Mexico, South Korea and Uzbekistan.

Extant varieties that have been notified by the Central Government under section 5 of the Seeds Act, 1966 are eligible for protection in India for 15 years from the date of notification. The ICAR has already filed applications for registration and protection of about 300 extant-notified varieties of the 12 notified crops with the PPVFR Registry.

The ICAR has developed, and transferred/ commercialized, first bacterial-blast resistant improved Basmati rice through molecular marker-assisted selection/pyramiding and backcross transfer of *'xa13'*, and *'Xa21'* in the genetic background of Pusa Basmati 1. Besides the identification and release of improved varieties of various crops, the ICAR institutes have also transferred/ commercialized several technologies aimed at overall increase in agricultural production, including crops and animals (Table 17.2). Some prominent among these include transgenic detection kit, biopesticides, diagnostic kits and vaccines for animal health, portable hatchery for aquaculture, and farm machinery and equipment.

ADMINISTRATION

The total number of employees and numbers of SC, ST and OBC (Table 17.4) and total number of employees including SC, ST, and OBC (Table 17.3) are given in Tabular form.

Filling up of vacant posts: A good number of vacant posts like Director (Finance) NAIP, Under-Secretaries, Senior Administrative Officers, Administrative Officers, Finance and Accounts Officers, Section Officers, Private Secretaries, Junior Analyst, Assistants, Personal Assistants, UDCs, Stenographers, Group 'D' posts were filled up.

Compassionate appointment: Peon (1) and LDC (1) were appointed on compassionate grounds.

Financial upgradation granted under the ACP Scheme: As per the Government of India instruction 'Financial upgradation' was granted to many eligible employees in various grades, viz. Section Officers, Assistant Administrative Officers, Assistant Finance and Accounts Officers, Assistant Director (OL), Stenographers, LDC and Group D employees, during this period.

Staff Welfare Fund Scheme: As per the recommendations of the Managing Committee of ICAR (Hq) Welfare Fund, financial assistance of Rs 25,000 each was extended to families of two deceased employees of the ICAR (Hq). Further Rs 20,000 each was also given as financial assistance in case of self-illness or illness of their dependent family member, to 3 employees of the ICAR (Hq).

Scholarships (45) were awarded to meritorious wards of the Council's employees under 'Staff Welfare Fund Scheme'.

Award for compassionate fund of the ICAR: An award of Rs 25,000/each out of the Compassionate Fund of ICAR was granted to 4 dependent family members of the ICAR (Hq)/Institutes.

Table 17.3 Total number of Group C and D employees and number of scheduled-castes, scheduled-tribes and other backward class

Posts	Total sanctioned	Employees in position	No. of SCs	Percentage to total employees	No. of STs	Percentage of total employees	No. of OBCs	Percentage to total employees
Lower Division Clerk	94	61	14	22.9%	4	6.5%	5	8.19%
Peon	76	67	21	31.34%	2	2.9%	5	7.46%
Farash	11	10	5	50%	2	20%	1	10%
Mali	5	4	–	–	–	–	–	–
Packer	5	4	1	25%	–	–	2	50%
Studio attendant	1	1	–	–	–	–	–	–
Store attendant	1	1	–	–	–	–	–	–
Daftary	45	45	8	17.77%	01	2.2%	–	–
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%
Dispatch rider	1	1	1	100%	–	–	–	–
Record Keeper	1	1	1	100%	–	–	–	–
Sr. Gestener operator	2	2	–	–	2	100%	–	–
Safaiwala	12	12	12	100%	–	–	–	–

Table 17.4. Total number of employees and number of scheduled- castes, scheduled- tribes and other backward classes at ICAR (Hq.)

Posts	Scale of pay (Rs)	Total sanctioned posts	Employees in position	No. of SCs	Percentage to total employees	No. of STs	Percentage to total employees	No. of OBCs	Percentage
Director (P)	14300–400–18300	01	01	–	–	–	–	–	–
Director (F)	14300–400–18300	02	02	–	–	–	–	–	–
Director (OL)	12000–375–16500	01	01	–	–	–	–	–	–
Dy Secretary	12000–375–16500	08	08	–	–	01	12.5%	–	–
Legal Advisor	12000–375–16500	01	01	–	–	–	–	–	–
Dy Director (F)	12000–375–16500	02	02	–	–	–	–	–	–
Dy Director (OL)	10000–325–15200	01	–	–	–	–	–	–	–
Under-Secretary	10000–325–15200	13	13	02	15.3%	01	7.6%	–	–
SA to Chairman, ASRB	10000–325–15200	01	01	–	–	–	–	–	–
Senior Finance & Accounts Officer	10000–325–15200	03	01	–	–	–	–	–	–
Law Officer	8000–275–13500	01	01	–	–	–	–	–	–
Finance and Accounts Officer	8000–275–13500	07	06	–	–	–	–	–	–
Assistant Legal Advisor	6500–200–10500	01	01	–	–	–	–	–	–
Assistant Director (OL)	6500–200–10500	02	02	–	–	–	–	–	–
Junior Analyst	6500–200–10500	02	02	–	–	01	50%	01	50%
Desk Officer	6500–200–10500	06	04	01	25%	–	–	–	–
Protocol Officer	6500–200–10500	01	–	–	–	–	–	–	–
Assistant Finance and Accounts Officer	6500–200–10500	06	05	–	–	–	–	–	–
Section Officer	6500–200–10500	80	75	9	12%	07	9.33%	03	4%
Private Secretary	6500–200–10500	30	30	04	13.33%	–	–	–	–
Assistant	5500–175–9000	163	121	19	15.70%	10	8.26%	03	2.47%
PA (Grade II)	5500–175–9000	54	47	06	12.76%	02	4.25%	03	6.38%
Sr. Sales Assistant	5000–150–8000	02	02	–	–	–	–	–	–
Steno (Grade III)	4000–100–6000	47	23	03	13.04%	01	4.34%	01	0.34%
UDC	4000–100–6000	188	184	39	21.195%	06	3.26%	–	–

PROGRESSIVE USE IN HINDI

DARE

The Department of Agricultural Research and Education (DARE) 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

The ICAR's Institutes/Centres (15) were notified in the Gazette of the Government of India thus raising the total number of notified Institution to under rule 10(4) of the Official Language Rule 1976. Joint Official Language Implementation Committee of the DARE and the ICAR, working under the Chairmanship of the Additional Secretary, DARE/Secretary, ICAR, met fourth time. Similarly, Official Language Implementation Committees constituted at ICAR Instiutes/Centres convened its meetings. Proceedings of the Official Language Implementation Committee meetings held by the Institute etc. as well as the quarterly progress reports regardings the use of Official Language Hindi received from ICAR institutes at the ICAR (Hq) were reviewed and proper measures were suggested to overcome the shortcomings found therein. Rosters were maintained for imparting training in Hindi, Hindi typing and Hindi stenography and officials were accordingly deputed for training during the reported year. This year, 14 stenographers and 16 typists were nominated for Hindi stenography and typing respectively. "Hindi Fortnight" was observed from 14 to 28 September 2007 at ICAR (Hq) and many programmes were organized for staff to promote the progressive use of Hindi in official work. A message of Hon'ble Minister of Agriculture was issued on this occasion. The Director-General, ICAR, also issued an appeal requesting the officers/staff to do their maximum official work in Hindi. Hindi Day/Week/Month were also organized at different Research Institutes/Centres of ICAR. Hindi workshops (4) were also organized for officers/staff. The '2006–07 Cash Awards' were given to 10 officials at ICAR (Hq) for doing their maximum official work in Hindi.

- "*Ganesh Shankar Vidyarthi Utkrist Hindi Krishi Patrika Purskar*" was launched in 2004–05 for the best in-house Hindi magazine, being published by various Institutions of the ICAR; assessment is being done to give prizes to the ICAR institutes.
- The *Rajbhasha Alok 2007* (10th issue) will be published shortly.

Table 17.5. Rajshri Tandon Rajbhasha Purskar

Following Institutes were awarded for doing maximum work in Hindi

Institutions	Category of Institutions	Prize
National Dairy Research Institute, Karnal	Big Institute	First
Indian Veterinary Research Institute, Izatnagar	Big Institute	Second
Indian Institute of Vegetable Research, Varanasi	A and B Region	First
Central Institute of Agricultural Engineering, Bhopal	A and B Region	Second
Central Institute of Fisheries Technology, Cochi	C Region	First
Central Research Institute for Dryland Agriculture, Hyderabad	C Region	Second

- 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 ICAR institutes during 2007, 18 offices were inspected and suggestions were given to overcome the shortcomings. Second sub-committee of the Parliamentary Official Language Committee inspected 5 Institutes/Centres of the Council
- The Council and its institutes are organizing regular training programmes for farmers in Hindi and in other regional languages and remarkable progress has been made at Krishi Vigyan Kendras belonging Hindi speaking region for the use of Hindi and in the other regional languages in their day-to-day official work. Besides, all the 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 many other meetings were prepared bilingually. The draft of speeches of Hon'ble Union Agriculture Minister and other higher officials of ICAR were prepared originally in Hindi and they delivered many speeches in Hindi.

Finance and Audit

The Budget Estimate (BE) and Revised Estimate

Table 17.6. Budget Estimate and revised estimate of DARE (Rupees in lakh)

Items	Budget 2006–2007		Revised Estimate 2006–2007		Budget Estimate 2007–2008	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451'						
090 Secretary	–	155	–	155	–	165
Major Head '2415'						
80 General						
International Co-operation						
(010032) – India's membership contribution to Commonwealth Agricultural Bureau International	–	10	–	10	–	10
(020032) – India's membership contribution to Consultative Group on International Agricultural Research	–	375	–	375	–	380
(030032) – Other programmes	4550	–	650	–	*950	–
(040032) – India's contributions to Asia Pacific Association of Agricultural Institutions	–	5	–	5	–	5
(050032) – India's contributions to NACA	–	12	-	12	–	12
(060032) – India's contributions to CGPRT	–	5	–	5	–	5
(070032) – India's contributions to Seed Testing Association	–	2.25	–	2.25	–	2.25
(080032) – ISHS Belgium	–	0.75	–	0.75	–	0.75

*Includes Rs 8.00 crore for National Fund for Basic and Strategic Research in Agriculture.

(RE) of DARE and ICAR (Plan, Non-Plan) for 2006–07 were Rs 2,160.00 crore and Rs 2,276.00 crore, respectively, and BE for 2007–08 (Plan and Non-Plan) is Rs 2,460.00 crore. The detail break-up of these financial figures are given in Tables 1 and Appendix III, Table 2.

The details in respect of BE and RE for 2006–07 and BE for 2007–08 of Department of Agricultural Research and Education (DARE) are given in Table 17.6. This excludes the payment to the ICAR.

ICAR AWARDS CEREMONY, 2007

The 'Annual ICAR Award Presentation, 2007' ceremony was held at the NASC Complex, Pusa, New Delhi, on 16 July 2007. Dr Mangala Rai (Secretary, DARE and DG, ICAR) welcomed Hon'ble Shri Sharad Pawar (Union Minister of Agriculture), Shri Kanti Lal Bhuria (Union Minister of Agriculture, State) and the audience. Hon'ble Shri Sharad Pawar (Union Minister of Agriculture) said that the work done by the awardees would add to the scientific knowledge. During this year, 54 awards under 12 different categories were given to honour 6 institutions, 41 scientists and their associates, 6 farmers and 1 journalist. Out of 41 scientist and their associates, 16 were women scientists (Annexure 12).

Vichar Manch

The ICAR *Vichar Manch*, a forum for intellectual engagement on a variety of issues beyond our professional life, was established by the ICAR (Hq.). Three eminent orators have presented their views on different themes since 7 September 2007.

TECHNICAL CO-ORDINATION

The co-ordination included the work of financial support to 54 Scientific Societies for publication of journals, 16 societies/associations/universities for holding National Seminars/Symposia/Conferences, and 19 for holding International Seminars/Symposia/Conferences and the work related to Best Annual Report Awards, Technical backstopping, Parliament Questions, VIP references and material for papers/talks/replies to various organisations. Technical notes and monthly summary reports on major breakthroughs in research and other related matters of all the Institutes/Project Directorates were sent to Cabinet Secretariat of the Government of India and other related departments. The Annual Conference of Directors of the ICAR Institutes/National Research Centres/Project Directorates/National Bureaux was organized from 16 to 18 July 2007. The meeting of the Regional Committee No. 1 for Jammu and Kashmir, Himachal Pradesh and Uttarakhand, was also organized on 1 and 2 November 2007 at Dr Y.S. Parmar University of Horticulture and Forestry, Solan.

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18. Partnership and Linkages

The International Co-operation in DARE/ICAR has been operating through the Memoranda of Understandings (MoUs)/Work Plans signed by the ICAR/DARE as the Nodal Department with various countries/International organizations, and through participation of DARE/ICAR in the MoUs/Work Plans signed by the Department of Agriculture and Cooperation as the Nodal Department. Besides, Ministry of Science and Technology has developed Programme of co-operation with various countries and international organizations in which DARE/ICAR is the participating agency in agricultural research. The Joint Commissions/Working Groups constituted by Ministry of External Affairs and Ministry of Commerce have component of agriculture/agricultural research in which DARE participates directly or through the Department of Agriculture and Co-operation.The activities of the Division are mainly carried out under Memoranda of Understandings (MoUs)/ Agreements/Work Plans signed with different international organizations/countries etc.

The Department is also organizing visits of foreign nationals under "*Ad-hoc* Category". The Department also receives proposals for customized training courses for foreign nationals.

MoUs/WORK PLANS

- A Memorandum of Understanding was signed on 26 February 2007 between the Indian Council of Agricultural Research, New Delhi, India, and the University of Western Australia, Australia, for co-operation in agricultural research and education.
- A Work Plan for 2007–2009 was signed on 6 July 2007 for co-operation in Agricultural Research and Education under the Memorandum of Understanding between Ministry of Agriculture,India and Ministry of Agriculture and Food Industry, Socialist Republic of Vietnam.
- During the visit of a four member delegation led by Dr Andrey I. Ivanov, Vice President, Russian Academy of Agricultural Sciences (RAAS), Russia, a Memorandum of Understanding was signed between the Indian Council of Agricultural Research (ICAR), New Delhi, India and the Russian Academy of Agricultural Sciences (RAAS), Moscow, Russia in New Delhi on 19 November, 2007.

- The Indian Council of Agricultural Research, New Delhi, has signed a Work Plan with International Centre for Research in Agro-forestry (ICRAF) in New Delhi on 19 November 2007.

INTERNATIONAL LINKAGES

During the reported period first 2 projects were finally approved for implementation and third project was extended.

1. Atmospheric brown cloud: The Indian Agricultural Research Institute (IARI), New Delhi, has been allowed to participate in the United Nations Environment Programme, Regional Resource Centre for Asia and Pacific, UNEP (RRC-AP) Programme on "Atmospheric Brown Clouds" to serve as a lead institution for Agricultural Impacts Assessment Study. The total cost of the project is US$ 100,000 and is for 18 months w.e.f. 23 July 2007. The IARI will conduct assessment studies on the impacts of atmospheric brown clouds on agriculture, and will serve as the South Asian Lead Regional Institution for co-ordinating work of the Atmospheric Brown Clouds.

Impact team on agriculture. The first Impact Assessment Meeting of the Project has already been held at Seoul, Republic of Korea from 27 to 29 August 2007 in which Dr A.K. Singh, the then Project Director, Water Technology Centre, Indian Agricultural Research Institute, New Delhi participated.

2. Multitrophic interactions in the rhizosphere and management of nematode pests and diseases: The Indian Agricultural Research Institute, New Delhi, has been allowed to participate in the collaborative project "Multitrophic interactions in the rhizosphere and the management of nematode pests and diseases" of Rothamsted Research, United Kingdom, for 3 years. The approval has been conveyed on 9 October, 2007. Total cost of the project is £149,999.85 (Rs 1.215 crore) out of which £ 90,940 (Rs 73.66 lakh) + 5% contingency is meant for the Indian Agricultural Research Institute, New Delhi. The aim of the project is to improve root health using approaches relevant to United Kingdom and India. The project will target soil-borne pests and diseases on the productivity of agricultural and horticultural crops.

3. Genetic improvement of *Penaeus monodon* tiger shrimp through selective breeding for growth and white spot disease resistance: This Indo-Norwegian Project was funded by Indo-Norwegian Programme Institutional Co-operation — and is being implemented at (i) Central Institute of Brackish Water Aquaculture, Chennai, and (ii) Central Institute of Fisheries Education, Mumbai. It has been extended up to 31 March 2009 at an additional cost of Rs 1,778,000 for Central Institute of Brakishwater Aquaculture, Chennai, and Rs 1,328,000 for Central Institute of Fisheries Education, Mumbai, and NOKS 295,000 for the Institute of Aquaculture Research Ltd. (AKVAFORSK), Norway.

Major event

An India – US Joint Workshop on 'Curriculum Development' under the Agriculture Knowledge Initiative (AKI) was organized in New Delhi from 22 to 23 January 2007.

CENTRAL AGRICULTURAL UNIVERSITY

The Central Agricultural University,Imphal, is an autonomous body and functions under DARE. The academic, research and development achievements are enumerated.

Academic achievements

- A new College of Post-graduate Studies was established during 2007–08 at Barapani in Meghalaya. The University has established 5 Schools, viz. Crop Improvement, Crop-Protection, Horticulture and Forestry, Natural Resource Management, and Social Sciences, at the Post-graduate College. The teaching programme is being conducted in collaboration with ICAR Research Complex for NEH Region, Barapani, by making best use of their scientists and laboratories.
- The University started Under-graduate Programme in Forestry at the College of Horticulture and Forestry, Pasighat (Arunachal Pradesh), during 2007–08 with intake capacity of 22 students of which 11 joined the course.
- The University also started Post-graduate Programmes in 3 new disciplines at College of Veterinary Sciences and Animal Husbandry, Aizwal (Mizoram), and 2 disciplines at College of Fisheries, Tripura (Agartala), in the academic year 2007–08, with intake of 3 students per department including a nominee of the ICAR in each department.
- The University organized its First Convocation on 9 June 2007.

Research achievements

- The varieties Bhawani in *toria* and Pusa Agrani and GM-2 in mustard; Meha in mungbean; JS 335, RKS 18 and JS 97-52 in soybean; ICGS-76, TG-51, TAG-24 and JL-24 in groundnut were suitable for Manipur.

Developmental activities

- The University has initiated steps to provide video-conferencing facilities to all college

campuses and as a result, most of the colleges have already received the necessary equipment and accessories, which are in the process of installation and operationalization.

- The laboratories of Thermodynamics and Heat Engines, Farm Power, Farm Machinery, Electrical Engineering, Electronics and Instrumentation, Soil-and-Water Conservation Engineering, Hydraulics and Fluid Mechanics, Soil Mechanics, Automatic Weather Station, Agricultural Processing, and Agricultural Science including Agronomy, Soil Science and Horticulture, were developed at College of Agricultural Engineering and Post-harvest Technology, Gangtok during 2007–08.The laboratories of Food Analysis, Apparel Designing, Multimedia Production and Food Service Management were developed at College of Home Science, Tura.

PROTOCOL ACTIVITIES

Foreign delegations

- His Excellency Mr Eric Cline, Minister of Industry and Resources, Province of Saskatchewan, Canada accompanied by delegation met Sh A.K. Upadhyay (Additional Secretary, DARE and Secretary, ICAR) on 26 February 2007.
- His Excellency Mr Francisco Laizez (Minister of External Affairs Relations of El-Salvador) and Mr Laizez visited Indian Agricultural Research Institute, New Delhi on 6 March 2007.
- His Excellency Mr Arefaine Berhe, Minister of Agriculture, Eritrea visited National Dairy Research Institute, Karnal on 7 April 2007 and Indian Agricultural Research Institute, New Delhi on 9 April 2007.
- His Excellency Mr Wan Baorui (Vice Minister Level), Chairman of Agricultural Trade Promotion Centre, Ministry of Agriculture, China, met Sh A K Upadhyay (Additional Secretary, DARE and Secretary, ICAR) on 22 May 2007.
- His Excellency Hon'ble Milroy Fernando (Minister of Public Estate Management and Development, Sri Lanka) and accompanied delegation visited TNAU/SBI/Cotton Research Station, Coimbatore from 1 to 6 July 2007.
- His Excellency Mr Lufto E. Dlamini (Minister of Enterprise and Employment, Swaziland) accompanied by business level delegation visited Indian Agricultural Research Institute, New Delhi on 21 August 2007.
- His Excellency Mr Chhabilal Biswakarma (Minister for Agriculture and Cooperatives, Government of Nepal) accompanied by a delegation met Dr Mangala Rai (Secretary, DARE and Director-General, ICAR) on 20 August 2007.
- His Excellency Mr Francisco Itai Meque (Hon'ble Governor of Inhambane, Government of Mozambique) visited CRIDA, Hyderabad, on 17 September 2007.
- Ms F B Marshoff, Premier (Free State of South Africa) visited Indian Agricultural Research Institute, New Delhi, on 11 September 2007.
- His Excellency Mr Barry Todd, Deputy Minister of Agriculture, Manitoba, Canada visited Indian Agricultural Research Institute, New Delhi on 2 November, 2007.
- His Excellency Mrs Vanya Dobreva, Deputy Minister of Education and Science, Republic of Bulgaria and accompanied 7-member delegation visited Indian Agricultural Research Institute, New Delhi on 15 November, 2007.

Delegations abroad

- Dr Mangala Rai (Secretary, DARE and Director-General, ICAR) visited Kathmandu, Nepal, for attending the 13th Meeting of the Regional Steering Committee on 12 and 13 of February 2007, and the 14th Meeting of Regional Technical Coordinating Committee (RTCC) of the Rice-Wheat Consortium from 14 to 15 February 2007.
- Dr Ramesh Chand (National Professor, National Centre for Agricultural Economic and Policy Research, New Delhi) visited Melbourne, Australia from 8 to 9 February 2007, for attending the Workshop on 'Indian Agricultural Market Reform' at University of Melbourne under ACIAR projects ADP/ 2002/089.
- Dr S K Sharma (Director, National Bureau of Plant Genetic Resources, New Delhi) visited Aleppo, Syria from 19 to 22 February 2007 for participating in the Global Diversity Trust/International Centre for Agricultural Research in Dry Area) ICARDA.
- Dr (Mrs) Saroj Sardana (Principal Scientist, NBPGR, New Delhi), Dr Shiv Kumar (Principal Scientist, IIPR, Kanpur) and Anita Roy (Aich Assistant Botanist, Murshidabad, West Bengal) visited Bangladesh for participating in the International Travelling Workshop on 'Lentil' being jointly organized by Bangladesh Agricultural Research Institute (BARI) and International Centre for Agricultural Research in Dry Areas (ICARDA) from 14 to 19 February 2007.
- Dr B Mishra (Project Director, DWR, Karnal),

Dr Alok K Sikka (Director, ICAR Research Complex for Eastern Region, Patna), Dr Rajender Prasad (National Fellow, IASRI, New Delhi), Dr Sain Dass (Project Director, Directorate of Maize Research, New Delhi) and Dr M L Jat (Scientist (SS), Project Directorate on Cropping System Research, Modipuram) visited Kathmandu, Nepal from 13 to 16 February, 2007 for participating in the 14th Regional Technical Co-ordinating Committee Meeting of Rice-Wheat Consortium-CIMMYT.

- Dr S N Shukla, ADG (F and FC), ICAR, and New Delhi, and Dr M. P. Pandey Director, CRRI,Cuttack, visited Vientiane, Lao PDR for attending the CURE Annual Meeting, 2007 and workshop on 'Socio-economic Aspects in Unfavourable Environment' from 21 to 23 February 2007.
- Dr J S Samra, DDG (NRM), ICAR, New Delhi, visited California, USA, for attending in the Central Steering Committee Meeting of Challenge Programme on 'Water and Food' from 6 to 8 March 2007.
- Dr Sanjoy Saha (Sr. Scientist, CRRI, Cuttack) visited IRRI, Philippines, for participating in the short-term training workshop on 'Ecological Management of Pest (Rodent, Insects and Weeds) : Biological Economic and Social Dimensions' from 19 to 30 March 2007.
- Dr Sanjoy Kumar Singh (Scientist (SS), DWR, Karnal) and Dr Gurvinder Singh Mavi (Assistant Plant Breeder, PAU, and Ludhiana) participated in the Wheat Improvement Course under ICAR-CIMMYT, bilateral programme in Mexico for 3 months i.e. from 26 February to 25 May 2007.
- Dr Raj K Gupta, OSD, NAIP, New Delhi, visited Tashkent to attend the Expert Consultation on Regional Research Need Assessment Jointly organized by CACAARI, GFAR and ICARDA from 7 to 9 March 2007.
- Dr S Ayyappan, DDG (FY), ICAR, visited Penang, Malaysia, to attend the Board of Trustees Meeting of World Fisah Centre in his capacity as Board Member from 11 to14 March 2007.
- Dr Mangala Rai, Secretary, DARE and DG, ICAR, visited Washington DC to participate in the Advisory Committee set up by the Consultative Group on International Agricultural Research (CGIAR) for interviewing the candidates short-listed for the post of Director, CGIAR from 5 to 6 March 2007.
- Dr Raj K Gupta, OSD, NAIP, New Delhi, visited Tashkent to attend the Expert Consultation on Regional Research Need Assessment jointly organized by CACAARI, GFAR and ICARDA from 7 to 11 March 2007.
- Dr V D Patil, ADG (O&P), ICAR, New Delhi, and Dr Arvind Kumar,Director, NRC on Rapeseed-Mustard, Bharatpur, and Dr J S Chauhan, Principal Scientist, NRC on Mustard, visited Wuhan, China to participate in the 12th International Rapeseed Congress from 26 to 30 March 2007, and Progress Meeting for ACIAR-ICAR Collaborative Project 'Oilseed *Brassica* Improvement in China, India and Australia' from 2 to 4 April 2007.
- Dr Masood Ali, Director, IIPR, Kanpur, visited Tunis, Tunisia, for attending in the International Meeting on Cool-season food legumes Model Legumes Congress 2007, from 24 to 28 March 2007.
- Dr K C Bansal, Professor, NRC on Plan Biotechnology, IARI, Pusa, New Delhi, visited China, under the ACIAR Project and also to participate in the 12th International Rapeseed Congress and Progress Meeting for the ACIAR-ICAR Collaborative Project on "Oilseed *Brassica* Improvement in China" from 26 to 30 March, 2007.
- Dr Jai Gopal,Principal Scientist, CPRI, Shimla, visited Lima Peru to act as a member of CGIAR/FAO panel for external review of International Potato Centre (CIP) from 10 to 14 April 2007 and 19 to 29 June 2007.
- Dr Mangala Rai, Secretary, DARE and DG, ICAR, visited Philippines to participate in the IRRI's Board of Trustees Meeting at IRRI (Headquarters), Philippines from 16 to 18 April 2007.
- Dr S K Yadav, Senior Scientist, Division of Seed Science and Technology, IARI, New Delhi, visited China for participating in the meeting of 12th International Rapeseed Congress, Wuhan, China from 25 to 30 March 2007.
- Dr N Sarangi, Director, Central Institute of Freshwater Aquaculture, Bhubaneshwar, and Dr K K Vass, Director, CIFRI, Barackpore, visited Hanoi, Vietnam for participating in the Final Workshop of Achieving Greater Food Security and Eliminating Poverty by Dissemination of Genetically Improve Carp Strain to Fish Farmer from 3 to 6 April 2007.
- Dr Mangala Rai, Secretary, DARE and DG, ICAR, visited Rome to participate in the first meeting of the Executive Board of the Global Crop Diversity Trust from 3 to 4 April 2007.
- Dr M P Pandey (Director), Dr O N Singh

(Principal Scientist), Dr A Gosh (Senior Scientist), Dr R N Das (Principal Scientist) and Dr P Samal (Senior Scientist, all from CRRI, Cuttack) visited Bangladesh for participating in the Annual Review and Planning meeting of the ADB funded Project "Development and disseminating water saving rice technology in South Asia" from 3 to 5 April 2007.

- Dr S P Tiwari, DDG (CS and Edn.), ICAR, visited Los Banos, Laguna, Philippines from 5 to 7 May 2007, and to Bangkok from 8 to 11 May 2007, for participating in the meeting with the members of IRRI Management and Scientific Staff to discuss various existing collaborative research activities between IRRI and ICAR, New Delhi, India, and INGER Technical Advisory Committee meeting.
- Dr J S Sandhu,Sr. Scientist (Pulses), PAU, Ludhiana, visited International Centre for Agricultural Research in Dry Areas, Mexico, to interact with legume researchers and other colleague from 12 to 18 May 2007.
- Dr Jai Gopal, Principal Scientist, CPRI, Shimla, visited Kenya, Uganda, and Tanzania from 13 to 19 May 2007, and Kazakhstan, Uzbekistan, Azerbaijan and Georgia, from 1 to 10 June 2007, as a Panel Member appointed by CGIAR for undertaking field visits for the review.
- Dr B C Viraktmath, Project Director, Directorate of Rice Research, Hyderabad, visited Bangkok for participation in the INGER Technical Advisory Committee Meeting from 8 to 11 May 2007.
- Dr Shiv Sewak (Sr. Scientist, IIPR, Kanpur) and Dr H K Dikshit (Sr. Scientist, IARI, New Delhi) visited ICARDA, Aleppo, Syria, to attend training programme as Junior Breeders as individual trainees on 'Lentil and Chickpea Breeding' from 20 April to 10 May 2007.
- Dr S K Naskar,Principal Scientist and Head, Regional Centre for CTCRI, Kerala, visited Manila, Philippines to participate in Workshop from 30 April to 2 May 2007.
- Dr S G Sharma, Principal Scientist, Dr (Mrs) Sanjukta Das,Senior Scientist from CRRI, Cuttack, and Dr N Shobha Rani, Principal Scientist, DRR, Hyderabad, visited Philippines for attending the International workshop on 'Clearing Old Hurdles with New Science: Improving Rice Grain Quality' from 17 to 19 April 2007.
- Dr R Kalpana Sastry, Principal Scientist, NAARM, Hyderabad, visited Caccarese, Rome, Italy for attending the Central Advisory Service on 'Intellectual Property' (CAS-IP) under Central National Partner programme meeting from 20 to 21 May 2007.
- Dr Seshu Madhav, Scientist (SS), DRR, Hyderabad, visited Philippines to undergo the training programme on Rice Research to Production, at International Rice Research Institute, Manila, from 14 May to 1 June 2007.
- Dr Anju Mahendru Singh, Senior Scientist, IARI, New Delhi visited Turkey for attending the Annual Meeting of Harvest and Consortium from 28 May to 2 June 2007.
- Dr Sant Kumar, Senior Scientist, and Dr Usha Rani Ahuja, Senior Scientist, NCAP, New Delhi, visited Nijoro, Kenya, for attending a training workshop on 'Planning Monitoring Evaluation and Impact Assessment of Research and Development Investments in Agriculture' from 16 to 27 July 2007.
- Shri A K Upadhyay, Additional Secretary, DARE and Secretary, ICAR, visited Lausanne, Switzerland to attend 3rd CGIAR Senior Leadership Programme from 2 to 6 July 2007.
- Dr C K Narayana, Senior Scientist, National Research Centre for Banana, Tiruchirapalli, Tamil Nadu, visited Ghana for attending workshop on 'Tools for Improving the Quality and Efficiency of Processed Products from Banana and Plantain for Small Processing Business' from 30 July to 3 August 2007.
- Dr George V. Thomas (Director) and Dr S Kalavathi (Senior Scientist, CPCRI, Kasaragod, Kerala) visited China for attending the Third Annual Project Planning Meeting of IFDA funded project "Overcoming Poverty in Coconut Growing Communities: Coconut Genetic Resources for sustainable Livelihoods' from 2 to 6 July 2007.
- Dr B Mishra, Project Director, Directorate of Wheat Research, Karnal, visited CIMMYT, Mexico, to participate in the meeting to discuss collaborative Project on 'Drought Tolerance in Wheat' under GC Programme from 6 to 8 August 2007.
- Dr A K Gogoi, ADG (Agronomy), ICAR, and Dr S K Dhyani,Director, NRC for Agroforestry, Jhansi, visited Sri Lanka to attend 3-day First Working Group meeting to develop a South Asia Regional Collaboration program on 'Agro-forestry at Topaz Hotel, Kandy, Sri Lanka from 28 to 30 June 2007.
- Dr Y S Ramakrishna, Director, CRIDA, Hyderabad, and Dr K P R Vittal, Director, CAZRI, Jodhpur, visited Montpellier, France for attending an oasis pro-proposal workshop organized by ICRISAT and ICARDA from

20 to 24 August 2007.

- Dr Mangala Rai, Secretary, DARE and DG, ICAR, visited Vientiane, Laos to attend IRRI's Board of Trustees Meeting from 19 to 21 September 2007.
- Dr M Prashar, Sr. Scientist, DWR, Karnal, and Dr J P Jaiswal, Assistant Professor, GBPUA&T, Pantnagar, visited Mexico to attend Programme for intensive agro-ecosystem for 6 weeks with effect from 1 September 2007.
- Dr Uma,Sr. Scientist, NRC for Banana, Thiruchirapalli, Tamil Nadu, visited South Africa for attending the Symposium on 'Recent Advances in Banana Crop Protection for Sustainable Production and Improved Livelihoods' from 10 to 15 September 2007.
- Dr J S Sandhu, Sr. Scientist, Department of Plant Breeding, Genetics and Bio-technology, PAU, Ludhiana, visited Western Australia, Australia, to attend Planning Meet for "Accelerated Genetic Improvement of Chickpea" and International alliance among DAFWA, CLIMA, COGGO and ICRISAT and joint work on DEST DY01-0003-Eco-geographical and physiological approaches to improve chilling tolerance in chickpea in Australia and India from 16 to 27 September 2007.
- Dr Gurubachan Singh, Director, CSSRI, Karnal, visited Philippines International Rice Research Institute from 5 to 11 October 2007.
- Dr S Ayyappan, DDG (Fy), ICAR, visited Colombo, Sri Lanka from 1 to 4 November 2007 to attend the 34th Board of Trustees Meeting.
- Dr M P Pandey, Director, Central Rice Research Institute, Cuttack, and Dr A K Singh (the then Project Director, WTC, New Delhi) visited Hanoi, Vietnam for attending the Steering Committee Meeting of the Irrigated Rice Consortium from 8 to 10 October 2007.
- Dr S Edison (Director, Central Tuber Crops Research Institute, Thiruvananthapuram) and Dr D P Balasubramanian (Director, Centre for Plant Molecular Biology, Tamil Nadu Agricultural University, Coimbatore) visited St. Louis, Missourri, USA, from 30 to 31 January 2007, to attend International Workshop on Cassava Genomics under the Indo-US Agriculture Knowledge Initiative.
- Dr R P Nachane (Principal Scientist, CIRCOT, Mumbai) and Dr K Gururajan (Principal Scientist, CICR, Nagpur) visited Egypt from 18 to 31 May 2007, for study in the field of "Cotton Improvement and Quality Assurance".
- Dr Nawab Ali,DDG (Engg.), ICAR, New Delhi, visited USA from 30 May 2007 to 8 June 2007, as a member of the Indian delegation led by Hon'ble Minister of State for Food Processing and Industries.
- A high level delegation led by Dr Mangala Rai (Secretary, DARE and Director -General, ICAR) and consisting of Shri A K Upadhyay (Additional Secretary, DARE and Secretary, ICAR), Dr S K Bandyopadhyay (Animal Husbandry Commissioner, Department of Animal Husbandry, Dairying and Fisheries), Dr S P Tiwari (DDG (Edn.), ICAR), Sh Virender Paul (Director (AMS), Ministry of External Affairs, New Delhi), Dr P L Gautam (Vice Chancellor, G B Pant University of Agriculture & Technology, Pantnagar), Shri Anurag Bhatnagar (Director-General, National Institute of Agricultural Marketing, Jaipur) and Shri Feroze Noshir Masani (Masani Farm, Nasik, Maharashtra) visited USA to attend the 5th Agriculture Knowledge Initiative (AKI) Board Meeting from 14 to 15 June 2007. Some members of the delegation also visited Ohio State University, USA from 12 to 13 June 2007.
- A 5-member multi-departmental delegation, viz Dr R K Khetrapal (Head, Division of Plant Quarantine, NBPGR, New Delhi), Dr V K Dilawari (Professor of Ecology, PAU, Ludhiana), Dr Ashish Motiram Paturkar (Professor, Bombay Veterinary College, Maharashtra Animal and Fisheries Science University, Mumbai), Shri Arvind Kumar Gupta, Advisor (WTO), Agricultural and Processed Food Products Export Development Authority (APEDA), Ministry of Commerce and Industry, New Delhi, and Shri Surendra Singh (Assistant Director, Ministry of Food Processing Industries, New Delhi, visited USA on cooperation exchange of information and SPS requirements, regulations and development under the Indo-US Agriculture Knowledge Initiative (AKI) from 11 to 16 June 2007.
- Dr (Ms) S Elain Apshara, Scientist (Senior Scale), Central Plantation Crops Research Institute, Kasaragod, visited Embrapa Coastal Tablelands Aracaju-SE, Brazil from 15 to 22 July 2007, for undergoing training in "Coconut and Cocoa Production".
- Dr Rajbir Singh, Senior Scientist, Central Institute for Post Harvest Engineering and Technology, Ludhiana, visited Embrapa Vegetables, Brasilia-DF, Brazil, from 16 to 20 July 2007, for undergoing training in "Post Harvest Technology and Value Addition".
- Dr K C Jain, ADG (CC), ICAR Headquarters, New Delhi, visited Bhutan as a member of

the delegation led by Agriculture Commissioner to participate in the India-Bhutan Joint Technical Working Group Meeting on Co-operation in Agriculture from 23 to 24 July 2007.

- Dr Ravender Singh (Principal Scientist) and Dr Atmaram Mishra, Principal Scientist, Water Technology Centre for Eastern Region, Bhubaneshwar, visited ARC, Egypt from 1 to 14 August 2007, for study on "On Farm Water Management".
- Dr Shyam Singh, Director, NRC for Citrus, Nagpur, visited Embrapa Cassava and Fruits, Cruzdas Almas-BA from 5 to 10 August 2007, for undergoing training in the field of Orange Production and Processing.
- Dr Pitam Chandra, ADG (PE), ICAR Headquarters, New Delhi, visited ARC, Egypt from 1 to 7 September 2007, for study in Post-harvest Management and Processing of Fruits (Date Palm and Pomegranate).
- Dr Khajanchi Lal, Senior Scientist, CSSRI, Karnal, visited ARC, Egypt from 1 to 14 September 2007, for study in the field of Water Quality and Bio-remediation.
- Dr Murari Shyam, Project Coordinator (Res.), CIAE, Bhopal, visited Nepal Agricultural Research Council, Nepal, for study in Renewable Energy Resource in Nepal from 15 to 21 September 2007,.
- Dr Lal Krishna, ADG (AH), ICAR Headquarters, New Delhi, visited ARC, Egypt, for study in "Animal Disease Diagnosis and Surveillancee," from 16 to 29 September 2007.
- Dr Sunil Goria, Assistant Librarian, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, visited USA (Washington) for training in "Strengthening the Knowledge Information System: Library and Information System", under Indo-US Norman Borlaug Fellowship covering Indo-US Agriculture Knowledge Initiative from 27 September to 10 November 2007.
- Dr R R Saxena, Associate Professor, Indira Gandhi Agricultural University, Raipur, Chhattisgarh visited USA for training in "Distance Learning and Agricultural Curricula Building", at Purdue University, West Lafayette, USA from 1 October to 11 November 2007.
- Dr N Gopalakrishna Pillai, Principal Scientist, Central Marine Fisheries Research Institute, Cochin), visited ARC, Egypt for study in the field of "Marine Fisheries Resources", from 20 October to 1 November 2007.
- Dr Hari Lal Kushwaha, Scientist, Central Arid Zone Research Institute, Jodhpur, visited University of Missourie, USA, for training in Biofuel Production from Mustard, Sesame and Cottonseed, under Indo-US Norman E. Borlaug International Agricultural Science and Technology Fellowship Program under Indo-US Agriculture Knowledge Initiative (AKI) from 1 November to 15 December 2007.
- Dr Srinivas Indravarapu, Scientist, Central Research Institute for Dryland Agriculture, Hyderabad, visited University of Missourie, USA for training in the field of Biodiesel, under Indo-US Norman E. Borlaug International Agricultural Science and Technology Fellowship Program under Indo-US Agriculture Knowledge Initiative (AKI) from 1 November to 15 December 2007.
- Dr A K Nayak, Senior Scientist, CSSRI Regional Station, Lucknow, will be visiting ARC, Egypt for study in the field of "Salinity Control" from 17 to 30 December 2007.

Delegations hosted

- Mr Sanjaya Kumar Kaflay and Mr Amber Bahadur Gurung (Accounts Officers from Nepal Agricultural Research Council, Nepal) came at National Academy of Agricultural Research Management, Hyderabad, for study visit/training in the field of 'Personnel and Fiscal Management training' for a period of 3 weeks from 10 to 30 July 2007 under the ICAR-NARC Work Plan for the years 2006–07.
- Mr S N Vaidhya and Pulkit Mandal, Senior Scientists (S-4), from Nepal Agricultural Research Council, Nepal, had observation visit at National Academy of Agricultural Research Management, Hyderabad, in the field of 'Management Institute' for 1 week from 16 to 21 July 2007 under the ICAR-NARC Work Plan for 2006–07.
- Mr Mahendra Jung Thapa and Mr Ram Bahadur K C (Senior Scientists) from Nepal Agricultural Research Council, Nepal, had observation visit at Indian Institute of Horticultural Research, Bangalore in 'Fruits and Vegetable Processing, Packaging and Product Diversification' for 1 week from 4 to 10 July 2007 under the ICAR-NARC Work Plan for 2006–07.
- Ms Sharmila Piya (Technical Officer) from Nepal Agricultural Research Council, Nepal, had Study visit/training to Indian Institute of Horticultural Research, Bangalore, in "Post Harvest Management in Ornamental Crops", from 16 to 26 August 2007 under the ICAR-NARC Work Plan for 2006–07.
- Mr Ram Bahadur Rane,Technical Officer (T-

6), from Nepal Agricultural Research Council, Nepal, had study visit/training in the field of Cryopreservation Technology in Cattle/ Buffaloes/Goats/Sheep at Indian Veterinary Research Institute, Izatnagar, for 3 weeks from 11 to 31 August, 2007 under the ICAR-NARC Work Plan for 2006–07.

- Mr Ram Babhu Peneru, Scientist (S-2), from Nepal Agricultural Research Council, Nepal had study visit/training at Indian Agricultural Research Institute, New Delhi, in Taxonomy and Identification of Insects of Agricultural Importance, for 1 month from 15 August to 14 September 2007; and Mr Govind Prasad Timilsha, Scientist (S-1), from Nepal Agricultural Research Council had study visit/ training at Indian Agricultural Research Institute, New Delhi, in 'Pesticides Residue Extraction and Analysis Procedures' for 1 month from 15 August to 14 September 2007, under the ICAR-NARC Work Plan for 2006–07.
- Mr Mathura Yadav (Technical Officer) from Nepal Agricultural Research Council, Nepal, had study visit/training at Indian Agricultural Statistics Research Institute, New Delhi, on 'Biometrics in Agricultural Research' for 2 months from 3 October to 1 December 2007, under the ICAR-NARC Work Plan for 2006–07.
- Dr Shambhu Bahadur Pandey (Director, NASRI) and Dr Adarsha Pradhan (Livestock and Fishery) from Nepal Agricultural Research Council, Nepal, had study visit/ training at National Dairy Research Institute, Karnal, from 8 to 10 October 2007, and Indian Veterinary Research Institute, Izatnagar, from 11 to 13 October 2007, for study in the field of 'Animal Science Research Institute' under the ICAR-NARC Work Plan for 2006–07.
- Mr Mishri Lal Sah, Senior Scientist, from Nepal Agricultural Research Council and Dr Siddhi Ganesh Shrestha (Senior Economist) from Ministry of Agriculture and Co-operative from Nepal, had observation visit to Indian Agricultural Research Institute, New Delhi, from 24 to 30 September 2007 under the ICAR-NARC Work Plan for 2006–07.
- Dr R K Mittal, (Principal Scientist, ICAR (Hq), New Delhi) visiting NARC, Nepal from 7 to 13 December 2007, for study in "Biological control agents and antagonists.
- Dr Ravi R Saxena (Associate Professor, Indira Gandhi Agricultural University, Chhattisgarh) visited Purdue University, West Lafayette, USA from 1 October to 11 November 2007, for training in "Distance Learning and Agricultural Curricula Building" under Indo-US Norman Borlaug Fellowship.
- Dr N Gopalkrishna Pillai (Principal scientist, CMFRI, Cochin, visited Agricultural Research Centre, Egypt from 20 October to 1 November 2007, for study in Marine Fisheries Resources under Indo-US Norman Borlaug Fellowship.
- Dr Hari Lal Kushwaha (CAZRI), Jodhpur, visited University of Missouri, USA from 1 November to 15 December 2007, for training in "Biofuel Production from Mustard, Sesame, Cottonseed" under Indo-US Norman Borlaug Fellowship.
- Dr Srinivas Indavarapu (CRIDA, Hyderabad) visited University of Missouri, USA from 1 November to 15 December 2007, for training in the field of "Biodiesel" under Indo-US Norman Borlaug Fellowship.
- Dr R K Mittal, ADG (EQR), ICAR Hq, New Delhi visited Indonesia from 30 to 31 October 2007, for attending the ASEAN-Indian Working Group Meeting held at Jakarta, Indonesia.
- Dr Mahavir Singh (Project Coordinator, AICRP on Micro- and Secondary Nutrients and Pollutant Elements in Soil and Plants, Bhopal) and Dr A K Sarkar (Dean, College of Agriculture, Birsa Agricultural University, Ranchi) visited Addis Abada, Ethiopia from 2 to 17 December 2007, for studying salinity problems and agriculture problems in Ethiopia for increasing output.
- Dr S P Tiwari (DDG (Edn.), ICAR Hq, New Delhi) visited Brasillia, Brazil from 21–24 November 2007, for attending the India-Brazil-South Africa Joint Working Group Meeting on Agriculture.

Scientists to foreign countries on deputation

- Dr G J N Rao (Head, Crop Improvement, CRRI, Cuttack) visited for building up anther culture laboratory and demonstration in Sierra Leone from 19 to 27 April 2007.
- Dr N Sarangi (Director, CIFA, Bhubaneshwar) attended NACA workshop at Bali, Indonesia, from 30 April to 5 May 2007.
- Dr C S Chaturvedi,SS (Fisheries) CARI, Port Blair, and Dr Prem Kumar, Sr. Scientist, NRC, Cold Water Fisheries, Bhimtal, deputed to China from 25 April to 24 June 2007.
- Dr Madhwan (Principal Scientist) and Dr C Palaniswami (Sr. Scale Scientist) visited Fizi under ITEC Programme of MEA for 1 year.
- Dr T C Santiago (Head, Aquaculture, Animal Health Division, CIBA, Chennai) attended ACIAR Project Co-ordination Meeting in Bangkok, Thailand, from 14 to 15 May 2007.
- Dr D K Sadana (Principal Scientist, NBAGR,

Karnal) attended Regional multi-stake holder workshop, Ethiopia, from 24 to 25 May 2007.

- Dr K V Prabhu (Head, Division of Genetics, IARI, New Delhi) participated in the FAO consultation to review the draft on Food Safety Assessment from 23 to 25 May 2007.
- Dr Sushil Pandey, Scientist (Senior Scale), Division of Seed Science and Technology, IARI, New Delhi, attended a Seed Quality Assurance Workshop under FAO's TCDC Programme at Baku, Azerbaijan, from 29 May to 2 June 2007.
- Dr P K Joshi (Director, NCAP, New Delhi) participated in IAASSTD, Bureau Meeting in Washington from 29 to 30 May 2007.
- Dr B M Khadi (Director, CICR, Nagpur) participated in the 3 Steering Committee Meeting of INCANA in Damascus from 19 to 21 June 2007.
- Dr P K Joshi (Director, NCAP, New Delhi) participated in GC Meeting of UNESCAP-CAPSA in Indonesia, from 18 to 19 June 2007.
- Dr P S Minhas, ADG (IWM), attended the Steering Committee Meeting in Ethiopia from 18 to 23 June 2007.
- Dr Ramesh Chand (National Professor, NCAP, New Delhi) visited Bangkok, under FAO Consultancy Programme in different spells, for 3 months from mid- June 2007.
- Dr L Joseph Shayarajan (Technical Officer, CIBA, Chennai) visited Australia for training under Commonwealth Programme from 30 August to 24 October 2007.
- Dr R S Misra (Principal Scientist and Head, Division of Protection, CTCRI, Thiruvananthapuram) visited China as FAO (TCDC) consultant on Konjac Seed Production and Storage from 25 August to 8 September 2007.
- Dr M Prabhakar (Principal Scientist) and Dr (Mrs) Girija Ganeshan (Principal Scientist, IIHR, Bangalore) participated in the 5th International ISHS symposium on Edible Alliance, and 2nd World Onion Conference, 2007 at Lelystad, Netherlands from 29 October to 3 November 2007.
- Dr S K Tandon,ADG (Engg.), attended UNESCAP-APCAEM Workshop from 24 to 28 October 2007.
- Dr A K Singh, Head, Germplasm Collection Division, NBPGR, New Delhi, visited Kathmandu, Nepal, to establish long-term conservation facility under consultancy proposal for 2 weeks.
- Dr Jagdish Rane, Senior Scientist, DWR, Karnal, visited Cali, Columbia, as a visiting Scientist at CIAT for MAFF, Japan Project for 2 years w.e.f. the date he is relieved from the Institute.
- Dr P K Joshi, FAO-GOI Strategic Alliance for South-South Cooperation, attended meeting of SAARC in support of National and Regional Programmes for Food Security at Dacca, Bangladesh from 3 to 5 November 2007.
- Dr R S Misra (Principal Scientist and Head, Division of Crop Protection, CTCRI, Thiruvananthapuram) visited Kabul under FAO Consultancy Programme from 2 November to 16 December 2007.
- Sh. Amar Pal (Technical Officer, NBFGR, Lucknow) visited Bangkok for training in the Fish Health Master Class sponsored by NACA, Bangkok, from 12 to 23 November 2007.
- Dr G Gopa Kumar, Principal Scientist, CMFRI, Kochi, participated in workshop on Marine Finfish Aquaculture in Indonesia from 7 to 10 November 2007.
- Dr B M Khadi, Director, CICR, Nagpur, attended World Trade Organization workshop on the development aspects of cotton in Geneva from 19 to 21 November 2007.
- Dr Sita Ram Aryal (Senior Scientist, Nepal Agricultural Research Council, Nepal) visited Indian Veterinary Research Institute, Izatnagar from 16 November to 4 December 2007, for study in Avian influenza of poultry culture identification.
- Dr (Mrs) Wafaa Taha El-Ater (Principal Scientist, Agricultural Research Centre, Egypt) visited Central Soil Salinity Research Institute, Karnal from 17 November to 4 December 2007 for study in the field of Saline Control.
- Dr Hossain Ali Ali Metwaly and Dr (Mrs) Fatma Esmat (Senior Scientist, Agricultural Research Centre, Egypt) visited Central Institute for Post-harvest Engineering and Technology, Ludhiana from 19 to 27 November 2007, for studying in Post Harvest Management and Processing of Fruits (Date Palm and Pomergranate.
- Dr Mahmoud Atiya and Dr Hassan Shams El-Din (Chief Researchers of Soil Water and Environment Research Institute, Agricultural Research Centre, Egypt) visited to Water Technology Centre for Eastern Region, Bhubaneshwar from 22 October to 7 November 2007, for studying in On Farm Water Management.

Approved deputation cases of the ICAR scientists

- Dr Sadhan Bag Senior Scientist, IVRI, Izatnagar availed Long-Term training at Germany under DBT, Biotechnology Overseas Associationship Programme to Germany, sponsored by Department of Biotechnology (DBT), New Delhi, for 12 months w.e.f. 6 September 2006.
- Dr T K Bhattacharya,Scientist (SS), IVRI, Izatnagar, visited Canada for availing training under DBT, Biotechnology Overseas Associateship Programme, sponsored by Department of Biotechnology (DBT), New Delhi, to Canada for 12 months w.e.f. 6 September 2006.
- Dr Aniket Sanyal,Scientist, Project Directorate on Foot-and-Mouth Disease, Mukteswar, visited for availing Biotechnology Overseas Associateship to CSIRO, Australia w.e.f. 1 September 2006 for 12 months. It was sponsored by Department of Biotechnology, New Delhi.
- Dr S B Barbuddhe, Scientist (SS) (Veterinary Public Health), ICAR Research Complex for Goa, visited Germany for availing DBT Biotechnology Overseas (Associateship (Long-term) 2005–06 for 1 year beginning from October/November 2006 to October/ November 2007. It was sponsored by Department of Biotechnology, New Delhi.
- Dr S K Mahanker, Scientist (SS), CIAE, Bhopal, visited USA for pursuing Ph.D, sponsored by Oklahoma State University, USA, for 3 years w.e.f. 9 August 2006.
- Dr M K Singh, Scientist, CIAE, Bhopal, visited Shizuka University, Johoku Hamamator, Japan, for pursuing Ph.D. programme, sponsored by Shizuoka University, Japan, for 3 years w.e.f. 1 October 2006.
- Dr N K Shivakumar Gowda, Senior Scientist, NIANP, Bangalore, visited USA to avail Biotech Overseas Associateship (Short-term) Programme 2005–06, sponsored by Department of Biotechnology, New Delhi, for 6 months tentatively and 15 January to 1 February 2007.
- Dr S Kannappan, Scientist (SS), CIBA, Chennai, visited USA to avail DBT Biotech Overseas Associateship (Long term) Programme 2005–06, sponsored by Department of Biotechnology, New Delhi, for 12 months w.e.f. 23 October 2006.
- Dr A K Singh, Senior Scientist, IARI, New Delhi, visited USA to avail DBT Biotechnology Overseas Associateship (Short-term) Program 2005–06, sponsored by Department of Biotechnology, New Delhi, for 6 months beginning from first week of November 2006.
- Dr T K Behra, Scientist (S-3), IARI, New Delhi, visited University of Wisconsion, Madison, USA, to avail DBT Biotechnology Overseas Associateship (Long-term) Programme 2005–06, sponsored by Department of Biotechnology, New Delhi for 12 months i.e. 5 October 2006 to 4 October 2007.
- Dr M Vanaja, Senior Scientist, CRIDA, Hyderabad, visited University of Essex, United Kingdom, to avail Commonwealth Academic Staff Fellowship, sponsored by Commonwealth Felloship Commission, United Kingdom, for 6 months i.e. from October 2006 to April 2007.
- Dr (Mrs) R Manimekalai, Scientist, CPCRI, Kasragod, visited Japan to avail DBT Biotechnology Overseas Associateship (Long-term) program 2005–06, sponsored by Department of Biotechnology, New Delhi, for 10 months tentatively from last week of March 2007.
- Sh Ranjan Bhattacharya, Scientist, VPKAS, Almora, visited UK for pursuing Ph. D. Programme at the School of Applied Sciences, University of Woverhamton, UK under BORASSUS Project for 3 years w.e.f. September 2006.
- Dr O P Yadav, Principal Scientist, CAZRI, Jodhpur, visited USA to avail DBT Biotechnology Overseas Associateship (short-term) sponsored by Department of Biotechnology, New Delhi, for 6 months w.e.f. 25 November 2006.
- Dr Rajsekhara Rao Korada, Scientist (SS), CTCRI's Regional Station, Bhubaneshwar, Orissa, visited Netherlands to avail long-term DBT Biotechnology Overseas Associateship, sponsored by Department of Biotechnology, New Delhi, for 12 months w.e.f. 25 March 2007.
- Dr Raveendra N Gadag (Senior Scientist, IARI, New Delhi) visited UK to undergo UGC's sponsored Commonwealth Academic Staff Fellowship to John Inne's Centre, Norwich, United Kingdom, sponsored by Commonwealth Fellowship Commission, United Kingdom for 6 months w.e.f. 2 October 2006.
- Dr P Das, Senior Scientist, CIFA, Bhubaneshwar, visited USA for availing DBT's Biotechnology Overseas Associateship (Short-term) program 2005–06 on "Aquaculture and Marine Biotechnology" to Eventual and Genomics Sec., Department

of Environ Pop Health, Tufts University, USA, sponsored by Department of Biotechnology, New Delhi, for 6 months w.e.f. 26 November 2006.

- Dr Pious Thomas, Senior Scientist (IIHR, Bangalore), visited Australia for availing Biotechnology Overseas Associateship (Short-term), 2005–06 training in "Molecular Endophytic Microbiology" to Elinders University, Adelaide, Australia, sponsored by Department of Biotechnology, New Delhi, for 6 months w.e.f. 17 March 2007.
- Dr C P Balasubramanian, Senior Scientist, CIBA, Chennai, visited USA for availing DBTs Biotechnology Overseas Associateship (Short-term), 2005–06 to California State University in USA, sponsored by Department of Biotechnology, New Delhi for 6 months w.e.f. February 2007.
- Dr K K Vijayan, Head, PNP Division, CMFRI, Cochin, visited Belgium for availing Biotechnology Overseas Associateship (Short-term), 2005–06, sponsored by Department of Biotechnology, New Delhi for 5 months and 3 weeks w.e.f. 8 March 2007.
- Dr R Thangavelu, Senior Scientist, N R C Biotechnology, Truchirappaly, Tamil Nadu, visited for availing DBT long-term Biotechnology Overseas Associateship to Department of Primary Industries and Fisheries, Indooroopilly, Brisbane, Australia, 2005–06, sponsored by Department of Biotechnology, New Delhi, for 12 months w.e.f. 01 January to 31 December 2007.
- Dr Murali Gopal, Senior Scientist, CPCRI, Kasaragod, visited United Kingdom for undergoing research work on the project entitled Evaluating the effect of coconut leaf vermicompost on the soil microbial, biomass, microbial diversity and glomalin production as biological indicators of soil fertility to UK, sponsored by Organizers (Rothamsted), for 12 months w.e.f. January 2007.
- Dr Ramesh Sundar, Senior Scientist (SBI, Coimbatore), visited Australia for carrying research work in the areas entitled "Functional Genomics of Transcription Factors Regulating Defence against Fungal Pathogens in Monocotyledonous Crops, e.g. sugarcane under DBT's Biotechnology Overseas Associateship 2005–06 Programme to CSIRO, Brisbane, sponsored by Department of Biotechnology, New Delhi, for 12 months w.e.f. 1 February 2007.
- Dr R S Kataria, Senior Scientist, NBAGR, Karnal, visited Iowa State University, Iowa, USA, for availing Biotechnology Overseas Associateship, 2005–06, sponsored by Department of Biotechnology, for 6 months w.e.f. January 2007.
- Dr Dinesh Kumar, Scientist (SS), NBAGR, Karnal, visited Iowa State University, Iowa, USA, for availing Biotechnology Overseas Associateship, 2005–06, sponsored by Department of Biotechnology for 12 months w.e.f. 23 January 2007.
- Dr Dinesh Singh, Senior Scientist, IARI, New Delhi, visited IRRI, Philippines for training course on Identification of Resistant Genes through Marker Assisted Selection, sponsored by IARI, New Delhi, under their budget head Human Resource Development 10th Plan, for 3 month w.e.f. 5 January 2007.
- Dr S K Chakravarty, Senior Scientist, IARI, New Delhi, visited IRRI, Philippines, for training course on Innovative approaches in Hybrid Seed Production of Rice, sponsored by IARI, New Delhi under their budget Head HRD 10th Plan, for 2 months w.e.f. 26 March 2007.
- Dr (Mrs) Latha Sabikhi, Senior Scientist, NDRI, Karnal, visited Italy for undergoing training course, organized by CoRFiLac, Ragusa, Italy on Cheese Making, for 13 days w.e.f. 29 April 2007.
- Dr Sanjay Gupta, Senior Scientist, ICAR Research Complex for NEH Region, Baarapani, Meghalaya, visited CSIRO, Canberra, Australia, for undergoing specialized training of young scientist in Niche areas of Biotechnology under DBT, sponsored by Department of Biotechnology, New Delhi, for 12 months w.e.f. 10 December 2007.
- Dr J P Mittal, National Coordinator, NAIP, New Delhi, visited USA for undergoing training course on Accessing Global Markets, sponsored by NAIP, New Delhi, and organized by Cornell University in collaboration with Sathguru Management, Hyderabad at Cochin, Kerela and at Ithaca, New York, USA from 15 to 20 April 2007 and from 2 to 9 May 2007 respectively.
- Dr Sant Kumar (Sr. Scientist, NCAP, New Delhi) attended training course on Accessing Global Markets, sponsored by NCAP, New Delhi, and organized by Cornell University in collaboration with Sathguru Management, Hyderabad, at Cochin, Kerala and at Ithaca, New York, USA from 15 to 20 April 2007 and from 2 to 9 May 2007, respectively. ❑

19. National Agricultural Innovation Project

The NAIP is for facilitating accelerated and sustainable transformation of Indian agriculture in support of poverty alleviation and income generation by collaborative development and application of agricultural innovation by public research organizations in partnership with farmers groups, private sector, civil society organizations and other stakeholders. The total budget for the project is US $ 250 million; the World Bank will fund US $ 200 million as credit and US $ 50 million will be contributed by the Government of India. The project is planned for 6 years, and was launched on 26 July 2006.

The NAIP will function through four components:

- The ICAR as Catalyzing Agent for Management of Change in the Indian NARS
- Research on Production to Consumption Systems (PCS)
- Research on Sustainable Rural Livelihood Security (SRLS), and
- Basic and Strategic Research in the Frontier Areas of Agricultural Sciences (BSR).

Achievements

- A total of 7 projects have been sanctioned in the first Component. They cover research on visioning, policy analysis and gender in NARS, establishment of a consortium for e-Resources in Agriculture (CeRA), development of e-Courses for B Sc (Agric.), B V Sc and Animal Husbandry degree programmes, and digitization of Ph D theses submitted since 2000, Knowledge Management in Agriculture, involving IIT Mumbai, IIT Kanpur and IIT Thiruvananthapuram, and ICRISAT; and strengthening learning and capacity-building in the NARS involving IIM Lucknow, MANAGE, Hyderabad and NIRD, Hyderabad. The project on "Visioning Policy Analysis and Gender (V-PAGe)" was launched on 26–27 June 2007 at the NCAP, New Delhi.
- In Component 2, a total of 15 projects have been developed into full proposals. Four have been approved and they include value-chain of biofuel crops in rainfed areas, value-chain for cotton, responsible harvesting and utilization of selected marine small pelagics and freshwater fishes, and value chain on small millets.
- In Component 3, so far 6 projects have been sanctioned. They include sustainable rural livelihood security in backward districts of Maharashtra, enhancement of livelihood security through sustainable farming systems and related farm enterprises in the North-West Himalaya, livelihood improvement and empowerment of rural poor through sustainable farming systems in the North-East India, sustainable rural livelihoods through enhanced farming system productivity and efficient support systems in rainfed areas in Andhra Pradesh, livelihood and nutritional security of tribal dominated areas through integrated farming system and technology models in 4 backward districts of Rajasthan and developing sustainable farming system models for prioritized microwatersheds in rainfed backward districts of Jharkhand.
- In Component 4, three projects have been sanctioned. They include arsenic in food chain: cause, effect and mitigation; unravelling molecular processes involved in adventive polyembryony towards genetic engineering for fixation of heterosis; and genomics of cotton boll and fibre development. Eight other projects were also approved.

- A number of short-and long-term consultancies have been finalized. They include Financial Management System, Monitoring and Evaluation of NAIP projects and for developing a road map for commercialization of technologies and business planning and development of NARS, and consultancy on Communication and Public Awareness in the NARS.
- The first call for concept notes made in November 2006 met with an overwhelming response, 992 concept notes have been received. The second call for concept notes was made in September 2007.

National Fund for Basic and Strategic Researches in Agriculture

Under the National Fund for Basic and Strategic Researches in Agriculture, 14 projects were sanctioned towards the end of 2006–07, and 7 have been sanctioned in 2007. These projects are in diverse, novel and advanced fields of researches: Understanding molecular and genetic bases of crop-plants, responses to biotic and abiotic stresses; studies on molecular and physiological bases of reproductive systems in buffaloes (a very important but not well understood area); autotransgenics in fish; rumen microbial manipulation to enhance feed efficiency in cattle; use of apomixis for hybrid development in plant; plant-biomass based decentralized production of hydrogen and urea in rural areas; and use of electromagnetic radiations for seed conservation. All projects are multi-institutional and multi-disciplinary. Project leaders are from ICAR institutes (16), State Agricultural Universities (2), IISc (1), CSIR (1) and ICRISAT (1). These projects will generate not only new knowledge and solve outstanding scientific problems but will also be directly applicable in the near future for technology development for solving problems in agriculture.

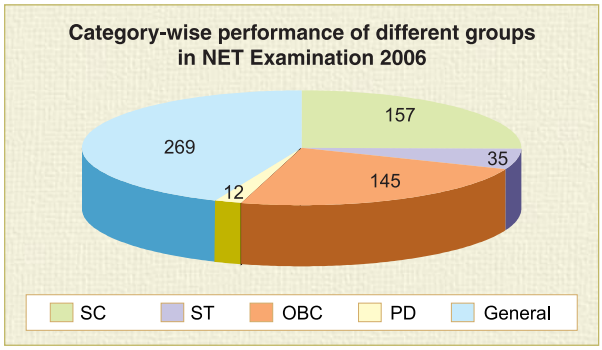
❑

20. Recruitment of Scientific Resource

The highlights of the various activities of the Agricultural Scientists' Recruitment Board (ASRB), an independent recruitment agency under DARE/ ICAR, undertaken during 2007–08 are briefly described.

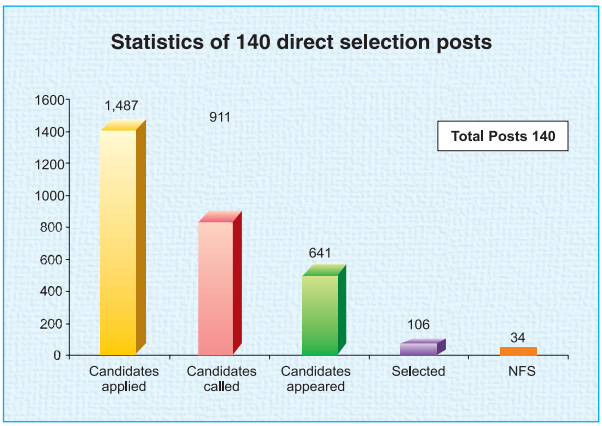
ARS/NET Examination 2006

The Agricultural Research Service (ARS)/ National Eligibility Test (NET) examination was held on April 2007 at 32 centres spread throughout the country. Of the 10,973 candidates appeared in examination, only 618 cleared NET in 49 ARS disciplines, but none qualified in 20 disciplines. The success ratio for NET was 1:17. A total of 419 candidates were called for ARS interview for the 220 advertized vacancies in 24 disciplines. The interview for ARS has been completed and the results would be declared shortly. The next examination is scheduled to be held in April 2008.

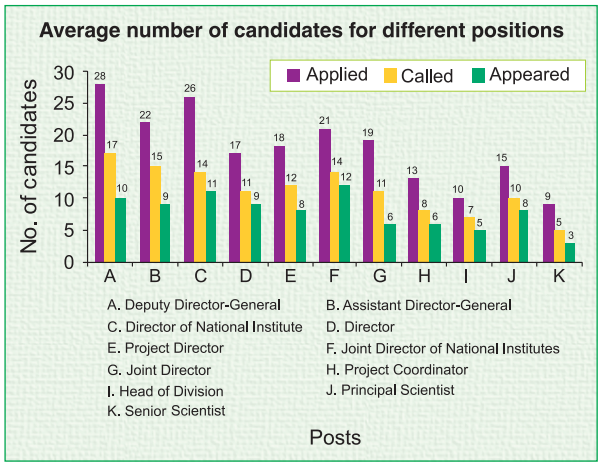


Direct Recruitment to Scientific Positions through Interview

The Board has completed recruitment process in respect of 140 posts during the current year (April–October 2007). Of these, 11 posts are Research and Management Positions (RMP), 24 middle-level management (Heads, Project Co-ordinators, Zonal Co-ordinators and Joint Directors), and the remaining of Senior and Principal Scientist category. The Board could make positive recommendations in 106 cases, whereas in rest of the cases no suitable candidates were available.



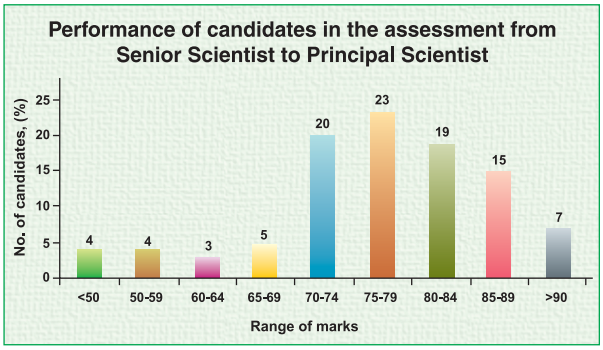
In all, the Board screened more than 1,487 applications and called about 911 candidates but only 641 attended the interview. Thus, on an average, there were 5 candidates for each position.



But the inter-category distribution of available candidates was highly skewed. The availability of the candidates for Senior Scientist posts was very low, and out of 96 posts, 31 could not be filled, as suitable candidates were not available.

Assessment

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 at the ASRB were constituted



with the approval of Chairman, ASRB. This year 305 proposals were received, out of which 9 cases could not be considered due to incomplete information. The performance in respect of assessment promotion was quite high, as 84% of the candidates were recommended for promotion to the next grade. Of the successful candidates, 415 secured more than 80% marks and amongst the unsuccessful candidates, 8% had less than 60% marks.

Reforms

New Scorecard for Direct Recruitment: A New Scorecard has been designed with revised weightage at Senior Scientist/Principal Scientist levels. This has been done to take care of the activities that are generally performed at these levels. Also, it has been decided that 45% would be the minimum marks for calling candidates for interview, provided they fall in the first 10 ranks. The cutoff marks for calling a candidate for personal interview at RMP level is 50%.

New Syllabus for ARS/NET Examination as per New Disciplines: Keeping in view the regrouping of disciplines, syllabus was prepared by the high level committee, which has been approved by the President. For the next ARS/NET examination Question Bank is being prepared. The next ARS/NET examination would be held according to the revised syllabus.

Modification of qualification for the Recruitment to the Post of Senior Scientists: The Board recommended reduction in the requirement of experience by one year in the previous grade and also for considering the candidates with post-doctoral experience in reputed institutions. These recommendations have been accepted by the Competent Authority.

Right To Information Act -2005

During the year, Board had received 34 cases, largely related to the disclosures of marks secured in the scorecard and interviews. Keeping in view the policy of complete transparency, the Board has now decided to disclose marks to individuals seeking this information under RTI. Out of 34 cases, only 2 candidates filed their appeals with CIC against the ASRB decision. All the cases were disposed successfully to the satisfaction of all the concerned parties.

(A) DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

APPENDIX I

THE GOVERNMENT OF INDIA (ALLOCATION OF BUSINESS) RULES
THE SECOND SCHEDULE
(RULE 3)

(A) Distribution of Subjects in the Department (*Vibhag*), Ministry of Agriculture (*Krishi Mantralaya*)

(B) Department of Agricultural Research and Education (*Krishi Anusandhan aur Shiksha Vibhag*)

Part I

The following subjects which fall within List I of the Seventh Schedule of the Constitution of India.

1. International co-operation in the field of agricultural research and education including relations with foreign and international agricultural research and educational institutions and organizations, including participation in international conferences, associations and other bodies dealing with agricultural research and education and follow-up of decisions at such international conferences, etc.
2. Fundamental, applied and operational research and higher education including co-ordination of such research and higher education in agriculture including agroforestry, animal husbandry, dairying and fisheries, including agricultural statistics, economics and marketing.
3. Co-ordination and determination of standards in institutions for higher education or research and scientific and technical institutions insofar as it relates to food and agriculture including animal husbandry, dairying and fisheries.
4. Cesses for financing to the Indian Council of Agricultural Research, and the commodity research programmes other than those relating to tea, coffee and rubber.
5. Sugarcane research.

Part II

For Union Territories the subjects mentioned in Part I above so far as they exist in regard to these territories and in addition the following subject which falls within List II of the Seventh Schedule of the Constitution of India.

6. Agricultural Education and Research.

Part III

General and consequential:

7. All matters relating to foreign aid received from foreign countries and International Organizations in sofar as agricultural research and education and allied subjects are concerned, including all matters relating to assistance afforded by India to foreign countries in the field of agricultural research and education and allied subjects.
8. Plant introduction and exploration.
9. All-India Soil and Land-Use Survey relating to research, training, correlation, classification, soil mapping and interpretation.
10. Financial assistance to state governments and agricultural universities in respect of agricultural research and educational schemes and programmes.
11. National Demonstrations.
12. Indian Council of Agricultural Research and its constituent research institutes, stations, laboratories and centres.
13. Offences against laws with respect to any of the subjects allotted to this department.
14. Enquiries and statistics for the purpose of any of the subjects allotted to this department.
15. Fees in respect of any of the subjects allotted to this department except fees taken in a court.

APPENDIX II

Total Number of Posts and Names of Important Functionaries

Group	Designation	Scale of pay (in rupees)	Santioned strength
A	Secretary	26,000 (Fixed)	1
A	Additional Secretary (DARE)/Secretary, ICAR	22,400 – 24,500	1
A	Financial Adviser and Additional Secretary	22,400 – 24,500	1
A	Director	14,300 – 18,300	1
A	Deputy Secretary	12,000 – 16,500	1
A	Senior Principal Private Secretary	12,000 – 16,500	1
A	Under Secretary	10,000 – 15,200	7
A	Principal Private Secretary	10,000 – 15,200	2
B	Assistant Director (Official Language)	7,500 – 12,000	1
B	Private Secretary	6,500 – 10,500	1
B	Section Officer	6,500 – 10,500	4
B	Assistant	6,500 – 10,500	4
B	Personal Assistant	6,500 – 10,500	4
C	Junior Hindi Translator	5,500 – 9,000	1
C	UDC-cum-Cashier	4,000 – 6,000	1
C	UDC	4,000 – 6,000	2
C	Steno Grade 'D'	4,000 – 6,000	7
C	UDC-Hindi Typist	4,000 – 6,000	1
C	Staff Car Driver	4,000 – 6,000	1
C	LDC	3,050 – 4,590	2
D	Daftry	2,610 – 4,000	1
D	Peon	2,550 – 3,200	5
	Total		50

Names of the Important Functionaries

S.No.	Name	Designations
1.	Dr Mangala Rai	Secretary, DARE and DG, ICAR
2.	Mr A K Upadhyay	Additional Secretary, DARE and Secretary, ICAR
3.	Dr Rita Sharma	Additional Secretary/Financial Adviser, DARE/ICAR
4.	Mr Rajiv Kumar Jain	Director
5.	Mr P R Meena	Joint Director
6.	Mr Ram Avtar	Deputy Secretary
7.	Mr J N Banati	Senior Principal Private Secretary
8.	Mr M S Nayar	Under-Secretary
9.	Mr Rakesh Sharma	Under-Secretary
10.	Mr Roopak Chaudhuri	Under-Secretary
11.	Ms Alka Ahuja	Under-Secretary
12.	Ms Sumita Dasgupta	Under-Secretary
13.	Mr Madan Lal	Under-Secretary
14.	Mr D K Chhatwal	Under-Secretary
15.	Ms Geeta Nair	Principal Private Secretary

APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2006–2007 are Rs 2160.00 crores and Rs 2276.00 crores respectively and BE for 2007–2008 (Plan and Non-Plan) is Rs 2460 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 2006–2007 and BE for 2007–2008 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 2005–2006		Revised Estimates 2005–2006		Budget Estimates 2006–2007	
		Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451'		–	155	–	155	–	155
090	Secretariat						
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	–	375	–	375	–	380
(030032)	-Other Programmes	*4550	–	650	–	950	–
(040032)	-India's contribution to Asia Pacific Association of Agricultural Institutions	–	5	–	5	–	5
(050032)	-India's contribution to NACA	–	12	–	12	–	12
(060032)	-India's contribution to CGPRT	–	5	–	5	–	5
(070032)	-India's contribution to Seed Seed Testing Association	–	2.25	–	2.25	–	2.25
(080032)	-ISHS Belgium	–	0.75	–	0.75	–	0.75

*Includes Rs 8 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	2006–2007 Budget			2006–2007 Revised			2007–2008 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
A. Budget Allocation, net of recoveries										
Revenue		1350.00	810.00	2160.00	1430.00	876.00	2276.00	1620.00	840.00	2460.00
Capital		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1350.00	810.00	2160.00	1430.00	846.00	2276.00	1620.00	840.00	2460.00
1. Secretariat - Economic Service Agricultural Research and Education Payments to ICAR	3451	0.00	1.55	1.55	0.00	1.55	1.55	0.00	1.65	1.65
2. Crop Husbandry										
2.1 Payments of net proceeds of cess under Agricultural Produce Cess Act, 1940	2415	0.00	40.00	40.00	0.00	40.00	40.00	0.00	40.00	40.00
2.2 Other Programmes of Crop Husbandry										
2.2.01 Crop Sciences	2415	312.00	194.00	506.00	300.00	205.69	505.69	303.00	202.50	505.50
2.2.02 Horticulture	2415	69.00	71.20	140.20	62.27	77.01	139.28	68.00	73.70	141.70
2.2.03 Agricultural Extension	2415	245.00	0.80	245.80	263.16	0.83	263.99	246.00	0.85	246.55
2.2.04 Agricultural Education	2415	196.00	5.25	201.25	426.00	5.34	431.34	290.00	5.45	295.45
2.2.05 Economics, Statistics and Management	2415	4.00	12.60	16.60	3.50	12.85	16.35	4.00	12.95	16.95
2.2.06 Agricultural Engg.	2415	40.00	23.90	63.90	37.00	25.18	62.18	40.00	24.80	44.80
2.2.07 ICAR Hq Admn. including ASRB and DIPA	2415	30.00	194.25	224.25	22.50	194.84	217.34	42.50	202.80	245.30
2.2.08 National Agril. Innovation Project	2415	92.00	0.00	92.00	10.00	0.00	10.00	270.00	0.00	270.00
2.2.09 Indo-French Proj. on Seabass Breedings and Culture	2415	0.50	0.00	0.50	0.50	0.00	0.50	0.00	0.00	0.00
Total other Programme of Crop Husbandry		988.50	502.60	1491.10	1124.93	521.74	1646.67	1263.60	563.05	1786.55
Total Crop Husbandry		988.50	542.60	1531.10	1124.93	561.74	1668.67	1263.50	563.05	1826.55
3. Soil and Water Conservation										
3.1 Soil and Water Conservation Institutes	2415	3.60	11.63	15.23	3.60	12.35	15.95	3.60	12.00	15.60
3.2 Other NRM Instts. including Agroforestry Research	2415	73.40	70.02	143.42	65.67	72.80	138.47	66.40	72.25	138.65
Total- Soil & Water Conservation		77.00	81.65	158.65	69.27	85.15	154.42	70.00	84.25	154.25
4. Animal Husbandry	2415	75.00	121.90	169.90	60.00	132.16	192.16	78.00	126.60	204.60
5. Fisheries	2415	29.30	58.70	87.70	26.30	61.30	87.60	37.00	60.30	97.30

(Contd . . .)

	Major Head	2006–2007 Budget			2006–2007 Revised			2007–2008 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
6. Lump-sum provision for Projects/ Schemes for the benefit of North-Eastern Region and Sikkim	2552	135.00	0.00	135.00	143.00	0.00	143.00	162.00	0.00	162.00
Total-Payments to ICAR		1304.50	804.35	2108.85	1423.50	840.35	2263.85	1610.50	834.20	2444.70
7. Contribution to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institutes	2415	45.50	4.10	49.60	6.50	4.10	10.60	9.50	4.15	13.65
8. Total-Agricultural Research and Education	2415	1350.00	808.45	2158.45	1430.00	844.45	2274.45	1620.00	838.35	2458.35
Grand Total		1350.00	810.00	2160.00	1430.00	836.00	2276.00	1620.00	840.00	2460.00
	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	1251.00	0.00	1251.00	1287.00	0.00	1287.00	1458.00	0.00	1458.00
2. North-eastern Areas	22552	135.00	0.00	135.00	143.00	0.00	143.00	162.00	0.00	162.00
Total		1350.00	0.00	1350.00	1430.00	0.00	1430.00	1620.00	0.00	1620.00
D. Major Head-wise Total		1350.00	810.00	2160.00	1430.00	846.00	2276.00	1620.00	840.00	2460.00
	2415	1251.00	808.45	2023.45	1287.00	844.45	2131.45	1458.00	838.35	2296.35
	3451	0.00	1.55	1.55	0.00	0.00	155.00	0.00	1.65	1.65
	2552	135.00	0.00	135.00	143.00	0.00	143.00	162.00	0.00	162.00
Grand Total	4552	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) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet, President of the Society*

1. Mr Sharad Pawar
Minister of Agriculture
Government of India, Krishi Bhavan
New Delhi 110 001

(ii) *Minister of State in the Union Ministry of Agriculture, dealing with the ICAR, Vice-President*

2. Minister of State (Agriculture)
Government of India, Krishi Bhavan
New Delhi 110 114

(iii) *Union Ministers holding charge of Finance, Planning, Science and Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/ Department concerned)*

3. Mr P Chidambaram
Minister of Finance, Government of India
North Block, New Delhi 110 001
4. Mr M V Rajasekharan
Minister of State for Planning
Yojana Bhawan, Government of India
New Delhi 110 001
5. Mr Kapil Sibal
Minister of Science & Technology, and
Human Resource Development
Government of India, Shastri Bhawan
New Delhi 110 001
6. Mr Arjun Singh
Minister for Human Resources
Government of India
New Delhi 110 001
7. Mr Kamal Nath
Minister of Commerce,Government of India
Udyog Bhawan, New Delhi 110 001

(iv) *Other Ministers in the Union Ministry of Agriculture*

8. Mr Kanti Lal Bhuria
Minister of State for Agriculture
Government of India, Krishi Bhavan,
New Delhi 110 114
9. Mr Taslimuddin
Minister 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

10. Mr N Raghuveera Reddy
Minister of Agriculture
Government of Andhra Pradesh
Hyderabad
(Andhra Pradesh) 500 022
11. Mr Fareeduddin Mohammed
Minister of Fisheries
Government of Andhra Pradesh
Hyderabad (Andhra Pradesh) 500 022
12. Mr Suryarao Gollapalli
Minister for Animal Husbandry and Dairy Development
Government of Andhra Pradesh
Hyderabad (Andhra Pradesh) 500 022

Arunachal Pradesh

13. Mr Tsering Gyurme
Minister for Agriculture, Animal Husbandry and Horticulture
Government of Arunachal Pradesh
Itanagar (Arunachal Pradesh) 791 111
14. Mr Chowna Mein
Minister of Fisheries
Government of Arunachal Pradesh
Itanagar (Arunachal Pradesh) 791 111

Assam

15. Ms Pramila Rani
Minister for Agriculture, Government of Assam
Janta Bhavan, Guwahati (Assam) 781 006
16. Mr Khor Singh Engti
Minister for Veterinary and Animal Husbandry
Hill Area Development
Government of Assam, Janta Bhavan
Guwahati (Assam) 781 006
17. Mr Nurjamal Sarkar
Minister for Fisheries
Government of Assam, Janta Bhavan
Guwahati (Assam) 781 006
18. Minister of Horticulture
Government of Assam, Janta Bhavan
Guwahati (Assam) 781 006

Bihar

19. Mr Sushil Kumar Modi
Deputy Chief Minister for Animal Husbandry and Fisheries
Government of Bihar
Patna (Bihar) 800 015
20. Mr Narendra Singh
Minister for Agriculture
Government of Bihar
Patna (Bihar) 800 015

Chhattisgarh

21. Mr Nanki Ram Kanwar
Minister for Agriculture, Animal Husbandry & Fisheries
Government of Chhatisgarh
Raipur (Chhattisgarh)

Delhi

22. Mr Raj Kumar Chauhan
Minister for Agriculture Development and Food
Animal Husbandry & Fisheries
National Capital Territory of Delhi
New Delhi 110 012

Goa

23. Mr Francisco X. Pacheco
Minister of Agriculture
Animal Husbandry and Horticulture
Government of Goa, Panaji (Goa) 403 001
24. Mr Joaquim Braz Alemao
Minister for Fisheries
Government of Goa,
Panaji (Goa) 403 001

Gujarat

25. Mr Bhupendrasinh M Chudasama
Minister for Agriculture, Animal Husbandry, Fisheries and Horticulture
Government of Gujarat
Gandhinagar, (Gujarat) 382 010

Haryana

26. Mr Harmohinder Singh Chatha
Minister for Agriculture, Horticulture, Animal Husbandry and Fisheries
Government of Haryana
Chandigarh (Haryana) 160 001

Himachal Pradesh

27. Mr Singhi Ram
Minister of Horticulture
Government of Himachal Pradesh
Shimla (Himachal Pradesh) 171 001
28. Mr Raj Krishan Gaur
Minister for Agriculture
Government of Himachal Pradesh
Shimla (Himachal Pradesh) 171 001
29. Mr Harsh Mahajan
Minister of State for Animal Husbandry and Fisheries
Government of Himachal Pradesh
Shimla (Himachal Pradesh) 171 001

Jammu and Kashmir

30. Mr Abdul Aziz Zargar
Minister for Agriculture, Horticulture and Fisheries
Government of Jammu and Kashmir
Srinagar (Jammu and Kashmir) 190 001
31. Mr Taj Mohi-ud-Din
Minister of Animal Husbandry
Government of Jammu & Kashmir
Srinagar (Jammu & Kashmir) 190 001

Jharkhand

32. Mr Nalin Soren
Minister of Animal Husbandry, Horticulture and Fisheries
Government of Jharkhand,
Ranchi (Jharkhand) 834 002

Karnataka

33. Mr Nagaraja Shetty
Minister of Fisheries
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001
34. Dv Revu Naik Belamagi
Minister for Animal Husbandry
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001
35. Mr Shashikanth Akkappa Naik
Minister for Horticulture
Government of Karnataka
Bangalore 560 001
36. Mr Bandeppa Kashempur
Minister for Agriculture
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001

Kerala

37. Mr Mullakkara Ratnakaran
Minister for Agriculture & Coir including Animal Husbandry and Horticulture
Government of Kerala
Thriuvananthapuram (Kerala) 695 001
38. Mr S Sharma
Minister of Fisheries
Government of Kerala
Thiruvananthapuram (Kerala) 695 001

Madhya Pradesh

39. Mr Choudhary Chanderbhan Singh
Minister for Agriculture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
40. Mr Moti Kashyap
Minister for Fisheries
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
41. Mr Ramakant Tiwari
Minister for Animal Husbandry
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
42. Minister for Horticulture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 432 006

Maharashtra

43. Mr Balasaheb Thorat
Minister for Agriculture
Government of Maharashtra
Mumbai (Maharashtra) 400 032
44. Mr Anees Ahmad
Minister for Fisheries, Animal Husbandry and Dairy Development
Government of Maharashtra
Mumbai (Maharashtra) 400 032
45. Mr Vinay Kore
Minister for Horticulture and Non-conventional Energy
Government of Maharashtra
Mumbai (Maharashtra) 400 032

Manipur

46. Mr M O Ibobi
Chief Minister holding the charge of Animal Husbandry and Fisheries
Government of Manipur
Imphal (Manipur) 795 001
47. Mr Ph. Parijat Singh
Minister for Agriculture
Government of Manipur
Imphal (Manipur) 795 001
48. Mr Gaikhangam
Minister for Horticulture
Government of Manipur
Imphal (Manipur) 795 001

Meghalaya

49. Mr Manirul Islam Sarkar
Minister for Agriculture, Fisheries and Horticulture
Government of Meghalaya
Meghalaya Secretariat
Shillong (Meghalaya) 793 001
50. Mr Paul Lyndoh
Minister for Animal Husbandry and Veterinary
Government of Meghalaya, Meghalaya Secretariat (C)
Shillong (Meghalaya) 793 001
51. Mr Sengran Songma
Minister for Fisheries
Meghalaya Secretariat (C)
Shillong (Meghalaya) 793 001

Mizoram

52. Mr H Rammawia
Minister for Agriculture and Horticulture
Government of Mizoram
Aizwal (Mizoram) 796 001
53. Mr Lalrin Chhana
Minister for Animal Husbandry
Government of Mizoram
Aizwal (Mizoram) 796 001

54. Mr B Lalthlengliana
Minister for Fisheries
Government of Mizoram
Aizwal (Mizoram) 796 001

Nagaland

55. Mr Neiphiu Rio
Chief Minister and holding charge of Horticulture and Fisheries
Government of Nagaland
Kohima (Nagaland) 797 001
56. Mr Kuzholuz Nienu
Minister for Agriculture
Government of Nagaland
Kohima (Nagaland) 797 001
57. Mr Thenucho
Minister for Animal Husbandry
Government of Nagaland
Kohima (Nagaland) 797 001

Orissa

58. Mr Surinder Nath Nayak
Minister for Agriculture and Horticulture
Government of Orissa
Bhubaneshwar (Orissa) 751 001
59. Ms Golak Bihari Naik
Minister for Animal Resources Development
Government of Orissa
Bhubaneshwar (Orissa) 751 001

Puducherry

60. Mr V Vaithilingam
Minister for Agriculture, Horticulture, Animal Husbandry
Government of Puducherry
Pondicherry 605 001
61. Mr MOHF Shajahan
Minister of Fisheries and Horticulture
Government of Pondicherry
Pondicherry 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. Mr Prabhu Lal Saini
Minister of State for Agriculture, Animal Husbandry and Horticulture
Government of Rajasthan
Jaipur (Rajasthan) 302 005

Sikkim

66. Mr Somnath Poudyal
Minister for Agriculture 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. Ms Geetha Jeevan
Minister for Animal Husbandry
Government of Tamil Nadu
Chennai (Tamil Nadu) 600 009

Tripura

71. Mr Tapan Chakravorty
Minister for Agriculture, Animal Husbandry and Horticulture
Civil Secretariat, Government of Tripura
Agartala (Tripura) 799 001
72. Mr Khagentra Jamatia
Minister for Fisheries
Government of Tripura
Agartala (Tripura) 799 001

Uttarakhand

73. Mr Trivendra Singh Rawat
Minister for Agriculture, Fisheries, Animal Husbandry and Horticulture
Government of Uttranchal
Dehradun (Uttranchal)

Uttar Pradesh

74. Mr Ashok Bajpai
Minister for Agriculture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
75. Dr Virendra Singh
Minister for Animal Husbandry
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
76. Mr Raj Kishore Singh
Minister for Horticulture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
77. Mr Shyam Narayan
Minister of Fisheries
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001

West Bengal

78. Mr Naren De
Minister for Agriculture
Government of West Bengal Writers' Building
Kolkata (West Bengal) 700 001
79. Mr Anisur Rahman
Minister for Animal Resources Development
Government of West Bengal
Kolkata, (West Bengal) 700 001
80. Mr Kironmoy Nanda
Minister for Fisheries & Aquatic Resources and Fishing Harbours
Government of West Bengal
Kolkata (West Bengal) 700 001
81. Mr Mohanta Chatterjee
Minister for Horticulture and Food Processing
Government of West Bengal
Writers Building
Kolkata (West Bengal) 700 001

(vi) *Member of Planning Commission, Incharge of Agriculture*

82. 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)*

83. Shri Harish Rawat — 25.11.2008
Member of Parliament (RS)
Village Mohanari
P.O. Chaunalia
Tehsil Bhikaiasen
Distt. Almora, Uttaranchal and
12-A, Canning Lane
New Delhi 110 001

84. Mr Sharad Anantrao Joshi — 04.07.2010
Member of Parliament (RS)
Angar Mala, Village Ambethan, Taluk khed,
Distt Pune and
40 Meena Bagh, New Delhi 110 001

85. Mr Mahdevrao Shivankar — Till the expiry of term in the Lok Sabha
Member of Parliament (LS),
Amgaon, Distt. Gundia 441 902
Maharashtra, and B-603, MS Flats,
BKS Marg,
New Delhi 110 001.

86. Mr K Manvendra Singh, — -do-
Member of Parliament (LS)
Amagarh House, Dampier Nagar, Mathura,
Uttar Pradesh and 20, Willingdon Crescent,
New Delhi 110 001.

87. Mr Kishan Singh Sangwan — -do
Member of Parliament (LS)
H. No. 563, Ward No. 4, Tehsil Road,
Gohana, Sonepat 131 001 Haryanan and
18, Dr Rajendra Prasad Road,
New Delhi 110 001.

88. 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*

89. Dr Mangala Rai
Director-General, ICAR
Krishi Bhavan, New Delhi 110 001

(ix) *All Secretaries in the Ministry of Agriculture*

90. Mr P K Mishra
Secretary (Agriculture and Co-operation)
Ministry of Agriculture, Department of Agriculture,
Krishi Bhavan,New Delhi 110 001

91. Ms Charusheela Sohoni
Secretary (Animal Husbandry and Dairying)
Krishi Bhavan,
New Delhi 110 114

(x) *Secretary, Planning Commission*

92. Mr R R Shah
Secretary, Planning Commission
Yojana Bhavan, New Delhi 110 001

(xi) *Secretary, Department of Biotechnology*

93. 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

94. Prof S K Brahmachari
Director General
Council of Science and Industrial Research
Anusandhan Bhawan, New Delhi 110 001

(xiii) *Chairman, University Grants Commission*

95. 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)*

96. Mr Anil Khakodkar
Chairman, Atomic Energy Commission and Secretary to the Government of India
Department of Atomic Energy
Anushakti Bhavan, Chhatrapati Shivaji
Maharaj Marg, Mumbai 400 039

(xv) *Member, Finance (Secretary/Additional Secretary in the Ministry of Finance), Government of India, Alternate Member—Financial Adviser (DARE/ICAR)*

97. Ms Rita Menon
Additional 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*

98. Dr Vijay Mehta — 9.4.2010
Vice-Chancellor
Dr Balasaheb Sawant Konkan
Krishi Vidyapeeth, Dapoli
Ratnagiri, Maharashtra

99. Dr S S Baghel — 18.07.2008
Vice-Chancellor
Assam Agricultural University
Jorhat, Assam 785 013

100. Mr N N Singh — 9.4.2010
Vice-Chancellor
Birsa Agricultural University
Ranchi, Bihar 834 006

101. Dr R B Dishmukh — 18.07.2008
Vice-Chancellor
Mahatma Phule Krishi Vidyapeeth
Krishi Vidyapeeth, Distt.
Rahuri (Maharashtra) 413 722

(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*

102. Dr N B Singh
Agricultural Commissioner — Ex-officio
Department of Agriculture and Co-operation
Krishi Bhavan,
New Delhi 110 001

103. Dr M L Choudhary — Ex-officio
Horticultural Commissioner, Department of Agriculture,
Krishi Bhavan, New Delhi 110 001

104. Dr S K Bandyopadhyay
Animal Husbandry
Commissioner
Department of Agriculture, Krishi Bhawan,
New Delhi

105. Mr M K R Nair — Ex-officio
Fisheries Development Commissioner
Department of Agriculture, Krishi Bhavan
New Delhi 110 001

106. Mr N K Joshi — Ex-officio
Inspector-General of Forests,
Government of India
Department of Environment and Forests
CGO Complex, Lodi Road,
New Delhi 110 003

(xviii) Fifteen scientists from within and outside the Council, including one from the Indian Council of Medical Research nominated by the President

107. 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)

108 Dr T J Pandian — 9.4.2010
National Professor
Madurai Kamaraj University
9, Old Natham Road
Madurai- 625 014
(Tamil Nadu)

109 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

110 Dr N Panda — 9.4.2010
Plot No. 62/63, Opp. Unit 8,
Boy's Singh School
P.O. Baramunda,
Bhubaneshwar 751 003 (Orissa)

111. Dr N N Goswami — 9.4.2010
JD 20D, Pitampura,
Delhi- 110 088

112. 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)

113. Dr Gyanendra Singh — 9.4.2010
Vice-Chancellor
Mahatama Gandhi Chitrakoot Gramodaya
Vishwavidyalaya
Chitrakoot Distt. Satna 485 331
(Madhya Pradesh)

114. Dr M Mahadevappa — 9.4.2010
Ex-Chairman
Agricultural Scientists Recruitment Board
1576, Ist Cross, Chandra Layout
Bangalore 560 040

115. Dr J B Chowdhary — 01.07.2010
906, Sumeru Towers
Kaushambi, Ghaziabad

116. Dr C D Mayee — 9.4.2010
Chairman
Agricultural Scientists Recruitment Board
New Delhi 110 012

117. Dr Asis Datta — 9.4.2010
Ex Vice-Chancellor
Jawaharlal Nehru University & Director,
NCPGR
Aruna Asaf Ali Margt, JNU Campus
Post Box No. 10531
New Delhi 110 067

118. Dr K Pradhan — 9.4.2010
Ex Vice-Chancellor
Orissa University of Agriculture & Technology
H-101, Som Vihar Apartments
R.K. Puram, New Delhi 110 022

119. Dr S S Acharya — 9.4.2010
Honorary Professor
Institute of Development Studies
8-B, Jhalana, Institutional Area
Jaipur 302 004 (Rajasthan)

120. 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)

121. Dr Vasantha Muthuswany — 31.07.2008
Senior Deputy Director-General
Division of Basic Medical Sciences
Indian Council of Medical Research
Ansari Nagar, PB 4911, New Delhi 110 029

(xix) *Three representatives of Commerce and Industry nominated by the President*

122. Mr Gokul Patnaik — 06.05.2010
Chairman
Global Agri. Systems Pvt. Ltd.
K-13 A, Hauz Khas Enclave, New Delhi 110 016

123. 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

124. 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*

125–132. Vacant

(xxi) *Four representatives of Rural Interest*

133–136. Vacant

(xxi) *Four Directors of the ICAR Research Institutes, nominated by the President*

137. Dr B M Khadi — 9.4.2.10
Director
Central Institute for Cotton Research
P.B. No. 2, Shankarnagar Post Office,
Nagpur 440 010 (Maharashtra)

138. Dr K A Singh — 9.4.2010
Director
Indian Grassland & Fodder Research Institute
Pahuj Dam, Jhansi-Gwalior Road
Jhansi 238 003 (Uttat Pradesh)

139. Dr Sushil Kumar — 9.4.2010
Director
National Dairy Research Institute
Karnal 132 001 (Haryana)

140. 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*

141. Mr A K Upadhyay
Member-Secretary, ICAR
Krishi Bhawan, New Delhi 110 001

APPENDIX 2

GOVERNING BODY

Chairman

1. Dr Mangala Rai
   Director-General
   Indian Council of Agricultural Research
   Krishi Bhavan, New Delhi 110 001

Ex-officio Members

Member-Finance

2. Ms Rita Menon
   Additional Secretary to the Government of India
   Ministry of Finance, Department of Expenditure
   New Delhi 110 001

Secretary, Planning Commission

3. Mr R R Shah
   Secretary
   Planning Commission
   Yojna Bhavan, New Delhi 110 001

Secretary, Agriculture

4. Mr P K Mishra
   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 110 001

Secretary, Animal Husbandry and Dairying

6. Ms Charusheela Sohoni
   Secretary (A H & D)
   Department of Animal Husbandry and Dairying
   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
    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 R B Deshmukh — 18.07.2008
    Vice-Chancellor
    Mahatama Phule Krishi Vidyapeeth
    Ahmednagar
    Rahuri (Maharashtra) 413 722

14. Dr S S Baghel — 18.07.2008
    Vice-Chancellor
    Assam Agricultural University
    Jorhat 785 013
    Assam

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
    40, Meena Bagh, New Delhi 110 001

Three Farmers/Representatives of rural areas nominated by the President

19. Vacant
20. Vacant
21. Vacant

Three Directors of Research Institutes of the Council nominated by the President

22. Dr B M Khadi — 09.04.2010
    Director
    Central Institute for Cotton Research
    P.B. No. 2, Shankarnagar Post Office
    Nagpur 440 010

23. Dr Sushil Kumar — 09.04.2010
    Director
    National Dairy Research Institute
    Karnal 132 001
    Haryana

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)
2. Dr A K Singh (Natural Resource Management)
3. Dr S Ayyappan (Fisheries)
4. Dr Nawab Ali (Agricultural Engineering)
5. Dr S P Tiwari (Education)
6. Dr H P Singh (Horticulture)
7. Dr P L Gautam (Crop Sciences)
8. Dr K M Bujarbaruah (Animal Sciences)

Assistant Directors-General

Crop Sciencces

1. Dr K C Jain (Commercial Crops)
2. Dr S N Shukla (Food and Fodder Crops)
3. Dr T P Rajendran (Plant Protection)
4. Dr N D Jambhale (Seeds)
5. Dr V D Patil (OP)

Horticulture

1. Dr S N Pandey (Horticulture-I)
2. Dr U C Srivastava (Horticulture-II)

Natural Resource Management

1. Dr P D Sharma (Soils)
2. Dr A K Gogoi (Agronomy)
3. Dr P S Minhas (IWM)

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 A D Diwan (Marine Fisheries)
2. Dr V V Sugunan (Inland Fisheries)

Education

1. Dr G C Tiwari (EPD)
2. Dr B S Bisht (HRD)
3. Dr R K Mittal (EQR)

Extension

1. Dr Rajinder Parshad (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)

Horticulture

1. Dr R C Upadhyay

Natural Resource Management

1. Dr D K Paul (IWM)
2. Dr O P Sharma (AF)
3. Dr P P Biswas (Soil)

Education

1. Dr G D Diwakar (Accreditation)

Fisheries

1. Dr Anil Aggarwal (Marine Fisheries)
2. Dr V R Chitranshi (Fisheries)

ARIS Unit

1. Dr D K Aggarwal

Extension

1. Dr G Appa Rao
2. Dr A M Narula
3. Dr (Ms) Tej Verma

Engineering

Nil

Others

1. Dr A K Bawa (DG Section)
2. Dr V S Upadhyaya
3. Dr D B S Sehra (ES&M)
4. Dr Ravindra Kumar (Awards)

National Agricultural Technology 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 H C Pathak, Director (F)
3. Mr H C Joshi, Director (OL)
4. Mr V P Kothiyal, Director (Works)
5. Mr D P Yadav, Director (F), NAIP

Deputy Secretaries

1. Mr Sanjay Gupta
2. Mr H L Meena

3. Mr A C Ghosh
4. Mr J Ravi
5. Mr B N Rao
6. Ms Shashi Prabha Razdan

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 Sanjay Kant, Secretary
5. Mr Vikram Singh, Controller of Examination

Directorate of Information and Publications of Agriculture (DIPA)

1. Dr T P Trivedi, Project Director
2. Mr V K Bharti, Chief Production Officer
3. Mr Kuldeep Sharma, Editor (Hindi) and Unit Incharge
4. Dr R P Sharma, Editor (English) and Unit Incharge
5. Mr Hans Raj, Information System Officer
6. Mr S K Joshi, Business Manager
7. Mr B C Mazumder, Incharge (Art Unit)

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 Sushil Kumar
   National Dairy Research Institute
   Karnal (Haryana) 132 001
4. Dr Dilip Kumar
   Central Institute of Fisheries Education
   Jaiprakash Road, Seven Bungalow (Versova)
   Mumbai (Maharashtra) 400 061
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
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7. Dr K P R Vittal
   Central Arid Zone Research Institute
   Jodhpur (Rajasthan) 342 003
8. Dr M M Pandey
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9. Dr T A More
   Central Institute of Arid Horticulture
   Bikaner (Rajasthan) 334 006
10. Dr B M Khadi
    Central Institute for Cotton Research
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    Bajaj Nagar,Nagpur (Maharashtra) 440 010
11. Dr B M C Reddy
    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
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15. Dr George V Thomas
    Central Plantation Crops Research Institute
    Kasaragod (Kerala) 671 124
16. Dr S K Pandey
    Central Potato Research Institute
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17. Dr Y S Ramakrishna
    Central Research Institute for Dryland Agriculture
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    Hyderabad (Andhra Pradesh) 500 059
18. Dr H S Sen
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    (West Bengal) 700 120
19. Dr M P Pandey
    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
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22. Dr V Krishnamurthy
    Central Tobacco Research Institute
    Rajahmundry (Andhra Pradesh) 533 105
23. Dr S Edison
    Central Tuber Crops Research Institute, PB 3502
    Sreekariyam, Thiruvananthapuram (Kerala) 695 017
24. Dr V S Korikanthimath
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25. Dr A K Sikka
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26. Dr S M Ngachan
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    Umiam (Meghalaya) 793 103
27. Dr S D Sharma
    Indian Agricultural Statistics Research Institute
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28. Dr K A Singh
Indian Grassland and Fodder Research Institute
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29. Dr G S R Murti
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31. Dr A Subba Rao
Indian Institute of Soil Science
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32. Dr V A Parthasarathy
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33. Dr R L Yadav
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34. Dr Bangali Baboo
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35. Dr Mathura Rai
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38. Dr H S Gupta
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Animal Sciences and Fisheries

39. Dr B P Singh
Central Avian Research Institute
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40. Dr R K Sethi
Central Institute for Research on Buffaloes
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41. Dr N P Singh
Central Institute for Research on Goats
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42. Dr K K Vass
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45. Dr N Sarangi
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46. Central Marine Fisheries Research Institute
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APPENDIX 5

NATIONAL BUREAUX AND THEIR DIRECTORS

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National Bureau of Agriculturally Important
Micro-organisms
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2. Dr S K Sharma
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Animal Sciences

4. Dr B K Joshi
National Bureau of Animal Genetic Resources
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5. Dr W S Lakra
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APPENDIX 6

PROJECT DIRECTORATES AND THEIR DIRECTORS

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   Project Directorate of Biological Control
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   Directorate of Cropping Systems Research
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   Meerut (Uttar Pradesh) 250 110
3. Dr Sain Dass
   Project Directorate of Maize Research
   Cummings Laboratory
   Indian Agricultural Research Institute,
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   New Delhi 110 012
4. Dr D M Hegde
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   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
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7. Dr S D Kulkarni
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   CIAE Complex, T T Nagar
   Bhopal (Madhya Pradesh) 462 018
8. Dr B Mishra
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Animal Sciences

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   Project Directorate on Cattle
   Grass Farm Road, PB 17
   Meerut (Uttar Pradesh) 250 001
10. Dr R P Sharma
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    Rajendranagar
    Hyderabad (Andhra Pradesh) 500 030
11. Dr K Prabhudas (Acting)
    Project Directorate on Animal Disease Monitoring and Surveillance
    Hebbal, Bangalore (Karnataka) 560 024
12. Dr B Pattnaik
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    IVRI Campus, Mukteshwar
    Kumaon (Uttaranchal) 263 138

APPENDIX 7

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

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1. Dr S K Dhyani
   National Research Centre for Agroforestry
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   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 Shyam Singh
   National Research Centre for Citrus
   PB 464, P.O. Shankar Nagar,
   Nagpur (Maharashtra) 440 010
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   National Research Centre on DNA Finger Printing
   NBPGR, Pusa Campus
   New Delhi 110 012
6. Dr P G Adsule
   National Research Centre for Grapes
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7. Dr M S Basu
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8. Dr O M Bambawale
   National Research Centre for Integrated Pest Management
   Lal Bahadur Shastri Building
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   New Delhi 110 012
9. Dr K K Kumar
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   Manchi House
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10. Dr Janardan Jee (Acting)
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    Patna (Bihar) 801 506
11. Dr Satyabrata Maiti
    National Research Centre for Medicinal and Aromatic Plants
    Boriavi Seed Farm,Boriavi
    Anand (Gujarat) 387 310
12. Dr R P Tewari
    National Research Centre for Mushroom
    Chambaghat,
    Solan (Himachal Pradesh) 173 213
13. Dr M Kochu Babu
    National Research Centre for Oilpalm
    Pedavegi (Andhra Pradesh) 534 450
14. Dr K E Lawande
    National Research Centre for Onion and Garlic
    Rajguru Nagar
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15. Dr R P Medhi
National Research Centre for Orchids
Pakyang (Sikkim) 737 106
16. Dr P Ananda Kumar
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17. Dr Vilas T Jadhav
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18. Dr Arvind Kumar
National Research Centre for Rapeseed and Mustard
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19. Dr B B Vashishtha
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20. Dr N Seetharama
National Research Centre for Sorghum
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21. Dr G S Chauhan
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22. Dr Ashwani Kumar
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23. Dr J G Varshney
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Animal Sciences and Fisheries

24. Dr K M L Pathak
National Research Centre on Camel
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25. Dr S K Dwivedi
National Research Centre for Equines
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26. Dr N Kondaiah
National Research Centre on Meat and Meat Products
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Hyderabad (Andhra Pradesh) 500 059
27. Dr Chandan Rajkhowa
National Research Centre for Mithun
ICAR Research Complex
Jharnapani, Medziphema (Nagaland) 797 106
28. Dr Anuprata Das
National Research Centre for Pigs
Panjabari Road, 6th Mile, Guwahati (Assam) 785 037
29. Dr Mohan Bhattacharya
National Research Centre on Yak
West Kemeng, Dirang (Arunachal Pradesh) 790 101
30. Dr P C Mahanta
National Research Centre for Coldwater Fisheries
Saurabh Cottage, Thandi Sarak
Naintal (Uttaranchal) 263 136

General

31. Dr P K Joshi
National Centre for Agricultural Economics and Policy Research
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32. Dr (Ms) Krishna Srinath
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APPENDIX 8

A. ALL-INDIA CO-ORDINATED RESEARCH PROJECTS AND PROJECT/NETWORK CO-ORDINATORS

Crop Sciences

1. Dr B Mallik
Project 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 M S Basu
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
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CSA University of Agriculture and Technology
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Directorate of Maize Research
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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
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ANGRAU, Rajendranagar
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15. Dr I S Khairwal
Project Co-ordinator (Pearl Millet)
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Jodhpur (Rajasthan) 342 304
16. Dr K K Sharma
Project Coordinator (Pesticide Residues)
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New Delhi 110 012
17. Dr N D Majumdar
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18. Dr D M Hegde
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Directorate of Oilseeds Research
Hyderabad, Andhra Pradesh 500 030
19. Dr S S Duhoon
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JNKVV, Jabalpur (Madhya Pradesh) 482 004
20. Dr S Seetharama
Project Co-ordinator (Sorghum)
National Research Centre for Sorghum
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21. Dr K T Krishne Gowda
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22. Dr G S Chauhan
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23. Dr O K Sinha
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24. Dr B C Viraktamath
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25. Project Co-ordinator (Rapeseed Mustard)
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26. Dr R S Tripathi
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27. Dr V Krishnamurthy
Project Co-ordinator (Tobacco)
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28. Dr R P Dua
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29. Dr B Mishra
Project Co-ordinator (Wheat and Barley)
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30. Dr Y S Mathur
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Horticulture

31. Dr T A More
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33. Dr Gopala Krishna Bhat
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34. Dr R L Misra
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35. Dr R P Tiwari
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36. Dr Satyabrata Maiti
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37. Dr S Arulraj
Project Co-ordinator (Palms)
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38. Dr P S Naik
Project Co-ordinator (Potato)
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39. Project Co-ordinator (Subtropical Fruits)
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Natural Resource Management

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47. Dr M S Gill
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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 Vashncy
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)
Central Institute of Agricultural Engineering
(Madhya Pradesh) 462 038

Animal Sciences

62. Project Co-ordinator (ADMAS)
Project Directorate on Animal Disease Monitoring and Surveillance
Hebbal, Bangalore (Karnataka) 560 024
63. Dr J K Malik
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. 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. Project Co-ordinator (FMD)
Project Directorate on Foot and Mouth Diseases
IVRI Campus
Mukteshwar (Uttar Pradesh) 263 138
68. Dr N P Singh
Project Co-ordinator (Goats)
Central Institute for Research on Goat
Mathura (Uttar Pradesh) 281 122
69. Dr J K Malik
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. 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 Improvement)
CSWRI
Avikanagar (Rajasthan) 304 501

Education

76. Dr Suman Agarwal (Home Science)
NRC for Women
Bhubaneshwar (Orissa) 751 001

APPENDIX 9

AGRICULTURAL UNIVERSITIES AND THEIR VICE-CHANCELLORS

1. Mr Ajeya Kallam
   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 S S Baghel
   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 K Suri
   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 Jagmon Singh
    Dr Yashwant Singh Parmar University of Horticulture and Forestry
    Nauni, Distt Solan (Himachal Pradesh) 173 230
12. Dr A P Sharma
    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. University of Horticulture and Forestry
    Ranichauri, Tehri Garhwal
15. Dr C R Hazra
    Indira Gandhi Krishi Vishwavidyalaya
    Raipur (Chhatisgarh) 492 012
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 R N Sreenivas Gowda
    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 R B Deshmukh
    Mahatma Phule Krishi Vidyapeeth
    Rahuri (Maharashtra) 413 722
21. Dr S S Kadam
    Marathwada Agricultural University
    Parbhani
    (Maharashtra) 431 402
22. Dr S L Mehta
    Maharana Pratap University of Agriculture and Technology
    Udaipur
    (Rajasthan) 313 001
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
    Rajasthan Agricultural University
    Bikaner (Rajasthan) 334 002
28. Dr N L Maurya
    Rajendra Agricultural University
    Samastipur, Pusa (Bihar) 848 125
29. Dr R C Maheshwari
    Sardar Krishi Nagar Dantiwada Agricultural University
    Dantiwada (Gujarat) 385 506
30. Dr M P Yadav
    Sardar Ballabh Bhai Patel University of Agriculture and Technology
    Modipuram, Meerut (Uttar Pradesh) 250 110
31. Dr Anwar Alam
    Sher-E-Kashmir University of Agricultural Sciences and Technology
    Srinagar (Jammu and Kashmir) 191 121
32. Dr Nagendra Sharma
    Sher-e-Kashmir University of Agricultural Sciences and Technology
    45-B, Gandhinagar, PB 37
    Jammu (Jammu and Kashmir) 180 012
33. Dr Priyadarshi Dash
    Sri Venkateswara Veterinary University
    Tirupati (Andhra Pradesh) 517 502
34. Dr C Ramasamy
    Tamil Nadu Agricultural University
    Coimbatore (Tamil Nadu) 641 003
35. Dr P Thangaraju
    Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu) 600 051
36. Dr P G Chengappa
    University of Agricultural Sciences, GKVK
    Bangalore (Karnataka) 560 065
37. Dr J H Kulkarni
    University of Agricultural Sciences
    Dharwad (Karnataka) 580 005
38. Dr C S Chakrabarti
    West Bengal University of Animal and Fishery Sciences, 68KB Sarani
    Kolkata (West Bengal) 700 037
39. Dr Arun S Ninawe
    Maharashtra Animal Sciences and Fisheries University
    Nagpur (Maharashtra) 440 006

40. Dr M L Madan
UP Deen Dayal Upadhyaya Veterinary and Animal Science University
Mathura (Uttar Pradesh) 281 001
41. Dr M K Majumder
Uttar Banga Krishi Vishwavidyalaya
Pundibari, Cooch
Bihar (West Bengal) 736 165

Central Agricultural University

1. Dr S N Puri
Central Agricultural University
Imphal (Manipur) 795 004

Central Universities

1. Dr Naseem Ahmad
Aligarh Muslim University
Aligarh (Uttar Pradesh) 202 002
2. Dr Panjab Singh
Banaras Hindu University
Varanasi (Uttar Pradesh) 221 005
3. Professor 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 Sushil Kumar
National Dairy Research Institute
Karnal (Haryana) 132 001
4. Dr Dilip Kumar
Central Institute of Fisheries Education
Jaiprakash Road,
Seven Bungalows, Versova
Mumbai (Maharashtra) 400 061
5. Dr R B Lal
Allahabad Agricultural Institute
Allahabad (Uttar Pradesh) 211 007

APPENDIX 10

Total number of employees in the ICAR and its research institutes and number of Scheduled Castes, Scheduled Tribes and Other Backward Classes*

Sl.No.	Post	Total posts sanctioned	Total employees in position	Total scheduled castes among them	Total scheduled tribes among them	Total OBC among them
1.	**Scientific Post**					
	Scientist	3,881	2,973	343	58	315
	Senior Scientist	1,651	675	54	5	41
	Prinicipal Scientist	749	437	41	4	13
	RMP Scientist	147	99	2	2	3
	Total	**6,428**	**4,184**	**440**	**69**	**372**
2.	**Technical Posts**					
	Category I	4,469	3,829	684	304	349
	Category II	2,798	2,648	514	165	248
	Category III	626	642	102	31	35
	Total	7,893	7,119	1,300	500	632
3.	**Administration Posts**					
	(a) Directors/Dy.Secretaries Under Secretaries/ Sr. Admn. Officer/ Sr. Accounts Officer/ Admn. Officer/ F&AO/Legal, PS etc.	242	187	32	24	7
	(b) Asstt. Fin. & Accounts Officer/Accounts Officer Section Officer/Hindi Officer/Desk Officer/	546	507	73	25	24
	(c) Assistants	1,267	1,027	187	95	58
	(d) Stenographers	466	454	82	17	27
	(e) UDC/Senior Clerk	1,429	1,426	270	94	82
	(f) LDC/Junior Clerk	864	754	142	48	107
	Total	**4,814**	**4,355**	**786**	**303**	**305**
4.	**Supporting Staff**					
	Grade I	3,378	2,871	745	145	530
	Grade II	3,476	3,100	924	221	180
	Grade III	1,947	1,867	479	144	83
	Grade IV	921	865	231	92	34
	Total	**9,722**	**8,703**	**2,379**	**602**	**827**
5.	**Supporting Staff** (*Safaiwala*)	219	226	123	2	2
	Auxillary posts (dying cadre)	39	35	4	–	–
	Total	**258**	**261**	**127**	**2**	**2**

*Based on the data available till 31 March 2007

APPENDIX 11

AWARDS

AWARD	AWARDEES
Sardar Patel Outstanding Institution Award (2006)	*ICAR Institutes* (i) Central Institute for Fisheries Technology, Cochin *State Agricultural Universities* Nil *NRC/Project Directorates* (i) Water Technology Centre for Eastern region, Bhabaneshwar
Jawaharlal Nehru Award for Outstanding Post-graduate Agricultural Research (2006)	*Crop Improvement* Nil *Biotechnology* (i) Dr M Sheshu Madhav, DRR, Hyderabad, Andhra Pradesh (ii) Dr J Keshari Mohapatra, Project Directorate on FMD, IVRI, Mukteswar, Uttarakhand *Plant Protection* (i) Hameeda Bee, RC Puram, Hyderabad, Andhra Pradesh (ii) Dr Binu Antony, Mekkadampu, Kerala *Natural Resource Management* (i) Dr B Asha Jyothi, Jaggapuram, Guntur Distt, Andhra Pradesh (ii) Dr T Sherenee Jenita Rajammal, Eruvadi, Tamil Nadu *Horticulture* (i) Dr K Dinesh Babu, ICAR Research Complex for NEH region, Umiam, Mehalaya (ii) Dr Deepa S Nair, KVK, Kottayam, Kerala *Engineering and Technology* (i) Dr D K Singh, CIAE, Bhopal, Madhya Pradesh (ii) Dr Ram Chandra Singh, CIAE, Bhopal, Madhya Pradesh *Animal Sciences* (i) Dr Paresh Nath Chatterjee, Shera Bazar Power House, Burdwan, West Bengal (ii) Dr S Gounalan, High Security Animal Disease Laboratory, IVRI, Izatnagar, Uttar Pradesh (iii) Dr S C Roy, NIANP, Bangalore, Karnataka *Fisheries* (i) Dr V Jyothi V Mallia, Pandikudy, Cochin, Kerala *Social Sciences* (i) Dr Pratima C Bilehal, Dharwad, Karnataka (ii) Dr P S Swathi Lakshmi CMFRI, Mangalore, Karnataka
N.G. Ranga Farmer Award for Diversified Agriculture (2006)	(i) Mr Patil Vishwas Rao Anandrao Lohara, Jalgaon, Maharashtra (ii) Mr Bhikhbhai Jivabhai Bhutadiya, Chamga Banaskontha, Gujarat (*Jointly*)
Panjabrao Deshmukh Women Agricultural Scientist Award (2006)	(i) Dr Kausalya Ramachandran, CRIDA, Hyderabad, Andhra Pradesh (ii) Dr Alka Goel, GBPUAT, Pantnagar, Uttarakhand
Vasantrao Naik Award for Research Applications in Dryland Agriculture (2006)	(i) Late Dr Asha Ram Pal and Associates Dr Dinesh Kumar Rusia and Onkar Prasad Dubey Dr Govind Prasad Pali and Dr Ramesh Chandra Srivastav, IGAU, Raipur, Chhattisgarh
Chaudhary Devi Lal Outstanding AICRP Award (2006)	(i) Regional Station, CICR, AICRP on Cotton Improvement, Coimbatore

Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research & Development (2005)	(i) Mrs Snehalata Srivastav *The Hitavada*, Nagpur
Hari Om Ashram Award for the Biennium (2005–06)	*Crop Science* (i) Dr Hari C Sharma, ICRISAT, Patanchuru, Andhra Pradesh *Natural Research Management* (i) Er Krishna Pratap Singh, Dr Somresh Kundu and Dr H S Gupta, VPKAS, Almora, Uttarakhand *Horticulture* (i) Dr Sanjay Kumar and Dr Vishaw Bandhu Patel, IARI, New Delhi *Animal Health* (i) Dr Niranjan Mishra and Associate Dr H K Madhav, High Security Animal Disease Laboratory IVRI, Bhopal
Lal Bahadur Shastri Young Scientists Award for the Biennium (2005–06)	*Crop Science* (i) Dr Mohd. Akram, CSAUA & T, Kanpur, Uttar Pradesh (ii) Dr Sanjay Kumar Singh, DWR, Karnal, Haryana *Soil Science, Agronomy and Agroforestry* (i) Dr Raveendra H Patil, AICRP on Safflower Annigeri, Dharwad, Karnataka (ii) Dr Anupama, IARI, New Delhi *Horticulture* (i) Dr Rhitu Rai, IARI, New Delhi *Engineering* (i) Dr Abhijit Kar, IARI, New Delhi *Animal Sciences* (i) Dr V Balamurugan, IVRI, Nainital Mukteswar (ii) Dr A Kumaresan, ICAR Research Complex for NEH region, Umiam, Nagaland *Social Sciences and Home Science* (i) Dr Ranjit Kumar, IISS, Bhopal (ii) Dr Cini Verghese, IASRI, New Delhi (*Jointly*)
Jagjivan Ram Kisan Puraskar (2006)	*Crop Protection* (i) Mr Sursing Madhavrao Pawar, Khandamabe Budruk, Rahuri, Maharashtra and Mr Ram Saran Verma, Daulatpur Barabamki, Uttar Pradesh and Mr Sharad Baburao Patil, Mawalgaon, Latur, Maharashtra and (ii) Ms Maltiben Joitaram Chaudhary, Pratappura, Kalol, Gujarat
Rafi Ahmed Kidwai Award for the Biennium (2005–06)	*Crop Improvement and Crop Protection* (i) Dr Banawari Mishra, DWR, Karnal, Haryana (ii) Dr Nagendra Kumar Singh, NRC on Plant Biotechnology, New Delhi *Natural Resource Management* (i) Dr Thakur Bahadur Singh Rajput, WTC, IARI, New Delhi *Engineeing and Technology* (i) Dr V N Sharda, CSWCR & TI, Dehradun, Uttarakhand *Horticulture* (i) Dr S K Pandey, CPRI, Shimla, Himachal Pradesh *Animal Sciences* (i) Dr A K Misra, Project Directorate on Cattle, Meerut (ii) Dr Devki Nandan Kamra, IVRI, Izatnagar, Uttar Pradesh *Fisheries and Aquatic Life Sciences* (i) Dr Indrani Karunasagar, College of Fisheries, Mangalore, Karnataka

Swami Sahajanand Saraswati Extension Scientist/Worker Award for the Biennium (2005–06)

Crop Production

(i) Dr Neeraj Singh, IIVR, Varanasi, Uttar Pradesh
(ii) Dr Satya Pal Goyal, KVK, Kurukshetra, Haryana (Jointly)

Livestock *Production*

(i) Dr Hans Ram Meena, IVRI, Mukteswar, Uttarakhand

Natural Resource Management

(i) Dr V Ramamurthy, NBSS & LUP, Hebbal, Bangalore, Karnataka

Home Science

(i) Dr Mamta Tiwari, Mahaveer Nagar, Kota, Rajasthan

APPENDIX 12

MINISTRY OF AGRICULTURE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Summary of Audit observation

Unfruitful expenditure

"National Institute of Research on June and Allied Fibre Technology (NIRJAFT), Kolkata, a unit of Indian Council of Agricultural Research (ICAR) undertook a project titled "Development of jute based ratine yarn, a fancy yarn, for making heavier type of upholstery and furnishing fabrics" in April 1996 at a cost of Rs. 10.86 lakh for a period of four years. The project was successfully completed in March 2000 after developing the ratine yarn. On the recommendations of the Research Advisory Committee (RAC), NIRJAFT undertook another project titled "Development of 10-spindle Jute based ratine yarn machine" in April 2000 for a period of one year. The objective of the second project was to design, develop and fabricate a machine for manufacturing jute based ratine yarn in large scale and also commercialise it. The project was declared complete in September 2001 after developing a 10-spindle machine with an expenditure of Rs. 10.22 lakh. As per the completion report of the project, the standardization of process variables for preparation of jute based fancy yarn on the developed machine was required to be taken up. In the meantime, NIRJAFT in January 2002 initiated the process for filing of patent on the technology developed and undertook the work of its standardization."

Audit examination disclosed that the patenting and standardization had not been done even as of October 2006. The process of patenting and standardization did not progress after November 2002 after the death of the concerned project investigator. The attempts of NIRJAFT towards patenting and standardization of the technology developed for commercialization did not succeed as it failed to trace the documents maintained by the deceased project investigator. Thus, the technology developed at a cost of Rs. 21.08 lakh could not be patented and commercialized.

Council's comments/reply

The ICAR has already submitted its reply to the Principal Director of Audit (Scientific Departments) that as per the mandate of the Projects, the jute based ratine yarn, a fancy yarn was developed in March 2000 and designing of a 10-spindle machine for making the fancy yarn was also completed in September, 2001. Accordingly, the Principal Investigator(PI) initiated the process of patenting of concept only. After sudden demise of the PI in November, 2002, the Institute has been actively pursuing the residual work. The same is expected to be completed shortly and accordingly action would be taken towards patenting and transfer of technology.

Acronyms

AAU	:	Assam Agricultural University
ACIAR	:	Australian Centre for International Agricultural Research
AER	:	Agro-ecological Region
AESR	:	Agro-ecological Subregion
AI	:	Artificial Insemination
AICRP	:	All-India Co-ordinated Research Project
AIIB	:	Agriculturally Important Insect Biodiversity
AINP	:	All-India Network Project
AKI	:	Agricultural Knowledge Initiative
AMU	:	Aligarh Muslim University
ANGRAU	:	Acharya NG Ranga Agricultural University
APEDA	:	Agricultural Products Export Development Agency
ARI	:	Agricultural Research Institute
ARIC	:	Agricultural Research Information Centre
ARIS	:	Agricultural Research Information System
ARS	:	Agricultural Research Service
ASRB	:	Agricultural Scientists' Recruitment Board
AU	:	Agricultural University
BARC	:	Bhabha Atomic Research Centre
BBF	:	Broad Bed and Furrow
BE	:	Budget Estimate
BGBP	:	ß-glucan Binding Protein
BHU	:	Banaras Hindu University
BRD	:	Bycatch Reduction Device
BTV	:	Bluetongue Virus
BVDV	:	Bovine Viral Diarrhoea Virus
CAU	:	Central Agricultural University
CAZRI	:	Central Arid Zone Research Institute
CCA	:	Copper Chrome Arsenic
CCSHAU	:	Chaudhary Charan Singh Haryana Agricultural University
CGIAR	:	Consultative Group on International Agricultural Research
CIAE	:	Central Institute of Agricultural Engineering
CIAV	:	Chicken Infectious Anaemia Virus
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
CIP	:	International Potato Centre
CIPHET	:	Central Institute of Post-harvest Engineering and Technology
CIRCOT	:	Central Institute for Research on Cotton Technology
CLA	:	Conjugated Linoleic Acid
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
CSFL	:	Colour Synthetic Female Line
CSML	:	Colour Synthetic Male Line
CTCRI	:	Central Tuber Crops Research Institute
CTRI	:	Central Tobacco Research Institute
CU	:	Central University
DAP	:	Diammonium Phosphate
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
FRP	:	Fibre Reinforced Plastic
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
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
IFS	:	Integrated Farming System
IGFRI	:	Indian Grassland and Fodder Research Institute
IGKVV	:	Indira Gandhi Krishi Vishwa Vidyalaya
IIHR	:	Indian Institute of Horticultural Research
InsCot	:	Information System on Cotton Cultivars

IPGRI	:	International Plant Genetic Resources Institute
IPM	:	Integrated Pest Management
IPMA	:	Immuno-peroxidase Monolayer Assay
IPR	:	Intellectual Property Right
IRRI	:	International Rice Research Institute
IVDMD	:	*In-vitro* Dry Matter Digestibility
IVF	:	*In-vitro* Fertilization
IVRI	:	Indian Veterinary Research Institute
JAU	:	Junagarh Agricultural University
JEE	:	Jatropha Ethyl Ester
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
LIS	:	Lift Irrigation Scheme
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
MZA	:	Marine Zobell Agar
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
NERIST	:	North-Eastern Regional Institute of Science and Technology
NET	:	National Eligibility Test
NGOs	:	Non-Government Organizations
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
OSD	:	Officer on Special Duty
OUAT	:	Orissa University of Agriculture and Technology
PAGE	:	Polyacrylamide Gel Electrophoresis
PAU	:	Punjab Agricultural University
PCR	:	Polymerase Chain Reaction
PE	:	Pan Evaporation
PG	:	Post-graduate
PPVFR	:	Protection of Plant Varieties and Farmers' Right
PD_ADMAS	:	Project Directorate on Animal Disease Monitoring and Surveillance
PSB	:	Phosphate Solubilizing Bacteria
PTO	:	Power Take Off
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
SAC	:	Space Application Centre
SAUs	:	State Agricultural Universities
SBI	:	Sugarcane Breeding Institute
SC	:	Scheduled Caste
SCC	:	Somatic Cell Count
SHGs	:	Self-help Groups
SNP	:	Single Nucleotide Polymorphism
SOC	:	Soil Organic Carbon
SRF	:	Senior Research Fellowship
SRI	:	System of Rice Intensification
SSNM	:	Site-specific Nutrient Management
SSP	:	Single Superphosphate
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
TMR	:	Total Mixed Ration
TNAU	:	Tamil Nadu Agricultural University
TSS	:	Total Soluble Solids/Sugars
TVCSC	:	Teaching Veterinary Clinical Service Complex
UG	:	Under-graduate
UGC	:	University Grants Commission
UNCTAD	:	United Nations Conference on Trade and Development
UTM	:	Uterine Milk Protein
VAM	:	Vesicular-arbuscular Mycorrhiza
VPKAS	:	Vivekananda Parvatiya Krishi Anusandhan Sansthan
WBNV	:	Watermelon Bud Necrosis Virus
ZECC	:	Zero Energy Cool Chamber

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Published by Dr T P Trivedi, Project Director (DIPA), Indian Council of Agricultural Research, Krishi Anusandhan Bhawan, Pusa, New Delhi-110 012; Lasertypeset by Xpedite Computer Systems, D-20, 2nd Floor, Ranjeet Nagar Commercial Complex, New Delhi-1100 08 and Printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi-110 028.