



Annual Report 2006-2007



सत्यमेव जयते

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



भारत
ICAR

Indian Council of Agricultural Research
New Delhi



Indian Council of Agricultural Research

President, ICAR Society and
Minister of Agriculture

Shri Sharad Pawar

Minister of State for
Agriculture

Shri Kanti Lal Bhuria

Director-General (ICAR)
and Secretary (DARE)

Dr Mangala Rai

Secretary (ICAR) and
Additional Secretary (DARE)

Smt Sushama Nath

(Up to 16.10.2006)

Shri A K Upadhyay

(Since 17.10.2006)

Financial Adviser (ICAR)
and
Additional Secretary (DARE)

Dr (Smt) Rita Sharma

ICAR



Foreword

Agricultural research has the power to decide the course of agriculture and concurrently of India. After realizing the potential of agriculture in changing socio-economic condition of millions of Indian, it has been considered one of the central elements of the planning efforts in the 11th Five Year Plan. It is widely accepted that concomitant with high growth rate in our economy, agriculture must grow at 4%. Improvement in productivity is the most important option to raise production. During the current year thrust has been on developing techniques for productivity enhancement through hybrid technology, genetic modifications, precision farming, and addressing concerns of entire value chain.

Efforts of ICAR scientists resulted in overall development of agricultural research. Accessions (12,607) of crops and their wild relatives were collected; 70 varieties and hybrids of crops were identified for release. During the year 5,026 tonnes of breeder seeds of major crops have been produced. A user-friendly, window-based and easy to access software Micro NBAIM was developed for digitization of microbial data available at the National Bureau of Agriculturally Important Microorganism. Endophytic bacteria *Bacillus* spp, *Erwinia herbicola* and *Enterobacter agglomerans* have been isolated for the first time from the healthy chickpea. A National Pesticide Residue Monitoring Project has been launched through the AINP on Pesticides. A prototype disease forecasting software for powdery mildew management in grape was developed. Brinjal genotypes were used for regeneration and transformation. A highly sensitive PCR technique was developed to detect potato leaf curl. High-yielding triploid hybrids of cassava were recommended for industrial areas of Tamil Nadu. Organic farming of elephant-foot yam gave higher corn yield. Pusa Gaurav rose was found best for cut flower production. Aluminium sulphate along with sucrose increased vase-life of roses. Aromatic crops in arecanut garden were more remunerative. A technology for making window shades from oil palm frond rachis was standardized. Black peppers stored in vacuum showed good quality even after 8 months of storage. Sequence analysis has confirmed the identity of virus causing mild chlorotic mottle and streaks on leaves of vanilla. Minimum tillage with crop residue treatment proved beneficial in conserving natural resources and increasing productivity under rainfed conditions in Doon Valley. In Western Rajasthan, surface run-off and soil loss due to water erosion could be reduced with the help of grass barriers (*Vetiveria/ Saccharum/ Cenchrus/ Dichanthium*). Resource conservation technologies, viz. double no-till, leaf colour chart and brown manuring, were found effective in increasing profitability of rice-wheat system. The impact of water harvesting and recharge filters in Antisar Watershed, Vasad (Gujarat) was enormous and resulted in mitigating drought impact, and in improving crop productivity. A low energy water application technology was developed specifically for small farm holder and close growing crops. Bio-drainage species of *Acacia* and *Casuarina* can be grown for reclamation of waterlogged wasteland. Drought tolerance was enhanced in greengram through *in vitro* shoot regeneration.

Basic data on production traits and physical characterization was completed on several cattle, sheep, goat, and poultry. Kenkatha cattle was identified as a valuable source of genetic material for meeting demands of future breeding programmes. Under *ex-situ* conservation programme a model was developed for conservation of indigenous cattle in *gaushalas*. Species specific molecular markers were developed for use in wild life forensic. Under synthesis breed development programme cloned buffalo embryo were produced from nucleus transfer of somatic cells.

Breeding efforts improved the productivity of cows, buffaloes, sheep and goats. In poultry birds fertility, hatchability and survivability till laying improved over the preceding generations. Krishibro broilers has become popular for intensive farming on low input, in areas having demand for colour broiler.

H5N1 strain of influenza A virus was detected in poultry for the first time in country, and a suitable vaccine was also developed. *In-ovo* vaccination in broiler chickens was standardized. Thematic maps depicting district-wise information on feed and livestock resources were prepared. Supplementation of 2% activated charcoal in the diet of lactating cattle reduced residual pesticide in milk. Efforts are being



made to produce designer egg through nutritional manipulation of diet. Embryos of transferable stage were successfully produced using oocytes derived from *in-vitro* grown prenatal follicles—apparently first report in buffaloes. First yak calf was born through embryo transfer technology. A test was developed for detecting adulterations of milk with synthetic milk by testing detergent in milk. Herbal ghee was prepared; it has sensory response similar to market ghee.

In marine sector, nearly 77 species of non-conventional deep-sea demersal finfishes, shell fishes and other organisms were recorded. Indian mackerel showed signs of recovery from the progressive decline in catches experienced since 2001. Under inland sector, different management practices were suggested for each zone in the river Ravi vis-à-vis fishery restoration due to the impact of changes in water flow. Mabe pearl production technology was extended to the blacklip pearl oyster *Pinctada margaritifera*. DNA barcodes of 32 marine fish species was prepared for the first time in India. The gasification of jute caddies briquettes may provide a new avenue for cogeneration of heat and power to meet industrial need by waste recycling and management. A prototype of an improved 45 saw ginning machine was developed. Educational Technology Cell at ANGARU, Rajendranagar, first of its kind in the country, was inaugurated. Placement of the passed-outs in Dairy Technology and Food Technology was 100%, Engineering and Technology 90% and a spectacular increase was observed in placement of students of Agriculture and Home Science. Bilateral collaborative programme was established between TANUVAS and Michigan State University, USA.

Study on seed system revealed that proper farm level seed management and supply chain could fulfill the quality seed requirement. The information and communication technology (ICT) saves 90–95% farmers time as well their money spent on acquiring agricultural technology information. A method was developed for estimating acreage under important crops in difficult terrains of Meghalaya. Role of balanced nutrition in long-term sustained productivity was studied. Efforts have been made to identify available farm technologies/ programmes/ policies from women perspective. A training module for gender sensitization in agriculture was prepared.

Activities organized at KVKs were—frontline demonstrations, training programmes for farmers, skill-oriented programmes for rural youth and in-service personnel; creating awareness about improved agricultural technologies; production of seeds, biofertilizers, biopesticides, baculoviruses, neem oil and bioagents for availability to the farmers.

At the ICAR Research Complex for NEH Region, Umiam, climatic atlas was prepared covering all growing seasons. Abbot, a kiwi fruit variety was propagated in Sikkim and Arunachal Pradesh. At Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, a low cost light trap was designed for efficient mass trapping of White grubs. At the Central Agricultural Research Institute, Port Blair, Plant growth promoting *Rhizobacteria* (PGPRs), i.e. *Pseudomonas* spp and *Bacillus* spp were isolated and characterized biochemically. Turkey birds were found highly suitable under hot and humid climate of the Islands ecosystem. The Council has taken several initiatives to improve working environment and to make research effective, efficient and relevant. During this year, 57 awards have been conferred, and out of 42 scientists, there are 11 women scientists and one farm woman. DARE/ICAR signed a Memoranda of Understanding between the Republic of India and Republic of Uzbekistan and Republic of Argentina in the field of Agricultural Research and Education. Work Plans were signed between ICAR, and European Union, Dubai etc. during 2006–07, and were implemented during the reported period. DARE/ICAR has signed Collaborated Projects. First edition of *Handbook of Fisheries and Aquaculture*, which fulfilled the long felt need of handbook in fisheries sector, was released.

Realizing the vital importance of a visionary approach to planning process, the Council has developed Perspective Plan–2025 individually for all of its 95 institutes/ NRCs/ Directorates/ Bureaus. The Governing Body of the ICAR Society approved the ICAR Guidelines for Intellectual Property Management and Technology Transfer/ Commercialization. The Indian Council of Agricultural Research in its endeavor to accomplish set target has moved quite forward, and the *DARE/ICAR Annual Report 2006–07* provides the necessary information on its achievements. I hope the agricultural policy makers and planners will find it useful.

(SHARAD PAWAR)
President, ICAR Society

Contents

Foreword

1. Overview	...	vii
2. Salient Achievements	...	1
• Crop Improvement and Management	...	3
• Improvement and Management of Horticultural Crops	...	37
• Natural Resource Management	...	62
• Livestock and Poultry Improvement and Management	...	76
• Fish Production and Processing	...	116
• Agricultural Engineering and Technology	...	124
• Agricultural Human Resource Development	...	145
• Social Sciences and Policies	...	157
• Technology Assessment, Refinement and Transfer	...	166
• Gender Issues for Technological Empowerment of Women in Agriculture	...	184
3. Research for Tribal and Hill Regions	...	190
4. National Agricultural Innovation Project	...	196
5. Organization and Management	...	198
6. Partnership and Linkages	...	205
7. Agricultural Scientists' Recruitment Board	...	216
8. Publications and Information	...	219
Appendices		
(A) DARE		
I. The Government of India (Allocation of Business) Rules	...	225
II. Total Number of Posts and Names of Important Functionaries	...	226
III. Activity Programme Classification (Budget estimates and revised estimates of DARE and ICAR)	...	227
(B) ICAR		
1. Indian Council of Agricultural Research Society	...	230
2. Governing Body	...	235
3. Standing Finance Committee	...	236
4. Senior Officers at the Headquarters of the ICAR	...	237
5. ICAR Institutes and their Directors	...	239
6. National Bureaux and their Directors	...	241
7. Project Directorates and their Directors	...	241
8. National Research Centres and their Directors	...	242
9. All-India Co-ordinated Research Projects	...	243
10. Agricultural Universities and their Vice-Chancellors	...	246
11. Total Number of Employees in the ICAR and its Research Institutes and Number of SC, ST and Other Backward Classes	...	248
12. Awards	...	249
13. Transaction Audit Observations	...	252
Acronyms	...	253



The Mandate of the Indian Council of Agricultural Research

- (i) To plan, undertake, aid, promote and coordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- (ii) To act as a clearing house of research and general information relating to agriculture, animal husbandry, home science and allied sciences; and fisheries through its publications and information system, and instituting and promoting transfer of technology programmes.
- (iii) To provide, undertake and promote consultancy services in the fields of education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- (iv) To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing co-operative programmes with other organizations such as the Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities.
- (v) To do other things considered necessary to attain the objectives of the Society.



2. Salient Achievements Crop Improvement and Management

PLANT GENETIC RESOURCES

Germplasm exploration and collection

Accessions 2,607 (2,080 cultivated and 527 wild accessions) were collected from Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Meghalaya, Nagaland, Rajasthan, Tamil Nadu, Uttarakhand and Uttar Pradesh through 34 explorations. And to the National Herbarium of Cultivated Plants (NHCP), 953 herbarium specimens, 129 seed samples and 17 economic products have been added.



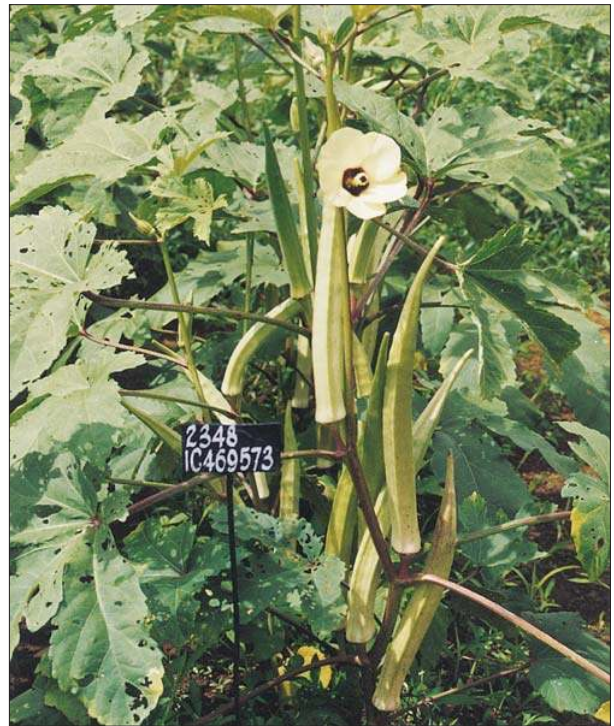
Profuse bearing in *Prunus armeniaca* from North-West Himalaya



Chilli variety Tangerine Dream (EC 583593) from the USA

- Accessions 25,847 of diverse crops introduced including transgenics and of international trials
- Out of 2,452 samples found infested with different pathogens, 2,441 salvaged
- Orthodox seed species accessions 29,404 added to National Gene Bank for long-term storage
- Pepino, a minor fruit plant of Andean region, and New Zealand spinach, a leafy vegetable of New Zealand and Australia, established successfully
- Brinjal (Pusa Purple Long) transformants with synthetic gene, resistant to kanamycin, regenerated and confirmed by PCR

Accessions 25,847 of diverse crops, including transgenics and international trials (2,691 entries), have been introduced, and 138 accessions have been exported. Inland supply of germplasm comprise 8,523 samples. And some promising introductions include



Promising accession IC 469573 of okra from Goa



bacterial blight and grassy stunt virus resistant lines in rice (EC583378-453) from Philippines; *Brassica napus* germplasm with low erucic acid and low glucosinolate from Russia (EC564728-29) and common bean lines resistant to bean golden yellow mosaic virus, anthracnose, angular leaf spot and leaf blight from Honduras (EC559573-74).

Plant quarantine

Exotic accessions of various crops including transgenics, trial materials, and germplasm lines have been processed for quarantine clearance. Samples 2,452 were found infested/infected with insects and mites, nematodes, fungi, bacteria and viruses; of these, 2,441 have been salvaged.

Important interceptions include: **insects**- *Brevipalpus phoenicis*, *Bruchus emarginatus*, *B. ervi*, *Lepidosaphes ulmi*, *Rhizopertha dominica*, *Sitophilus oryzae*, *S. zeamais*; **nematodes**- *Aphelenchoides besseyi*; **fungi**- *Colletotrichum graminicola*, *Peronospora manshurica*, *Phoma lingam*, *Puccinia helianthi*; **viruses**- Alfalfa mosaic virus, Bean common mosaic virus, Broad bean wilt virus and Peanut stripe virus. Phytosanitary certificates numbered 142 have been issued.

Transgenic imported planting materials—164 of *Brassica oleracea*, *Gossypium* spp., *Oryza sativa*, *Zea mays* have been processed for quarantine clearance.

Germplasm conservation

Orthodox seed species accessions (29,404) have been added to the National Genebank for long-term storage. For seed viability, seed quantity and seed health, 517 accessions were monitored after 10 years of storage.

Cereals (15), forages (3), legume (1), oilseeds (6), vegetables and tuber crops (4), fruit (1), spices (6), sugar-yielding plant (1), medicinal (3) and beverages (5) crop species have been approved



New Zealand spinach at the NBPGR Regional Station, Shimla



Pepino (*Solanum muricatum*) at the NBPGR Regional Station, Shimla

for registration for unique traits.

A total of 579 accessions of fruits and nuts, industrial crops, mulberry dormant buds and pollen of mango varieties have been cryostored. And 205 accessions have been added of different crops in *in-vitro* gene bank, and 1,889 accession belonging to 152 species have been maintained. Shoot tips of *Morus alba*, *M. indica* and *M. sinensis* have exhibited 30–35% post-thaw recovery following liquid-nitrogen freezing.



Germplasm field day on chilli at the NBPGR Regional Station, Bhowali



Development and digitization of extant-notified plant varieties

Extant/notified varieties documentation has been taken up using software "INDUS" (Indian Information System). For this training has also been provided to all DUS test centres for statistical analysis of the DUS traits data.

Germplasm characterization, evaluation and maintenance

Accessions 16,183 of various crops have been characterized, evaluated and maintained at the NBPGR Headquarters and regional stations.

Pepino (*Solanum muricatum*), a minor fruit plant of Andean region, and New Zealand spinach (*Tetragonia expansa*), a leafy vegetable of New Zealand and Australia, were collected from Nilgiris, and have been established successfully at the Shimla regional station.

DNA fingerprinting

Forty-five new STMS primer pairs suitable for DNA profiling of mungbean and urdbean and 38 for generating polymorphic alleles in pigeonpea have been identified. Forty-eight new STMS primers containing core repeat motif (AG)_n have been developed and identified in brinjal for cultivar identification.

Development of detection protocols for transgene testing:

Transgenic lines of cotton, rice, maize and potato (180) were tested for terminator gene technology cassette using primer specific to *cre* sequence amplifying amplicon of 1031 bp. No evidence has been found for the presence of terminator gene in any of the samples.

Genetic diversity studies: PCR-RFLP (Polymerase Chain Reaction- Restriction Fragment Length Polymorphism) analysis of *trnH* intergenic spacer region and ITS 1 region in 149 selected accessions representing 35 species of *Vigna* has indicated primitiveness of *V. hainiana* to closest wild relatives of mungbean and urdbean. Others related to mungbean-urdbean group include

Patenting of technique for detection of transgenes

Three patents have been filed for the technique elaborating simultaneous detection of 2 transgenes, 35S promoter and EPSPS, in soybean, maize and wheat. Technology transfer of these patents is under negotiations.

V. trinervia and *V. grandiflora*.

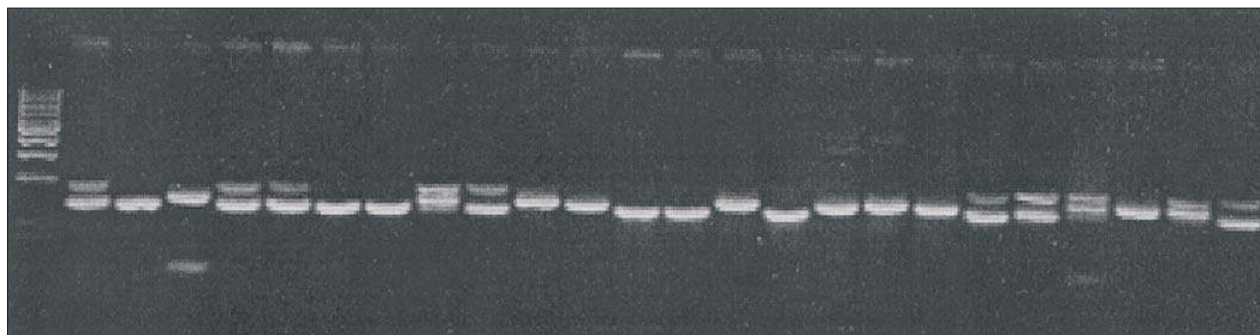
Analysis of genetic diversity in horsegram accessions using molecular markers have indicated that the ones from Uttarakhand and Madhya Pradesh have high diversity compared to the rest of the country. And Indian horsegram cultivars are found more diverse than those from African countries.

Plant biotechnology

Development of Bt-brinjal: Chemical control of brinjal shoot and fruit borer (BSFB) is not only expensive but is also ineffective. A codon-modified gene encoding a delta-endotoxin of Bt (*Cry1*



Brinjal Pusa Purple Long has been transformed by the synthetic gene to contain the damage caused by the brinjal shoot and fruit borer. Its limited contained field test has been conducted. (Undamaged fruits harvested from Bt (left) and non-Bt plots (right))



Profile of rice varieties with Sequence Tagged Micro-Satellite (STMS) markers



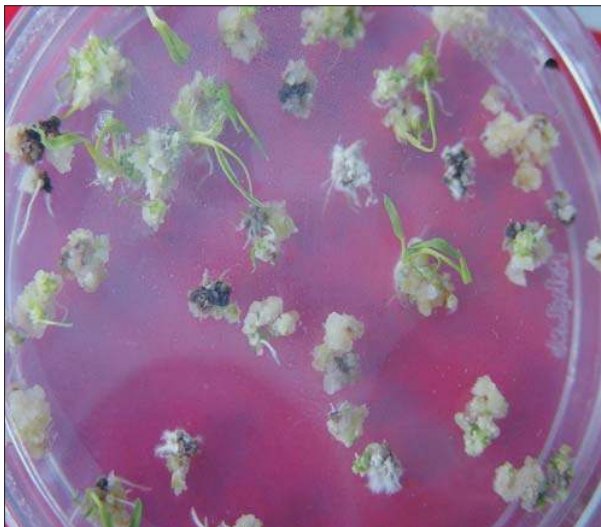
Intellectual Property Rights

- ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization have been approved by the Governing Body and President, ICAR. These are made operative from 2 October 2006.
- National Phase Applications based on the PCT Application entitled "Rapid Detection of Bt-Cry Toxin" to seek protection in (i) Uzbekistan, (ii) South Africa, (iii) China, (iv) South Korea, (v) Mexico have been filed, and are being pursued.
- New patent applications (76), replies of 32 examination reports and 10 requests for examination have been filed with the Patent Office, Delhi. So far, 14 patents have been sealed and another 21 applications have been accepted for grant of patent. These represent technologies from the Subject Matter Divisions of Crop Sciences (64), Horticulture (24), Animal Sciences (37), Agricultural Engineering (16), Fisheries (11) and NRM (1).
- Two fresh PCT application (i) An artificially synthesized peptide, and (ii) *In-vitro* pearl production using marine organisms, have been filed at the International Bureau of World Intellectual Property Organization.

Fa1) was constructed. Brinjal (cv. Pusa Purple Long) could be transformed with synthetic gene under the control of a constitutive promoter (CaMV 35S). Transformants resistant to kanamycin were regenerated and confirmed by the polymerase chain reaction (PCR) analysis. Transgenic lines with very high-level protection against BSFB have been identified. The fruit damage in transgenic lines was 5% in contrast to 47% in normal lines.

Cloning of blast resistance gene *Pi-k^b* and its transfer to rice: A blast resistance gene *Pi-k^b* from rice line Tetep has been cloned. Complete candidate rice blast resistance gene has been

Regeneration of transformed rice-calli having a rice-blast disease resistance gene *Pi-k^b*



cloned in plant transformation vector pCAMBIA 1301.5, which contains CaMV 35S promoter, gene for hygromycin resistance (*hpt*) and gene for kanamycin resistance (*nrp11*), as selectable marker. A japonica rice line TP 309 was used for transformation analysis. Mature scutellum calli were used as explants. Transformed calli have been regenerated to rice-plants.

Development of an improved CMS line of *Brassica juncea*. CMS line developed through hybridization between *Diplotaxis berthautii* and *Brassica rapa*, followed by backcrossing with *B. juncea* had low female fertility and flowers lacked



Male sterile flowers of CMS (*Diplotaxis berthautii*) *Brassica juncea* line; suitable for commercial use Flowers of fertility restored plant through restorer of *Moricondia arvensis* system

nectarines; and so was commercially unsuitable. An improved CMS line of this has been obtained by further backcrossing and selection. This has flowers with well developed nectarines and stable male fertility. The restorer of *Moricondia arvensis* system is able to confer male fertility to this CMS, and the mode of restoration is gametophytic.

FOOD CROPS

Rice

Crop improvement: Thirty hybrids/varieties have been released for different ecosystems.

- Released hybrids/varieties 30 of rice, 8 of wheat, 1 of barley, 7 of maize and 1 of sorghum
- System of Rice Intensification technique recorded 11.47% higher grain yield of hybrid rice over rice transplanting
- Identified superior wheat and barley genetic stocks
- Promising wheat genotypes with various parameters, wet gluten, dry gluten, sedimentation value, extraction rate, grain hardness index, micronutrients, β -carotene selected
- Identified promising entries of barley for malting quality traits
- Maize performed significantly better under ridge-and-furrow and broad-bed systems than under flat sowing and minimum tillage
- New maize hybrids found less susceptible to *Chilo partellus*
- HHB 67-Improved, the first finished product of marker-assisted selection for downy-mildew resistance in pearl millet, notified for release at the national level



CROP IMPROVEMENT AND MANAGEMENT



Rice VL Dhan 85. It is an early-maturity, June-sown variety for Uttarakhand hills in irrigated areas. And is tolerant to neck blast and leaf blast



VL Dhan 207. This is a spring-sown, direct-seeded rice variety with medium maturity for Uttarakhand hills in rainfed areas



VL Dhan 208 rice. This variety is suitable for rainfed uplands of Uttarakhand

Crop production: System of Rice Intensification (SRI) technique has recorded 11.47% higher grain yield of hybrid rice over transplanting.

Phosphobacterium treatment in nursery or through dipping of roots of seedlings prior to transplanting or through application in the main field increased grain yield of rice by one tonne/ha over control.

Rice varieties/hybrids released

Variety	Flowering duration	Grain type	Ecosystem	Yield (tonnes/ha)	Reaction to pests/diseases	Recommended state/region
Central Releases						
Naina	110–115	LS	Alkaline areas	3.91	R-LBL, RTD, GLH	Haryana, Pondicherry
Jarava	110–115	SB	Coastal saline areas	3.3–5.4	R-LBL; Tol-BLB, BPH	West Bengal, Pondicherry, Andamans
Warangal Samba	105–110	MS	Irrigated areas	5.5–6.5	R-RTD; Tol-BPH, ShBl, Andhra Pradesh, Kerala ShR	
NDR 1045-2	75–80	LB	Rainfed upland areas	3.5	Tol-LBL	Uttar Pradesh, Orissa, Bihar
NDR 8002	105–110	LS	Irrigated areas	5.5	Tol-LBL, BS, WBPH	Madhya Pradesh, Chhattisgarh
DRRH 2	86	LS	Irrigated areas	5.4	R-LBL, RTD	Uttarakhand, Haryana, West Bengal, Tamil Nadu
State Releases						
Pratikshya	112	MS	Irrigated and rainfed medium lands	4.8	R-BS, ShR, GM1, LF, SB; MR-BL, ShBl, WBPH, BPH	Orissa
Sidhanta	66	SB	Rainfed uplands	3.4	R-BS, BL, GM 1, 5, SB, LF; MR-NBL, BLB, RTD, ShR, WBPH, BPH	Orissa
Jogesh	59	MB	Rainfed uplands	2.3	R-BS, BL, GM1; MR-BL, ShBl, BLB, SB, BPH	Orissa
Uphar	132	SB	Shallow and semi-deep water lowlands	3.5	R-BL, GM1; MR-ShBl, BLB, RTD, ShR, SB, LF	Orissa



Overview

Efforts of the Indian Council of Agricultural Research are aimed at making an increasingly intensified knowledge-based agriculture so that an all-round success is possible in the country. Realizing this urgent requirement several result-oriented initiatives were taken in desired direction. A number of useful techniques and technologies were developed to improve the productivity and quality of the farm produce. Steps were also taken towards institutional capacity building to improve the quality of education being imparted in our State Agricultural Universities (SAUs). An overview of the salient achievements is presented here and the detailed accounts of activities/achievements are presented in the specific sections devoted to each thematic area.

In July 2006, National Agricultural Innovation Project (NAIP) with a total outlay of US \$ 250 million was launched. The main features of the project include research on production to consumption system, sustainable livelihood security in disadvantaged areas and basic and strategic research at the frontiers of science. This is considered as the next step towards attaining excellence in science, using science for enhancing rural livelihood security and making agriculture a profitable commercial venture through integration of technology with agricultural economy. The innovativeness of the project lies in its emphasis on holism, integration of basic, strategic, applied and anticipatory research, social re-engineering in terms of consortia mode of operation, and management and combining social, economic, ecological and participatory governance features. We are confident that in conjunction with the intensified on-going research efforts and with the continued co-operation and support of all the stakeholders, the project will prove to be a worthy initiative in transforming Indian agriculture into a commercial venture with enhanced on- and off-farm employment, profitability and livelihood security.

An India-US Knowledge Initiative to explore and work on mutually reinforcing priority areas of agricultural education, research, service and commercial linkage was launched with initial focus on education; food processing, use of byproducts and biofuels; biotechnology; and water management. Work plan was signed in February 2006 and 15 young scientists under Borlaug Fellowship Programme from the ICAR institutes/State Agricultural Universities (SAUs) were deputed to different universities in the United States. Six joint research projects are formulated



and put to implementation.

A National Fund for Basic and Strategic Research in Agricultural Sciences under the chairmanship of Dr C.N.R. Rao with eminent scientists as members has been launched. The initiative aims to serve as an apex body for providing overall policy framework and priorities for promoting and supporting basic research, building strength in chosen emerging areas of Science and Technology (S&T) and to co-ordinate various scientific departments/agencies for evolving a focused approach and avoid overlapping areas of research and funding. Under the scheme 14 projects have been approved.

The ICAR implemented the **Guidelines for Intellectual Property Management and Commercialization of Technologies in the ICAR** system with effect from 2 October 2006. This system will facilitate enhanced institutional partnerships in agricultural research and transfer of Intellectual Property Rights (IPR) enabled technologies; protection of IP through patents, plant variety protection and other forms of IPR; safeguarding the animal/fish genetic resources; and allow scientist entrepreneurship in a responsible manner with liberalized incentives. The ICAR has now delegated powers to Directors of the ICAR institutes to file patent applications under the Intellectual Property Rights. Thirty-eight new patent applications have been filed.

The ICAR had the privilege to host three major international events to promote research collaboration and partnerships among countries/organizations in different parts of the world. These were 2nd International Rice Congress, inaugurated by Hon'ble Prime Minister; The Third Triennial Conference of Global Forum on Agricultural Research (GFAR) inaugurated by His Excellency, the President of India, and Asia Pacific Association of Agricultural Research Institutions (APAARI) Expert Consultation on Linking Farmers to markets inaugurated by Hon'ble Agriculture Minister. The events witnessed participation of nearly 2,000 delegates representing nearly 100 countries and several International Agricultural Research Organizations/Institutions. Besides, the Council signed MoUs with several countries including China during 2006 for co-operation in agricultural research.

The ICAR not only enhanced its resource generation substantially but also received Rs 46 crore as Matching Grant from the Ministry of Finance towards the resources internally generated. A system of electronic remittance of funds has been operationalized in 56 institutes reducing the time lag from 5–10 days to 1 day. Eighty per cent of the audit paras pertaining to the period 1985–86 to 2004–05 have been settled during the year 2005–06 as a result of a concerted drive. About one-third of our institutes are free from any audit para. The reform process is on.



OVERVIEW

Crop sciences: Collection and conservation of germplasm is essential for improvement of crop. During the year 2,607 accessions of crops and their wild relatives have been collected through 34 explorations, and 25,847 accessions were introduced. Besides, 579 accessions of fruits and nuts and industrial crops have been cryopreserved. During this year, over 45 improved varieties of cereals and forage crops have been released. In commercial crops, two hybrids of cotton and four varieties of tobacco have been released. Two hybrids of castor, DCH 519 and Sagarshakti, having high oil content and enhanced resistance to biotic stresses have been released. Four varieties of soybean (PS 1347, DS 98-14, JS 95-60 and PRS 1), two hybrids of safflower (NARI-H 15 and JSF 99), two varieties each of niger (JNC 1 and JNS 9) and linseed (Sharda and LMS 9-2 K), six varieties of sesame and a sunflower hybrid (DRSH 1) were released during the year. Besides, the first CMS-based hybrid MRSA 521 of safflower has been identified for release. Drought tolerance was enhanced in greengram through *in-vitro* shoot regeneration. A protocol was standardized for *in-vitro* micro-propagation of elite provenances of *bhimal* (*Grewia optiva*). New rice variety CSR 36 for salt-affected areas of Haryana and Pondicherry and *raya* variety CS 54 were developed for saline/alkali soils. Test Guidelines for Distinctness, Uniformity and Stability more for economically important crops were developed raising their number to 35. During the year 5,026 tonnes of breeder seeds of major crops have been produced. Designed and developed a polymerase chain reaction (PCR)-based diagnostic kit using *Ustilago scitaminea* specific primer sequences for detection of incipient infection of smut disease of sugarcane. The diagnostic kit is highly sensitive and is useful in production of healthy seed cane and tissue culture-raised plantlets. Validated integrated pest management (IPM) protocols in Pusa Basmati 1, Baghpat (Uttar Pradesh), Taraori Basmati, Panipat (Haryana) and in Dehraduni Basmati, Dehradun (Uttarakhand). IPM technologies for mustard and groundnut crops were validated in Navgaon (Alwar) and Sriganganagar and rendered 17 to 24 per cent higher yields than Farmer Practice.

Horticulture: Software for grape germplasm information and disease forecasting for powdery mildew management in grape were developed. An advanced generation hybrid papaya with high keeping quality was developed. Three potato varieties, viz. Kufri Surya, Kufri Arun and Kufri Chipsona, were released. A highly sensitive PCR technique was developed to detect potato leaf curl. High-yielding triploid hybrids of cassava, Sree Athulya and Sree Apoorva, were recommended for industrial areas of Tamil Nadu. A reproducible protocol for regeneration of plantlets in cassava was standardized. A technology for making light colour chips from tubers was standardized. Geriatric health drinks from cassava and arrowroot starches were made. Aonla beverage was developed in



the form of juice with attractive colour, appealing flavour and smell. Pusa Gaurav rose was found best for cut flower production. Aluminum sulphate along with sucrose was found to increase vase-life of roses. A total of 86 coconut germplasm types were collected. New cashew Bhaskara was released. A protocol for *in-vitro* fleshy root formation in Safed Musli was standardized. Black peppers stored in vacuum showed good quality even after 8 months of storage. Varied levels of curcumin were observed in ginger and turmeric. Sequence analysis has confirmed the identity of virus causing mild chlorotic mottle and streaks on leaves of vanilla. A software package for identification of medicinal and aromatic plants was developed. An eco-friendly strategy for the management of the coconut eriophyid mite involving nutrient management, organic manuring, and botanical pesticides has been developed and popularized among the coconut growers through the state departments of horticulture and agriculture in Karnataka, Tamil Nadu and Kerala.

Natural resource management: Soil resource survey and mapping of 12 districts of 8 states was done for land-use planning, and 254 atlases for 22 districts in Andhra Pradesh were generated. Soil loss maps generated for Andhra Pradesh and Orissa are useful in soil-conservation measures and prioritizing the implementation programme and resource allocation.

Minimum tillage with crop residue treatment proved beneficial in conserving natural resources and increasing productivity under rainfed conditions in Doon Valley. In Western Rajasthan, surface run-off of about 20–22% of cropping seasonal rainfall and soil loss of nearly 1.5–2.0 tonnes/ha due to water erosion could be reduced to 14–16% and 0.7–1.1 tonnes/ha, respectively, with the help of grass barriers (*Veteveria/ Saccharum/ Cenchrus/ Dichanthium*). Resource conservation technologies, viz. double no-till, leaf colour chart and brown manuring, were found effective in increasing profitability of rice-wheat system. Multiple uses of water showed the highest income (374.13%) from fish in dug-out pond and horticulture on dykes, followed by fish in dug-out secondary reservoir (234.53%), compared to rice and wheat with fish refuge in the centre (6.18%). The impact of water harvesting and recharge filters in Antisar Watershed, Vasad (Gujarat), was enormous and resulted in mitigating drought impact, and in improving crop productivity. Bio-drainage species of *Acacia* and *Casuarina* can be grown for reclamation of waterlogged wasteland.

Research in nutrient management led to mitigation of reduced soil carbon stocks in intensified cropping system, correction of boron and sulphur deficiency with a new boron source granular borax and new sulphur source gromor sulphur bentonite, respectively, and sustenance of higher productivity of maize-niger cropping system in acid soils of high altitude.



OVERVIEW

Profitable winter maize-based diversified cropping systems, agroforestry systems for different agroclimatic regions and fruit crop-based multi-tier cropping systems were identified. Cultivation of amaranth proved a commercially viable proposition and a good source of protein for farmers in arid Kachchh. The vegetative propagation of *Jatropha* through stem cutting has been standardized. *Jatropha*-forage grass (*Aeluropus logopoides*) was found suitable intercropping system for biosaline agriculture. Drought management software has been developed for Andhra Pradesh.

Animal Sciences: The rapidly upcoming poultry sector in the country received a big setback, as it was struck with bird flu caused by deadly H5N1 virus. The ICAR accorded high priority to develop a vaccine against the bird flu. As a result of concerted efforts a cost-effective vaccine has been developed using cell culture rather than chick embryos, in a short span of 3 months. The trials of vaccine indicate its superior efficacy over the imported vaccine.

The first mithun calf in India was born through artificial insemination. Elite herds of Nili-Ravi, Surti, Jaffarabadi, Bhadwari, Pandharpuri, Godavari buffalo breeds were established under Network Project on Young Bull Production. Body weight at birth in Garole × Malpura sheep showed 64% improvement. Krishibro broilers has become popular for intensive farming on low input, in areas having demand for colour broiler.

Animal disease surveying revealed that foot-and-mouth disease (FMD) returned to Andaman and Nicobar islands after a lapse of 16 years, and infection has gone from mainland. Polymerase chain reaction (PCR) was developed for determination of lineage of the type Asia 1 field isolates of FMD. At the Project Directorate on Animal Disease Monitoring and Surveillance (PDADMAS), BHV 1 genome was detected in peripheral blood leucocytes, aborted materials etc. A blue tongue virus vaccine was developed, which gave promising results in local and Bharat Merino sheep.

In clinical cases of diarrhoea a herbal medicine was found effective. Various essential oils completely paralyzed *Gastrothylax crumenifer*, *Haemonchus contortus*, *Fasciola hepatica* and *Gigantocotyle explanatum*. *In-ovo* vaccination in broiler chickens was standardized. Species specific molecular markers were developed for identification of species from remnants of body parts or tissues, which is important for wild life forensic.

Thematic maps depicting district-wise information on feed and livestock resources were prepared. Anifeed supplementation in ration of lactating crossbred cows improved milk yield by 10.16%. Vitamin E-selenium injections improved udder health of cows. Supplementation of 2% activated charcoal in the diet of lactating cattle reduced residual pesticide in milk. *Pleurotus ostreatus* fungi proved



efficient in lignin breakdown of ragi straw. Extracts of *Allium sativum* reduced methanogenesis without affecting *in-vitro* digestibility. Zinc sulphate-treated soybean cake enhanced protein utilization in buffaloes. Byproducts based complete feed was prepared for intensive goat production. Feeding of complete blocks to lactating camels improved their milk yield. Earthworm meal proved an alternative ideal animal protein source for poultry. Formic acid (1%), propionic acid (1%), lactic acid (1%) and fumeric acid (0.5%) in quail diet proved suitable dietary alternate for antibiotic feed supplement.

Isolation and partial purification of buffalo hormones, viz. buFSH, buLH and buPRL, were completed. Embryos of transferable stage were successfully produced using oocytes derived from *in-vitro* grown prenatal follicles—apparently first report in buffaloes. Kids of 5.5 to 7.0 months of age showed fully developed thermoregulatory mechanisms. First yak calf was born through embryo transfer technology.

Methods for preparation of several milk products were standardized. A test was developed for detecting detergent in milk, and it helps in detecting adulteration of milk with synthetic milk. Herbal ghee was prepared; it has sensory response similar to market ghee. Shelf life of mango *lassi* was enhanced. Mozzarella cheese was developed from Jamunapari goat milk using starter culture method. Process was developed for use of chicken neck in value-added meat products. Technology developed for preparation of different products from mithun meat. Black pepper extract proved an effective preservative for chicken gizzard snacks. Different products of very high quality were prepared from mithun leather.

Fisheries: In marine sector, nearly 77 species of non-conventional deep-sea demersal finfishes, shell fishes and other organisms were recorded. Dense and profuse growth of deep-sea glass sponge *Hyalonema* sp. indicated great commercial value, as the bio-silica extracted has wide applications in medicinal field. Besides, eight species of deep-sea shrimps also indicated commercial concentrations. Indian mackerel showed signs of recovery from the progressive decline in catches experienced since 2001.

Under inland sector, different management practices were suggested for each zone in the river Ravi vis-à-vis fishery restoration due to the impact of changes in water flow. The other work carried out led to mapping of water bodies for 15 districts of Orissa and all districts of Rajasthan, development of biotic integrity index for riverine ecosystem, standardization of methods for detection of microbes having capacity to degrade trichloroethylene, and evaluation of performance of ascorbic acid in diet containing it as an antidote for pesticide in common carp. In culture fisheries, significant achievements were—the multiple breeding of *Labeo fimbriatus* in peninsular rivers, development of sexual maturity in *Puntius pulchellus*



OVERVIEW

under captivity, possibility of incorporation of silver barb in grow-out carp culture system, successful breeding and mass seed production of highly relished fish pabda (*Ompok pabda*) in North and Eastern regions, significant breakthrough in upscaling the captive breeding of *Chitala chitala*, artificial propagation of catfish, *Pangasius pangasius* for diversification of aquaculture and effective tagging with visible implant elastomer tags in juvenile *Macrobrachium rosenbergii* in freshwater aquaculture. Development of formulated feed for grow-out culture of mud crabs and upscaling of seabass seed production were the important findings of brackish water aquaculture.

In mariculture, seed production technology of orange clown, false clown, blue damsel, spot damsel and humbug damsel has been standardized. Mabe pearl production technology was extended to the blacklip pearl oyster *Pinctada margaritifera* at Port Blair. The work in fish harvest and processing technology resulted in : successful erection of eight community fish smoking kilns for benefit of fishermen community, effectiveness of fibre glass reinforced plastic as a physical barrier for chemically treated wood for boat construction in reducing leaching, estimation of presence of bioactive substances having analgesic healing properties in the roots of *Eichhornia crassipes*, development of eco-friendly tunnel fish dryer, preparation of high value products from fish and fish-processing waste, preparation of ready-to-cook freshwater fish streaks from *Labeo rohita* and fabrication of fish meat-bone separator.

In area of fish genetic resources, important achievements have been completion of DNA barcodes of 32 marine fish species for the first time in India, isolation and characterization of more than 36 microsatellite markers from rohu genome, cloning and characterization of vitelogenin cDNA in catla, purification and characterization of a β -glucan binding protein from *M. rosenbergii*, and PCR-based gender identification of marine mammals.

Agricultural engineering and technology: Many new farm implements and tools were designed and improved upon to achieve higher efficiency of farming operations/processes by making them user friendly. Some of these are lug wheel puddler for high speed shallow puddling of rice, rotary furrower/trencher for crops like sugarcane or for drainage or conveying water, twin auger digger sugarcane planter, garlic planter, flail-type forage harvester-cum-chopper were the implements developed as tractor-operated machinery. Air-assisted seed drill and groundnut digger were fabricated as power tiller-operated machinery. Biasi cultivator was developed by modifying light weight rotary tiller under self-propelled machinery. Prototype feasibility testing was carried out successfully for new machines/implements.

Renewable energy technologies development resulted in fabrication of solar



tunnel dryers, high rate anaerobic treatment system for dairy effluent, floating dome type biogas plant for solid state digestion of cattle dung, biogas burner for community applications and industrial scale solar drying of fruits and vegetables. The gasification of jute caddies briquettes may provide a new avenue for cogeneration of heat and power to meet industrial need by waste recycling and management.

Development of belt and chain conveyer feeding system reduced drudgery of workers during feeding of harvested crop in the high capacity thresher. The work carried in area of post-harvest technology led to development of: cleaner-cum-grader for light seeds, curry leaf stripper, rotary maize cob sheller, hand-operated aonla picking machine, cryofreezer seed pelletizer and HCl gas-based cotton seed delinting plant. Besides, process parameters for hulling of pigeonpea were optimized. Pulse beetle disinfestations of stored pigeonpea, chickpea and greengram could be done using eco-friendly thermal and vacuum techniques.

Agricultural human resource development: A special grant of Rs 200 crore for strengthening infrastructure facilities in SAUs and Rs 100 crore to the Punjab Agricultural University (PAU) was approved. The scheme for Experiential Learning, i.e. setting up of facilities for hands on training in SAUs was launched. The financial amount of National Talent Scholarships for the students admitted against 15% seats at undergraduate level, was enhanced from Rs 700 per month per student to Rs 1,000 per month per student. Similarly, the rates of Junior Research Fellowships (JRFs) and Senior Research Fellowships (SRFs) were enhanced and brought at par with Department of Science and Technology (DST) rates. To improve the quality of education and upgradation of skills, Deans' Committee was constituted, report received, national and international interaction held including brain-storming session in India involving over 30 distinguished professions/academicians of the USA and Vice-Chancellors of all SAUs to improve our agricultural education further. It is hoped that contemplated improvement would go a long way in providing a cutting-edge in human resource development.

Educational Technology Cell at the ANGARU, Rajendranagar, Hyderabad, first of its kind in the country, was inaugurated. A very positive development was a high percentage of placements of our students from Dairy Technology, Food Technology, Engineering and Technology, Agriculture and Home Science. Agro-industrial Tie Up programme was launched at the TNAU, and students were trained in marketing. A training module for gender sensitization in agriculture was prepared. Skill training needs and interests of women Self-help Groups (SHGs) were identified for their entrepreneurial development. A training programme on Entrepreneurship Development among farmwomen was developed at the National Research Centre for Women in Agriculture (NRCWA),



OVERVIEW

Bhubaneswar.

Agricultural extension: Additional new Krishi Vigyan Kendras (KVKs) were sanctioned in rural districts thereby raising their number to 541. A new Framework for Technology Development and Delivery System in agriculture was prepared where the processes right from basic and strategic research to technology generation and transfer to the end users are in a continuum.

The KVKs conducted 4,109 on-farm trials involving 537 technologies on varietal evaluation, nutrient management, insect and pest management, cropping system, weed management, resource conservation, and farm implements and tools. Activities at KVKs organized were—frontline demonstrations on oilseeds, pulses, cotton and other important crops; training programmes for farmers, skill-oriented programmes for rural youth and in-service personnel; creating awareness about improved agricultural technologies; production of seeds of cereals, oilseeds, pulses and vegetables, saplings/seedlings of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species; fingerlings; biofertilizers, biopesticides, baculoviruses, neem oil and bioagents (Cards) for availability to the farmers.

Hill and tribal areas: At the ICAR Research Complex for NEH Region, Umiam, climatic atlas was prepared covering all growing seasons. Plant regeneration and transformation protocol for pigeonpea was developed. Abbot, a kiwi fruit variety, was propagated in Sikkim and Arunachal Pradesh. Raised and sunken bed technology was developed for increasing cropping intensity in marshy lands. Protocol for sex diagnosis of ducks was developed. Captive breeding of chocolate mahseer was achieved.

At Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, during the year under report nine varieties of different crops were released. At the VPKAS, Almora, a user-friendly low cost (Rs 570) light trap was designed for efficient mass trapping of white grub that causes severe economic loss in crops. At the Central Agricultural Research Institute, Port Blair, the breeding lines and somaclones of Annada developed *in situ* produced 6 and 8 tonnes/ha respectively. Gas exchange parameters were measured in maize cultures Seedtech 22324, VL Makka 16 and X 3342, grown in hill slopes. Molecular characterization of *Dioscorea vexans*, an important endemic medicinal plant species, revealed ample genetic divergence among diverse collections. The developed IPM module for brinjal reduced the damage to the extent of 74.52%. Plant growth promoting *Rhizobacteria* (PGPRs), i.e. *Pseudomonasi* spp. and *Bacillus* spp., were isolated and characterized biochemically. Supplementation of propionate chelated organic trace minerals significantly improved the daily milk production in crossbred cows. Turkey birds were found highly suitable under hot and humid climate of the



Islands ecosystem. *Azolla (Azolla pinnata)* an aquatic fern was found to be good feed supplement for livestock and poultry. Diverse fishery resource of Andaman and Nicobar Islands were documented. Economic status and scope of dairy farming in Andaman and Nicobar Islands was analyzed.

Organization and management: The Council has taken several new initiatives to improve working environment and to make research effective, efficient and relevant. Full powers were delegated to the Directors of the Institutes to sanction foreign deputation cases under approved projects. Towards right-sizing the manpower at the Headquarters, about 20 per cent posts of Assistant Directors-General have been redeployed to the field. A committee is also looking into personnel and promotion policy of scientists. The Council amended the composition of ICAR Society and the Governing Body. Now, Secretary, Department of Biotechnology (DBT) and Director-General, Council of Scientific and Industrial Research are also its members. Scientists in the private sector/international organizations are also being invited as members on Research Advisory Committees of the institutes.

Scholarships were awarded to the meritorious wards of the Council's employees under Staff Welfare Fund Scheme. During this year, 57 awards under 13 different categories have been conferred, honoring nine institutions, 42 scientists and their 57 associates, six farmers and one journalist. Out of 42 scientists, there are 11 women scientists and one farm woman.

(Mangala Rai)

Secretary, Department of Agricultural Research and Education
and
Director-General, Indian Council of Agricultural Research



Improvement and Management of Horticultural Crops

FRUIT CROPS

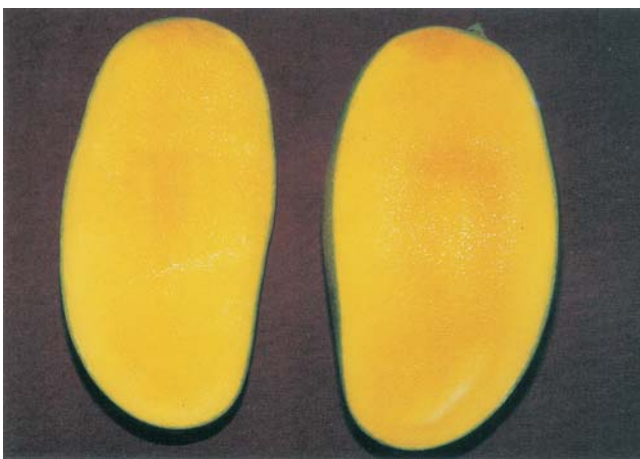
Mango

Mango superior trees of different varieties were identified and scion sticks collected at IIHR, Bangalore. Eighteen accessions in mango were characterized morphologically. *Mangifera odorata* recorded maximum TSS (21.7° Brix). The pulp recovery was found 83 and 81% in mango Keraligoa and Khudadath (variant), respectively. Distinct physiological shift of seed into germination

- Eighteen accessions of mango were characterized
- T 19 and T 20, clones of mango Himsagar, were promising
- Salem and Javori, clones of mango Bangalore were promising
- Hybrid H 311 gave maximum fruit yield
- Rejuvenation of mango orchards was done

mode allows the seed to act as a stronger physiological sink, enabling it to draw water and other nutrients from adjoining mesocarp resulting in spongy tissue. The survey of mango orchards of Krishna district for nutrient status indicated that the age of orchards decides the deficiency of micronutrients and their management for yield and quality. The correction of micronutrient disorders in mango Banganapalli in Krishna districts recorded 12–18% increase in yield. The causes of low yield in mango orchards

Fruit quality of treated tree



in Kolar district in Karnataka indicated zinc (13–17 ppm) and boron (34–45 ppm) deficiencies. Zinc (15–17 ppm), manganese (28–32 ppm) and boron (42 ppm) deficiencies were also found in Krishnagiri. The studies on pest risk analysis of *Bactrocera caryeae* showed that it is restricted to west coast of India and major mango belts of South India are free from it. Extensive surveys carried out for mango fruit fly and stone weevil infestation in South India on Banganapalli showed that Krishna, Mehaboobnagar/Rangareddy districts of Andhra Pradesh, were free from these pests.

At CISH, Lucknow, plastic mulch enhanced flowering in mango. The response of black plastic mulch (100 µ) was evaluated against root growth, nutrient status of soil and plant, flowering and yield of mango Chausa. Mulching was done during flower-bud differentiation (October–November) stage. The mulch stimulated the lateral root growth particularly in nutrient rich upper soil layer. However, there was no difference in dry weight of roots. The data on nutritional status revealed the improvement in levels of Ca (521.05 ppm), Zn (0.93 ppm), Cu (1.61 ppm), Mn (6.66 ppm) and Fe (4.90 ppm) in mulched soil as compared to control (440.95, 0.75, 0.66, 4.52 and 3.6 ppm, respectively). Among different nutrients, phosphorus (0.21%) and potash (0.8%) were found significantly higher in leaves of mulched plants in comparison to control (0.15 and 0.56%). Enhancement in flowering and yield (38–70 and 40–60%) were also recorded in 'off' and 'on' year because of mulch. Increase in these attributes may be associated with increase in root area along with enhanced ability of tree to take more nutrients particularly phosphorus and potassium from soil under mulched condition.

Single application of five bacterial antagonists isolated from mango pathosystem and leaf based organic liquid pesticides were found effective against mango bacterial canker disease. These organisms were identified as species of *Bacillus*, *Pseudomonas* and *Acinetobacter*.

Under All India Coordinated Research Project on Sub-Tropical Fruits, Dudhiya Malda performed very well followed by Dholikothi Maldah at Sabour, Bappakai and Sensation at Sangareddy, Bangalore Goa followed by Zafrani Gola at Pantnagar and Keraligoa, Khudadath and Navneetham at IIHR, Bangalore. Peddapur-16 seedling at Sangareddy and collection Nos. 7/80, and 10/80 were found promising at Sabour. Two clones, T19 and T20, of Himsagar



were found promising for high yield at Mohanpur and clone Rati Banganpalli having cluster bearing habit, early Baneshani having early maturity, Pedda Benishan and Allahabad Benishan bearing bigger sized fruits than Banganpalli performed well at Sangareddy. Similarly, two clones of Bangalora, i.e. Salem and Javori having big fruits (300–500 g) were found promising at Periyakulam. Hybrid H-311 (Alphonso × Neelum) recorded maximum yield and was found free from spongy tissue disorder at Vengurle. Neeleshwari and Neeleshan were found promising at Paria.

In planting system-cum-high-density planting trial, double hedgerow system of planting gave significantly higher yield at most of the centres. In pruning trial for high-density planting, maximum number of fruits and yield were recorded in the trees pruned on alternate limbs after harvesting with application of paclobutrazol at Sangareddy, whereas at Paria and Vengurle, heading back of 20 cm terminal shoot biennially with application of paclobutrazol during rest period gave higher yield. Heading back of branchlet at 50 cm level with the application of paclobutrazol during rest period gave higher yield in trees planted at normal distance at Vengurle. Rejuvenation of overcrowded orchards (heading back up to crowded branchlets and centre opening) along with use of paclobutrazol during the rest period gave maximum cumulative yield of last seven years at Sangareddy and Pantnagar.

Maximum hopper population was recorded on panicles during flowering stage, i.e. second fortnight of March (65.5) followed by that on trunk of tree (57.1) in first fortnight of April and on leaves in first fortnight of July (58.6) at Mohanpur. Higher activity of hopper was observed during flowering stage, while thrips had two peaks (October–November and March–May) coinciding with new flush period at Paria. Three sprayings of Imidacloprid and Endosulphon starting first spray of Imidacloprid (0.005%) at panicle emergence followed by the rest two sprays of Endosulphan (0.07%) at 15 days and 21 days intervals proved highly effective by reducing hopper population by 20.07% with highest yield of 346.6kg/tree at Sabour. Number of fruits set at marble and harvesting stages were significantly higher in treated plots sprayed with Imidacloprid (0.005%) at panicle emergence than in untreated control at AES, Paria. Module-II (Imidacloprid (0.005%), NSKE (5%) and Endosulphan (0.07%) was highly effective by resulting in lowest survival of hopper population (8.64%) and maximum fruit yield (259 kg/tree) in mango Langra at Sabour.

Banana

Forty-six exotic accessions of banana were introduced from Belgium at NRC for Banana, Trichy. Phylogenetic relationship among 45 AB diploid accessions was analysed using microsatellite markers. Embryogenic cell suspensions of banana Nendran (French Plantain) and Ney Poovan were developed. Kanai Bansi,

- Forty-six exotic accessions of banana were added
- Primers, OPB1, OPB7 and OPB17, showed polymorphism
- Four distinct bacterial clones were isolated
- A total of 1,1000 suckers of banana were supplied at Arabhavi, 50,000 at Jorhat and 680 at Mohanpur

M. balbisiana, Athiakol, Bhimkol and Attiakola were potential resistant donors against burrowing and root lesion nematodes, while Ankur was moderately resistant to root-knot nematode. Nattu Poovan, Thella Chakkarakeli, Teraben, Mannan, *Musa balbisiana*, Ladan, Erode Kai and Pisang Berlin were drought tolerant based on leaf water retention capacity.

In Red Banana, plants grown under paired row planting system with a population of 3,800 plants/ha recorded 29.5% more yield than 2,500 plants/ha. The fruits recorded highest TSS (23.5° Brix), total sugars (20.96%), ascorbic acid (12.53 mg/100 g), peel carotene (3.02 mg/100 g) and low acidity (0.26%) under paired row planting.

In Rasthali, application of 15 kg rice husk ash + 80% recommended NPK + 25 g VAM/plant recorded highest average bunch weight of 12.3 kg with 30% increase over control (9.4 kg). Under high soil pH (>8.5) condition, soil application of iron and boron and foliar application of zinc increased bunch weight in Ney Poovan banana. Fertilizer adjustment equations were developed for optimum production of banana Rasthali.

For integrated pest management in banana, a semi-chemical Eicosane evoked higher response (0.732 eV) to female antenna, whereas cyclohexane responded to male antenna (0.292 eV). Complete mortality of burrowing nematode was observed with application of flower and root extracts of *Tagetes erecta*. Applications of 30 g *Trichoderma viride* at planting, and 3 and 5 months after planting or in combination with *Pseudomonas fluorescens* reduced nematode population significantly with increased plant growth.

Primers, OPB1, OPB7 and OPB17, showed polymorphism and differentiated different foci by cluster analysis. Nit mutants were generated for VCG grouping of different foci isolates. Presence of VCG's 0124, 0125, and 0128 of foci in India has been confirmed. Two of the rDNA-ITS sequences of foci have been deposited in the NCBI genbank. Complete genome of banana streak virus (BSV) was cloned, sequenced and deposited with the NCBI genbank (Accession 859899). The viral genome was 6950 bp in length and had three ORFs. This BSV sequence is more similar to BSV-OL and GD sequences, 900 bp intergenic BSV sequence was cloned for assessing the promoter activity. The BBTV cp gene was cloned into an expression vector for producing recombinant coat protein.

The ACC oxidase gene was isolated and fused with CaMV 35S promoter and terminator in anti-sense orientation to develop



IMPROVEMENT AND MANAGEMENT OF HORTICULTURAL CROPS

transgenic banana with delayed ripening. This whole cassettes of ACC oxidase in anti-sense orientation with respect to CaMV 35S promoter was shuffled to binary vectors of pGreen and pCAMBIA.

Under AICRP on Tropical Fruits, four accessions of banana have been catalogued for their morphological traits at Coimbatore. At Kannara, 15 regenerated new accessions of banana were planted for field evaluation. At Coimbatore, 20 crosses were made using Manoranjitham and Karpooravalli as female parents and Rose, YKM 5, Pisang Lilin and H-65 as male parents, which yielded 106 seeds. The hybrid progeny from different crosses were established in field under Kannara conditions. At Kovvur, RAPD analysis corroborated the genetic variability discovered by isoenzyme analysis between *Fusarium* wilt resistant Silk banana Martman from other susceptible members of group. The cultivar can directly be deployed in *Fusarium* (race-1) endemic areas. Banana hybrid, 96/7 and H 212, tolerant to nematodes were proposed as pre-release cultures at TNAU, Coimbatore. Application of fertilizers of 200 : 50 : 200 N, P₂O₅ and K₂O respectively/plant/crop along with spraying of 2,4-D at 10 ppm gave higher yield during plant crop of banana under Arabhavi conditions, while at Kannara, 2, 4-D (25 ppm) as bunch spray along with soil application of 200 g N and foliar application of urea (2%) recorded yield increase in banana Nendran. At Coimbatore, combined treatment of 300 g N and 300 g K₂O with two post-shooting spraying of CPPU (4 ppm) gave maximum bunch weight of 37.25 kg. The treatment propiconazole (0.1%) + spraying of *Bacillus subtilis* @ 5 ml/litre controlled Sigatoka leaf spot effectively under Arabhavi and Kannara. A total of 1,100 suckers of banana were supplied at Arabhavi, 50,000 at Jorhat and 680 at Mohanpur.

For molecular characterization of fruit fly species, molecular differences in mitochondrial cytochrome oxidase I (mtCOI) gene of three fruit fly species, viz. *Bactrocera dorsalis*, *B. correcta* and *B. zonata* (Tephritidae: Diptera) were carried out using mtCOI specific primers. Sequence analysis of PCR amplified fragments showed appreciable differences in nucleotide sequences of three fruit fly species.

Four distinct bacterial clones were isolated from bacterial contamination displaying *in vitro* cultures of banana Grand Naine and single colony-purified and identified through 16SrDNA sequence analysis. These organisms included *Pantoea agglomerans*, *Bacillus subtilis*, *Klebsiella variicola* and *Staphylococcus epidermidis*. All these endophytes appeared detrimental to banana cultures overrunning them within 2–4 weeks of *in vitro* culturing.

Citrus

At NRC for Citrus, Nagpur, one early-maturing clone (N₂) of Nagpur mandarin (early-February) and another less-seeded clone

(N₄) of less than 3 seeds/fruit were identified for evaluation at farmers' fields. In germplasm collection, 49 exotic germplasm comprising 30 scions (14 of mandarin, 9 of sweet orange, 7 of grapefruit and pummelo from USA, France, Japan and Niger) and 19 of rootstocks (mostly from USA, a few from Australia) and 532 indigenous collections have been maintained at Nagpur. Besides, 75 superior clones of Nagpur mandarin, 12 of acid lime and 5 of Mosambi were under field evaluation. For micronutrient-use efficiency in Nagpur mandarin, suboptimum Zn and Fe nutrition are considered to be the global concerns for sustainable citrus production. Better efficiency of soil applied Zn over foliar application and vice-versa in case of Fe, was observed with respect to response on flowering intensity, fruit setting, tree canopy volume,

- Seventy-five clones of Nagpur mandarin, 12 of acid lime and 5 of mosambi were evaluated
- On selection each of sweet orange and pummelo were collected

fruit yield and quality indices. Higher movements of Zn through xylem compared to Fe and of Fe through phloem in comparison to Zn, were identified as the major distinguishing factor in understanding the differential response between Zn and Fe fertilization.

Continuous trenching between two rows of trees across the slope (3.8%) conserves 30–35% run-off and 25–30% soil and available nutrients (N, P, and K) in young Nagpur mandarin, producing better plant growth. In bearing acid lime as well, continuous trenching produced the best response conserving 35–38% run-off and 32–35% soil and available N, P, and K in addition to raising fruit yield by 18% with better fruit quality (43.2% juice) over control (35.4% juice). Harvested rainwater from 3.1 ha of catchments through a tank of 35 m × 35 m × 3 m size was successfully recycled through drip irrigation with plastic mulch in 1 ha (288 plants) of 3-year-old Nagpur mandarin orchard.

Of the nine biopesticides tested, choicest biopesticides/new molecules in their order of toxicity to blackfly and leaf miner were found – abamectin > spinosad > novaluron and to psylla and – spinosad > abamectin > novaluron to leaf minor. Oviposition

Use of Bioagents

In field release of bioagents against citrus insect pests, release of *Mallada boninensis* @ 30 larvae/tree and *Tamarixia radiata* @ 40 adults/tree resulted in 28–30, 42–45 and 23–26% reduction in blackfly, psylla and leaf miner, respectively.



preference by leaf miner, blackfly and psylla on Nagpur mandarin revealed that citrus blackfly and leaf miner preferred 15–20 and 5–10 days old leaves, respectively, whereas psylla preferred 5 days old twig for egg laying.

Under AICRP on Tropical Fruits, one selection in sweet orange and another in pummelo were collected and planted at Tirupati. Sweet orange mosambi selections 2 and 4 and acid lime promising selection RHR-L-124 continued to record their superiority for yield and fruit quality at Rahuri. At Tinsukia, Khasi mandarin selection CRS-4 continued to be superior among 12 clonal selections. Addition of VAM (500 g/plant) + PSB (100 g/plant) + *Azospirillum* (100 g/plant) + *T. harzianum* (100 g/plant) to 100% RDF/plant/year produced highest yield of sweet orange at Rahuri. Fifty-seven grafts of sweet orange Mosambi and 315 seedlings of acid lime (Sai Sharbati) were supplied to farmers at Rahuri. Virus-free kinnow was budded on 2,000 plants of Rough lemon at Ludhiana.

Grape

Eight exotic accessions of *Vitis vinifera* were introduced in addition to collection of four wine grape accessions from private winery at NRC for Grapes, Pune. The National Grape germplasm collection now has 415 accessions. A total of 149 accessions were characterised based on berry and bunch characters. Forty-four accessions were characterised using RAPD and microsatellite markers and genetic relationship among these accessions was established.

Several hybrids of indigenous species and varieties with introduced cultivars were found promising for early ripening and quality traits. Germplasm was screened for resistance to thrips and downy mildew and several accessions showing varying levels of tolerance were identified, which can be used in breeding programme to develop resistant commercial varieties. In microsatellite analysis of a large number of downy mildew resistant and susceptible grape accessions identified a marker which is present in only susceptible accessions.

Thompson Seedless grafted on 110R produced significantly more bunches and higher yield as compared to those grafted on other rootstocks as well as own roots. Nutrient uptake pattern was found to be different for different nutrients in grafted and own

- A total of 149 accessions were characterized
- A software for grape germplasm information system was made operational
- A prototype disease forecasting of software for powdery mildew management in grape was developed
- Statistical model was developed to predict powdery mildew incidence in grape

Software in Grape Production

The software for grape germplasm information system was made operational. Database for molecular data of grape accessions was designed.

rooted vines. Vines grafted on Dogridge and 110R accumulated lower chlorides in tissues than those grafted on Salt Creek. The shiny spot symptoms was found to be due to potassium deficiency. Similarly, low potassium content was found to be associated with marginal necrosis of leaf blade.

The IBA concentration was standardized for propagation of grape rootstocks using hardwood cuttings. No adverse effect on growth, yield and quality parameters were observed in nine years old Tas-A-Ganesh grafted on Dogridge rootstock with different levels of stock scion growth ratio (inverted bottleneck symptom). In Thompson Seedless, maximum photosynthetic rate and internal CO₂ was recorded during fruit-bud differentiation and full bloom stages on 110R rootstock compared to other rootstocks. Stock scion ratio of 0.9–1.0 was recorded in Tas-A-Ganesh when grafted on 110 R and B2/56 rootstocks, while it was 0.8–0.9 on Dogridge indicating higher vigor inducing nature of Dogridge. However, yield and number of bunches were maximum on 110 R followed by that on Dogridge rootstock.

Increased root : shoot length ratio and water-use efficiency were observed in most of the rootstocks at 50% moisture stress over control. At 50% moisture stress, although Dogridge recorded maximum root : shoot length ratio, 110R showed maximum water-use efficiency. Total phenolic compounds and individual class of phenols like flavonoids, flavonols, flavon – 3 – ols were estimated in Thompson Seedless grafted on different rootstocks at three different berry growth stages. Preliminary investigation revealed positive correlation between phenolic compositions and reduced incidence of powdery mildew.

In Thompson Seedless, higher bud fruitfulness was recorded in upward positioned shoots with maximum bud fruitfulness at 5–7th bud position. In Tas-A-Ganesh horizontal single cordon training modification recorded higher yield than double cordon system. Double stem four cordon system in Tas-A-Ganesh though resulted in higher yield as compared to single stem and other training modifications, however berry and bunch quality characteristics were low in this treatment. In plastic covered Tas-A-Ganesh girdling at 6–7 mm berry size resulted in improved performance of vines with respect to berry weight, diameter and length, total soluble solids and early berry setting. In Sharad Seedless, girdling at 6–8 mm berry size resulted in higher berry diameter, and berry and bunch weight. In Merlot and Sauvignon



Blanc maximum bud fruitfulness was recorded when spur pruned at 5th and 4th bud respectively.

At reduced level of irrigation, vines raised on B2/56 performed better than Dogridge and own roots. The cost : benefit ratio was highest for B2/56 at 75% and 50% of recommended irrigation level. Similarly, cost : benefit ratio of subsurface irrigation at 75% of recommended level was on par with recommended level, thus resulting in a saving of 25% irrigation water. In another experiment, irrigation requirement could be reduced by 25% using mulch and antistress, although the cost : benefit ratio of this treatment was less than the recommended levels of irrigation.

A prototype disease forecasting software for powdery mildew management was developed. The software takes daily weather data, field data and generates diagnosis and recommends the choice and dose of fungicides. The software was released and made available to growers.

Several environmentally safe chemicals and new molecules were tested and found promising for controlling powdery mildew. The efficacy of Carbendazim was improved by adding citric acid @30 g/100 litres of spray water. Biocontrol agent, *Trichoderma* was tested for antagonism to *Elsinoe ampelina* and significant mycoparasitism was observed.

Among several antagonistic microorganisms isolated from grape rhizosphere and endophytes, three were found to be promising for the control of post-harvest decay and three were promising against *Botryodiplodia theobromae*.

At Bangalore, three promising Thompson Seedless vines producing loose bunches and bold berries were identified. Total antioxidant capacity was significantly higher in Bangalore Blue grape seed followed by peel due to higher total phenols in seeds and anthocyanins and phenols in peel when compared to whole fruit. Raisins from Thompson Seedless grape had higher total antioxidant capacity (FRAP - 474 mg AEAC/100 g dwt), radical scavenging capacity (DPPH - 4339.4 mh/100 g) and total flavonoids (112 mg of catechin equivalents/100 g) compared to fresh grapes (430, 3922 and 91 mg/100 g dwt of FRAP, DPPH and total flavonoids respectively). Residues of Imidacloprid (Confidor 200 SL) on grapes was evaluated following spray applications (4 times) at recommended dose, revealed that crop was free of any Imidacloprid residue at harvestng, 105 days after treatment. Statistical model was developed to predict powdery mildew incidence in grapes The prediction power of empirical model was worked out to be 68.3%. Further, optimized model developed using maximum temperature, relative humidity and rainfall predicted powdery mildew incidence reasonably well ($R^2 = 0.60$) and possessed minimum average prediction errors. Statistical models were developed to optimize the role of weather factors and simultaneously to predict anthracnose incidence in grapes

cv. Anab-E-Shahi. The optimized model showed that morning and evening relative humidity could predict the incidence to 77.5%.

Papaya

An advanced generation hybrid has been developed at IIHR, Bangalore, which has medium-sized fruits (800 g), with deep pink coloured pulp, high TSS (13–14° Brix) and good keeping quality. For quick detection of virus in plants and seedlings, molecular diagnostic assay based on RT-PCR was developed using coat protein gene specific primers. Under AICRP on Tropical Fruits at Coimbatore, genotypes G 22, G 27, and G 15 were found early and

- An advance generation hybrid of papaya was developed
- Papaya genotypes, G 22, G 27 and G 15, were found early and tolerant to cold

tolerant to cold. Fruits from these genotypes were harvested and seeds collected to raise F_3 generation. Survey at Coimbatore revealed 20–40% incidence of papaya ring spot virus (PRSV).

Sapota

Eleven accessions of sapota were characterized at IIHR, Bangalore, using standard descriptors. The average fruit weight ranged from 26.44 g in Badam to 130.42 g in DHS 2. Thirty-two germplasm collections were studied for their susceptibility to chiku moth (*Nephopteryx eugraphella*), bud-borer (*Anarsia achrasella*), leaf miner (*Acrocercops gemoniella*) and ash weevil (*Mylloceris* sp.). Leaf nutrient guides for sapota have been developed for economic and balanced nutrient management. The nutrient guides for micronutrients have also been developed for sapota farmers. Potash has been identified as the most limiting nutrient in orchards surveyed in Karnataka.

- Eleven accessions of sapota were characterized with standard descriptors.
- Thirty-two germplasm accessions of sapota were studied

Under AICRP on Tropical Fruits, high-yielding clone DHS 1(2/1) identified earlier continued to show its superiority at Arabhavi. Application of 5 kg vermicompost with 200 g N, 40 g P_2O_5 and 150 g K_2O /plant/year in Kalipatti recorded higher yield. The treatment carbendazim (0.1%) effectively controlled leaf spot disease of sapota.

Guava

CISH-G4, a selection from population of Apple Colour guava,



was found promising, at CISH, Lucknow. It was released as Shweta for commercial cultivation. This has globose, medium-sized fruits, creamy white exocarp with red blush, snow white pulp, high TSS (12.5–13.2%) content and vitamin C (300 mg/100 g EP) with good keeping quality.



Guava Shweta

Under AICRP on Sub-Tropical Fruits, six germplasm accessions were added to the germplasm collection. Lucknow-49 followed by Allahabad Safeda and Lucknow-46-2 gave high yield at Sangareddy. Guava Allahabad Safeda excelled under Sabour conditions. The evaluation of germplasm at Bangalore revealed that fruit weight was maximum (246.5 g) in Dhareedar followed by Local Pink (244.2 g). The quality parameter revealed that TSS

- Six accessions of guava were added
- Three accessions of litchi were added
- Twelve fruit species were collected from Kerala
- In Jammu, 12 collections were evaluated
- Seven genotypes of aonla were added
- Three genotypes of date palm were added
- Aonla Selection 1 was identified
- F 6/a, a new mateera, was ready for release
- BS 1, a genotype of ber, was identified
- Storage life of pomegranates of Bhagwa could be extended for 3 weeks

ranged from 9.0° Brix in Aneuploid to 21.09° Brix in Local Pink. The acidity was low (0.524%) in Thailand 2, followed by Thailand 1 (0.613%). The vitamin 'C' was more (298.2 mg/100 g pulp) in Dhareedar. In planting system-cum-high-density planting, maximum yield was recorded in 'double hedgerow system' of planting and minimum in 'square system'.

Litchi

Three accessions were added to the gene bank making a total of

55 cultivars of litchi at NRC for Litchi, Muzaffapur. Litchi Shahi proved to be more robust compared to other cultivars. Allied species of litchi, longan (*Dimocarpus longan*) came to fruiting three years after planting. The keeping quality of longan fruit was very good and taste was sweeter than litchi with small seeds.

Major insect pests of litchi were identified. Trichogramma @ 50,000/ha with Ninbicide (0.5%) or cypermethrin @ (0.005%) with Nimbicide 0.5% sprays proved superior in minimizing the damage by fruit-borer when sprayed at fruit setting (lentil-sized) and at colour development stages.

One thousand four hundred litchi layers were supplied to litchi growers during 2006. Qualitative characteristics of Shahi and China litchi were analysed for wine making purpose.

Under AICRP on Sub-Tropical Fruits, double hedgerow system of planting gave highest yield at Pantnagar, while square system at Mohanpur. Shoots pruning up to 50 cm at the time of harvesting of fruits, followed by removal of new flush in November–December, 2006, provided maximum yield of quality fruits at Pantnagar.

Leaf roller incidence reached its peak in October (42–43%) and caused 51.5% fruit damage 67 days after fruit setting at Mohanpur. Incidence of leaf roller was low in March, 2006 and gradually increased maximum level in July at Pantnagar.

Mango Karpuria, Hathijhool, Audhia Maldah, Police, Maldah (Surajgarha) and Maldah (Dholikoth) showed only one per cent of malformation. Critical temperature (19.45°–35.61°C) and relative humidity (52.98–96%) with 9.01 h/day sunshine have been found to favour the maximum disease development of powdery mildew in Himsagar at Mohanpur. At Sangareddy, powdery mildew was observed during fourth week of January, 2006 on susceptible Ratna and Swarnajehangir with PDI of 61–80 when mean minimum temperature and mean maximum temperature were 10.71°C and 28.8°C.

The incidence of powdery mildew was first noticed on second flush in first week of January at Vengurle. It was found to be positively correlated to minimum temperature and panicle age. At Paria, maximum disease (86%) was observed in Alphonso at mean maximum temperature of 22.99°C, minimum of 14.17°C, RH of 68.64%, sunshine hour of 9.6 hours/day and vapour evaporation at 5.51 litre/day with clean sky position.

Passion fruit

Irrigation and fertilizer schedules for passion fruit revealed that irrigation at 75% of evaporation replenishment recorded higher yield as compared to irrigation at 50% of evaporation replenishment and basin irrigation. Fertigation with 75 and 100% of recommended dose of fertilizer recorded higher yield as compared to soil application of fertilizer. This indicates a saving of 25% of water and fertilizer.



Jackfruit

Jackfruit grafts of selected plants for raising clonal stocks at Kannara and those of Palur 1 from Periyakulam centre are maintained at Vellanikkara under AICRP on Tropical Fruits. At Mohanpur, four new germplasm have been identified. Twelve elite jackfruit clones were collected at Kovvur.

Underutilized fruits

In under-utilized fruits, three species of Pandanus, one each of *Baccaurea ramiflora*, *Spondias cytherea*, *Dillinia indica*, *Averrhoa bilimbi*, *Malpigia glabra*, *Baccaurea sapida*, *Cordia oblique*, *Artocarpus* spp. and *Garcinia* spp. were added from Andaman island. Another 12 fruit species found in Kerala forests were also collected: *Antidesma ghaesmbilla* (Black current), *Salacia chinensis*, *S. beddomei*, *Flacourtia Montana*, *Syzygium zeylanicum*, *Elaeagnus serratus*, *Chrysophyllum cainito* (Star apple), *Flacourti (lovi-lovi)*, *Averrhoa bilimbi* (Bilimbi), *A. carambola* (sour type), (*Carambola*), *Psidium guineense* (*Guva* sp.), *Aporosa lindleyana* and *Psidium littorale*. In jamun, 12 collections were observed for their variable reaction to leaf miner, *Acrocercops* sp., fruit weevil, *Balaninus c- album*, bark eating caterpillar, *Indarbela* sp. and ash weevil, *Mylloceros* sp. Fifteen pummelo germplasm collections were evaluated for resistance to citrus leaf miner and *Phyllocnistis citrella*.

Temperate fruits

At CITH, Srinagar, medium high-density plantation with 625 budded plants of almond/ha at 4 m × 4 m distance was compared with 278 plants/ha planted traditionally at 6 m × 6 m distance. The budded plants commenced into bearing only after 3 years in comparison to 7 years of seedling trees. Consequently, the productivity has been raised from existing 0.86 tonne/ha to more than 3 tonnes/ha from 6 years old plants. This showed the possibility of increasing the productivity manifold with use of varieties like Waris, Shalimar, Makhdoom and Non-Pareil.

Arid zone fruits

Seven genotypes of aonla and three of date palm were added to national repository. Large collections of bael, jamun, karonda, tamarind, mahua, chironji and wood apple were also made at CHES, Vejalpur, Godhra. However, due to sub zero temperatures, which prevailed continuously for 3–4 days during January 2006, all germplasm of ber (except Tikadi and Snaur), aonla, pomegranate and lasora were severely affected with frost injury while date palm and khejri germplasm were not affected.

A selection of aonla (Aonla Selection 1) was identified, which is early-maturing and high-yielding due to more number of female flowers under rainfed conditions of semi-arid region. A new variety of mateera (F6/a), which is free from cracking, good in TSS (9.5–

11.2° Brix), low in seed content, red in pulp is ready to be released.

For tissue culture plant, a three step hardening process involving primary in acclimatization hood made of plastic tray covered with polycarbonate sheet with ventilation devices, subsequent transfer to evaporative cool chamber and thereafter,



Medium high-density plantation in almond



Almond bearing in medium high-density plantation



Non-pareil

Shalimar

acclimatization of plantlets either in shade house or low-cost polyhouse equipped with intermittent fogging device has been found effective in surviving of plants.

The fertigation practices has been standardized in Kinnow mandarin and results revealed that 70 and 40% of recommended



dose of nitrogen and phosphorus during February–June, 20, 50 and 40% of recommended dose of nitrogen, phosphorus and potash during July–September and remaining 10% of N and P and 60% of potash during October–December may be applied through micro-irrigation (drip and micro-sprinkler) for optimum productivity with maximum water and nutrient-use efficiency.



Veneer grafting in khirnee (*Manilkara hexandra*)



Aonla cider

Under microirrigation system, maximum root volumes were estimated in 20–40 cm deep soil layers in pomegranate, kinnow and ber trees. During April–June 28–45% more moisture was conserved under black polythene mulch in aonla. In arid conditions, FYM mulch (140 tonnes/ha) increased the water-use efficiency, moderate the extreme soil temperatures and increased fruit yield in brinjal and kachri crops. The use of vermicompost in sandy soils has better influence on soil moisture retention in root zone for a longer period, which also helps to make the nutrients available for plants.

Pomegranate and aonla fruits infested by post-harvest pathogens were investigated for presence of mycotoxins with special reference to Aflatoxins. Aonla, NA-6, NA-7, Chakaiya and Krishna were observed with infection due to *Aspergillus* spp. and it was maximum (33.2%) in Krishna, followed by NA 6 (17.8%). Four pathogenic isolates of *Aspergillus* spp. were tested for mycotoxins and aflatoxins, viz. B₁, B₂, G₁ and G₂. These were produced in growth media and fruits as well. Detection of aflatoxins in pomegranate arils by agar plugs method showed positive response with different compounds when the samples were loaded on silica gel (TLC). Aflatoxin B₂ was secreted by all isolates in growth media and infected arils. The fungicidal seed dressing with ridomil Mz @ 2.5 g/kg seed was adjudged as best treatment which provide maximum transplant yield with least mortality due to post-emergence damping off disease.

Under AICRP on Arid Zone Fruits, a genotype of ber 'BS-1' has been identified. It is tolerant to fruit fly and resistant to powdery

mildew. The genotype has been registered as a promising line of ber by NBPGR, New Delhi.

In custard-apple (*Annona squamosa*), additional pollination gave best fruit setting, size and shape in both dry and wet years without significantly affecting fruit quality. Under integrated nutrient management programme, 50% of recommended doses of NPK and S along with biofertilizers and recommended dose of FYM proves to be best combination for aonla, ber, date palm and pomegranate at different centers.

Application of neem oil 60 EC (A) @ 3% and neem oil 60 EC @ 30% effectively reduced powdery mildew of ber and *Trichoderma viride* 10 g/kg of soil reduced root rot incidence in different fruit crops.

Post-harvest management

Mango fruit peels were found to possess very high antioxidant activity. The antioxidants can be extracted from peels as valuable byproducts from waste. Hot water treatment of fruits of mango Chausa, Amrapali and Mallika at 48°C ± 1°C for 1 hour controlled all stages of mango fruit fly (*Bactrocera zonata*). Individual shrink-wrapping of mature green fruits of Alphonso and Banganapalli with semi-permeable polymeric films extended their green storage life to 5 weeks at 8°C without any chilling injury symptoms. Alphonso mangoes packed in bulk by inner lining of entire 4 kg CFB box with micro-perforated semi-permeable films could be stored for 1 month at 8°C in unripe hard green condition without any chilling injury symptoms.

The storage life of pomegranate fruits (Bhagwa) could be extended to 3 weeks by bulk MAP and 1 month by individual shrink wrapping at ambient temperature. At 8°C, storage life could be extended to 3 months by these packing methods with a weight loss of less than 1% as compared to 20% weight loss in non-wrapped fruits.

VEGETABLE CROPS

Crop improvement

Chilli Kashi Anmol a determinate variety, suitable for production of green fruits, has been developed. Its fruits are dark green, 5–6 cm long and 2 cm girth, pungent (0.6% capsaicin) with smooth surface, early fruiting, first picking 55 days after transplanting, with an average yield of 250 q/ha (green fruits). Kashi Early is a hybrid with early fruiting suitable for production of green fruits. Its fruits are dark green, 6–7 cm long, 2.3 cm girth with smooth surface; first picking starts 45 days after transplanting. Its average yield is 275 tonnes/ha (green fruits). It is recommended for cultivation in Bihar, Uttar Pradesh, Uttaranchal, Jharkhand, Delhi and Punjab. Kashi Vishwanath is a cms based hybrid suitable for dry fruit production. Its fruits are 10–11 cm long, 2–2.3 cm girth with wrinkled surface, light yellow-green, average yield of 200 q/ha (red ripe fruits). Its is



- A number of new vegetable varieties were released
- More than 85 putative transgenic plants were regenerated
- Brinjal genotypes were used for regeneration and transformation
- F_1 hybrids of chilli were analysed for purity
- A total of 200 primers were used for screening polymorphism
- A technique to estimate antioxidant activity in tomato has been standardized
- Thirty-two isolates of *A. flavus* were studied

recommended for cultivation in Bihar, Delhi, Haryana, Andhra Pradesh, Karnataka and Tamil Nadu.

Okra IIVR 11 is a new variety. Its plants grow 110–130 cm high, flowering starts 30–34 days after sowing. It is suitable for cultivation during rainy as well as summer season. Fruits are of five ridges, green and 13–15 cm long. This is resistant to YVMV with an average yield of 150–170 q/ha. It is recommended for cultivation in Chhattisgarh, Orissa, Andhra Pradesh, Rajasthan, Gujarat, Haryana and Delhi.

Cauliflower Kashi Kunwari is an early-maturing variety. Its curd is semi-dome type, white compact; fine texture, curd weight 300–450 g with an average yield of 300–350 q/ha. It is suitable for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand.

Radish Kashi Hans is suitable for September to February planting and harvesting can be done 40–45 days after sowing. Its roots are straight, tapering, 30–35 cm long, 3.5–4.2 cm diameter; with an yield potential of 430–450 q/ha. It is released for cultivation in Uttar Pradesh, Punjab, Bihar and Jharkhand. Cowpea Kashi Gauri is bushy, dwarf, photo-insensitive and early variety suitable for sowing in both spring-summer and rainy seasons. It flowers in 35–38 days and pods becomes ready for harvesting 45–48 days after sowing. Pods are 25–30 cm long, green, tender, fleshy, less fibrous and free from parchment layer. Resistant to golden mosaic virus and *Pseudocercospora cruenta*. It produces 100–125 q/ha green pods.

Genetic transformation: Transformation was performed using *Agrobacterium tumefaciens* in tomato H 86 using *Cry IAc* gene from T-DNA of binary vector plasmid pBinAR. More than 85 putative transgenic plants were regenerated and are being maintained under laboratory conditions. The putative transgenic plants were tested for confirmation of inserted gene through PCR analysis. The inserted gene was detected by *npt II* gene and *Cry IAc* gene specific primer which shows 700 bp for *npt II* and 900 bp for *Cry IAc* gene. After PCR analysis, positive plants were subjected to southern blot hybridization. The PCR positive plants were also tested for strip test (strip that contain Anti *Cry IAc* antibody) and

ELISA test. PCR and southern positive plants are being used for insect bioassay and segregation analysis.

Transformation: Brinjal genotypes Punjab, Sadabahar, Pant Rituraj, VR Baigan 1 (IVBR 1), VR Baigan 3 (IVBR 3), VR Baigan 9 (IVBL 9) and VR Baigan 14 (BRSPS 14), were used for regeneration and transformation. Transformation was performed using *Agrobacterium tumefaciens* in VR Baigan 9 (IVBL 9) using *Cry IAc* gene from T-DNA of binary vector plasmid pBinAR. More than 80 putative transgenic plants were regenerated. The gene integration was detected by PCR analysis. The amplification of 0.7 kb band for *npt II* and 0.9 kb for *Cry IAc* shows the presence of inserted gene. The transformants were further analyzed by southern blot hybridization. Southern analysis revealed 1 kb band with single blot hybridization in most of the transformants. The presence of *Cry IAc* toxin protein in plant was confirmed strip



Chilli Kashi Anmol



Chilli Kashi Vishwanath



Cauliflower Kunwari



Radish Kashi Hans



Cowpea Kashi Gauri



Symptomless GKC 29 scion grafted on susceptible Pusa Jwala

coated with anti *cry 1 Ac* antibodies. Insect bioassay was also done using neonate larvae (*Leucinodes orbonalis*) brinjal shoot-and fruit-borer with PCR and southern blot analysis confirmed transformants. Segregation analysis was done with only PCR and Southern positive plants and most of plant showed 3 : 1 ratio.

Resistance sources to Pep-LCV: From field screened 307 genotypes against pepper leaf curl virus (PepLCV) during previous season, selfed progenies of eight symptom-less and highly resistant lines were challenged by viruliferous white fly under glasshouse conditions. Of them, GKC 29, BS 35, EC 497636, showed no symptoms. Using scion and rootstock of susceptible genotype (Pusa Jwala), these three putative symptomless genotypes were further challenged by grafting and alternate grafting. The resistant reactions of GKC 29, BS 35, EC 497636 were confirmed because even after 50 days of successful grafting/alternate grafting, no viral symptom appeared on all grafted plants of Pusa Jawala in all three genotypes. When subjected to PCR amplification with degenerate primers designed to detect begamovirus like PepLCV, three symptom-less genotypes did not show any amplification, suggesting that resistant reaction in three identified resistant sources was because of absence/non-replication of viral genome and these lines are not symptom-less carrier.

Genetic purity testing: Two commercial F_1 hybrids of chilli, CCH 2 ($A_1 \times$ Pusa Jwala) and CCH 3 ($KA 2 \times$ R Line), and their

corresponding parents were analyzed for purity testing. A total of 200 primers (10 mer) were used for screening polymorphism between two pairs of parents. Of these primers, 145 produced clear amplification products. On an average each primer amplified three scorable bands. The primers that generated bands specific to male parent were repeated at least 2–3 times. These primers giving the same pattern in two or more replicates were chosen for further use. The 4 primers were found useful in determining seed purity. For hybrid CCH 2, 2 male specific bands were found with primers OPZ 6 and OPY 20 and among these, OPZ 6 was found most suitable for hybrid purity testing with band size of 700 bp. For hybrid CCH 3, 2 male specific bands with primers (OPS 1 and OPQ 18) were found amongst which OPS 1 was found most suitable for hybrid purity testing with band size of 400 bp.

Crop production

Integrated nutrient management: Ten organic nutrient sources, i.e. FYM @ 20 tonnes/ha, sewage sludge @ 20 tonnes/ha, vermicompost @ 10 tonnes/ha, neem cake @ 5 q/ha, NPK @ 150 : 60 : 80 kg/ha, FYM @ 20 tonnes/ha + Azotobactor, sewage sludge @ 20 tonnes/ha + Azotobactor, vermicompost @ 10 tonnes/ha + Azotobactor, neem cake @ 5 q/ha + Azotobactor, NPK @ 150 : 60 : 80 kg/ha + Azotobactor were given to tomato Sartaj. The observations reveal that application of vermicompost @ 10 tonnes/ha + Azotobactor gave significantly higher yield (962.5 q/ha), plant height (118.6), fruit size (37.8 cm²) compared to other treatments. The minimum values were noted under sewage sludge treated plots.



Staked tomato grown under IPNM

Antioxidant activity (AOA) in tomato: A technique has been standardized for estimation of antioxidant activity in tomato fruits to assess variability. Total antioxidant activity of sample extracts was analyzed using 2, 2-diphenyl-1-picryl-hydrazyl (DPPH) by recording absorbance at 515 nm. The standard curve was prepared for the reaction of TROLOX with DPPH and data was converted to activity in terms of μ moles trolox equivalents/100 g sample. Significant differences ($p > 0.05$) were recorded for antioxidant activity among 15 cultivars which ranged from 2.19 to 5.79 μ moles trolox equivalents/g with an overall mean for all the entries of 3.854 μ moles trolox equivalents/g.

Effect of bioagents: Thirty-two isolates of *A. flavus* were studied for radial growth inhibition against *Trichoderma viride*, *T. harzianum* and *T. koenigii*. Mean radial growth inhibition of 30 plates of *A. flavus* by three biocontrol agents in dual culture showed general inhibition of mycelial diameter above 60% in almost all test combinations. Relative inhibition efficacy varied among test bioagents. Maximum inhibition of *A. flavus* isolates with bioagent *T. viride* which not only restrict the growth of meeting point but also fully overlap growth of test organism.

Use of bait: During peak infestation period, molasses (10%) + carbaryl (0.1%) cover spray recorded significantly lowest (20.36%) fruit infestation being at par with spot spray of molasses (10%) + carbaryl (0.1%) manifesting 27.4% fruit damage while in control plot 55.28% fruits were damaged by fruit fly. Mean cumulative fruit damage over all the pickings indicated the superiority of molasses bait in either of the treatments. Molasses bait spray in spots recorded minimum (18.51%) followed non-significantly by molasses + insecticide cover spray (19.94%). The level of fruit damage in most usually applied insecticide cover spray was 26.67%. The control plot recorded 37.54% fruit damage. Maximum healthy fruit yield was recorded in molasses bait spray applied in spot.

Effect of seed treatment: The mean seedling length (25.26 cm) and vigour index (2,357.82) were maximum in

thiamethoxam treated seeds days after sowing. Seedling vigour index in carbosulfan treatment was adversely affected due to low germination. Thiamethoxam was most ideal treatment with maximum plant dry weight (70.01 g) 50 days after sowing. In jassid population thiamethoxam also was significantly superior to all treatments harbouring least number of jassids (9.46/plant) compared to control (27.59 jassids/plant). The yield in this treatment was also highest (126.82 q/ha) followed by imidacloprid (112.01 q/ha).

Tomato varieties at farmers' fields

Tomato Kashi Amrit, Kashi Anupam and Kashi Vishesh developed by IIVR Varanasi, were demonstrated at farmers' fields of Varanasi, Chandauli, Sonebhadra and Mirzapur districts in Uttar Pradesh. On an average, all varieties gave 520.83 q/ha compared to 365.25 q/ha (control). All these varieties are spreading at



Yield of tomato Kashi Vishesh at farmers' fields



Performance of Kashi Vishesh at farmers' fields



farmers' fields very rapidly due to their better productivity. Tomato Kashi Vishesh has proven a boon for mid-season tomato growers. In rainfed condition, in Sonebhadra district farmers taking only wheat as a major crop now are growing tomato as a major cash crop. The farmers express that flesh and hardness of all the varieties are like hybrids, which help them for distant marketing and improving their socio-economic status.

MUSHROOM

The National Mushroom Repository has been enriched by adding 312 mushroom cultures. Of which, a few are new records for India. Genetic improvement studies of temperate and tropical mushrooms

- Of the 312 mushroom cultures, a few of them are new ones.
- Fifty-three strains of mushrooms were evaluated
- Spent mushroom substrate and coir pith gave highest mushroom yield
- Polypropylene bags were best for containers
- A semi-automatic compost turner has been fabricated

revealed the identity of several single spore selections in *Volvariella volvacea*, *Agaricus bisporus* and hybrids in *Pleurotus sajor-caju*. Fifty three hybrid strains of *Pleurotus sajor-caju* were evaluated on wheat straw. Of them, 10 strains gave more than 68-85% BE. In paddy straw mushroom, 42 single spore isolates were compared for their different growth characters. Molecular characterization of various *Mycogone* cultures collected from different mushroom farms revealed no genetic variability, whereas *Trichoderma* isolates collected from various locations were identified as *Trichoderma asperellum*, *T. harzianum* *T. longibrachiatum* and *T. virens*.

The spent mushroom substrate and coir pith gave highest mushroom yield. Polypropylene bags proved to be best containers for cultivation of *Flammulina velutipes*. Supplementation of 20% wheat bran proved better for increasing productivity of shiitake mushroom. Another medicinal mushroom (*Schizophyllum commune*) has been also successfully cultivated on sawdust. Among different cultures of *Ganoderma lucidum*, Thai culture gave highest yield followed by Korean OE 53. The cultivation of button, oyster and paddy straw mushrooms in low-cost bamboo huts with good yields were demonstrated to framers. The design of semi-automatic compost turner of 5 tonnes/hour capacity is being fabricated.

TUBER CROPS

Potato

Germplasm collection was raised to 2,850 accessions by augmenting cultivated and wild species obtained from 30 countries.

Two parental lines, i.e. JW/96 (a good combiner of yield) and E/79-42 with combined resistance to late blight and potato cyst nematode have been registered as elite germplasm by ICAR/NBPGR germplasm. Potato Kufri Surya, Kufri Arun and Kufri Chipsona 3 were released for commercial cultivation. Hybrid MP/97-644 combining high dry-matter and low sugar contents, acceptable chip colour having resistance to late blight has been identified. Nine transgenic lines expressing *AmA1* gene had significantly higher (20–49%) total soluble protein content. The osmotin gene cloned from wild species, *Solanum chacoense*, was introduced into late blight susceptible cultivars. Transgenic lines of these lines was confirmed by molecular analysis. Reduction in lesion size due to

- Germplasm collection of potato was enriched to 2,850 accessions
- JW/96 and E/79-42 were registered as elite germplasm
- Kufri Surya, Kufri Arun and Kufri Chipsona 3 were released
- Nine transgenic lines of Kufri Badshah had better colour in their chips
- Russet scab has been important disease of potato
- A highly sensitive PCR technique to detect potato leaf curl was developed
- Eight meiotic cultivars showed resistance to late blight
- Potato salties, potato sweet nuggets and potato sewia—new value-added products—were developed
- Sree Athulya and Sree Apoorva, new cassava varieties, were recommended
- Two orange-fleshed clones of sweet potato were identified

late blight pathogen was observed in all these lines. Work on production of transgenic lines carrying resistance to bacterial wilt and potato tuber moth had yielded promising results. Fourteen transgenic lines of potato Kufri Badshah harbouring tobacco invertase inhibitor gene, Nt-Inhh showed substantial improvement in chip colour compared to non-transgenic control tubers. Putative subunits of potato RNase P (an endonuclease) were identified, cloned and sequenced.

At Patna, rice equivalent yield and economic returns were highest in potato–onion–rice followed by potato–maize–rice crop sequence,



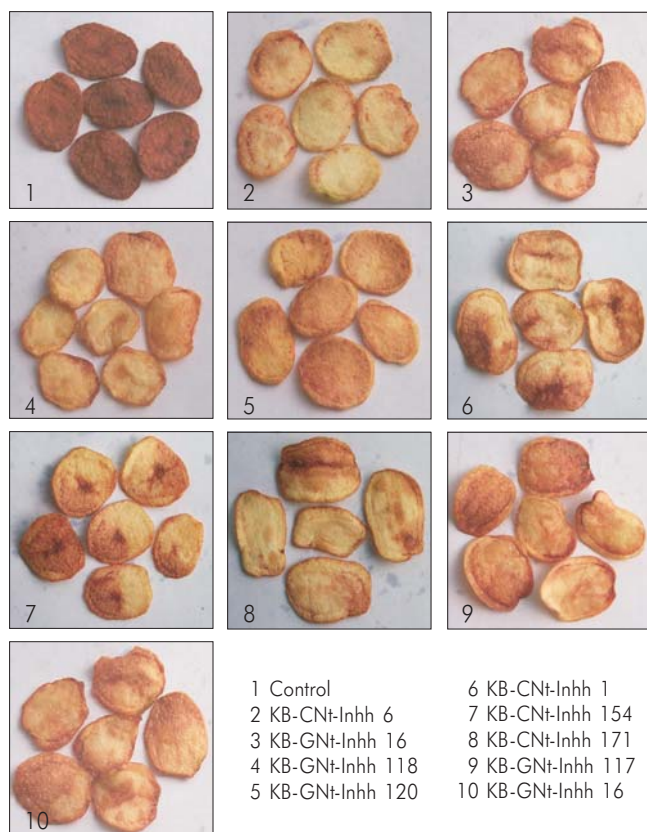
Leaf, flower, sprout, DNA fingerprints and tubers of MP/97-644 a promising hybrid for hills



IMPROVEMENT AND MANAGEMENT OF HORTICULTURAL CROPS

while at Ooty in southern hills, potato + French bean intercropping in a 75 : 50 ratio was best. Fertilizer requirements for maize in potato + maize intercrop for Shimla were also worked out. In a 3 : 1 ratio of potato + maize intercropping, maize required only 75% of recommended N (100 kg/ha) on population basis.

Kufri Pukhraj was mostly N and K efficient cultivar. In acidic soil, *Azotobacter* and vermincompost was superior to *Azospirillum* and FYM in terms of increased ammonical and nitrate availability in soil and its utilization by potato crop. Integrated use of 25% vermincompost and 75% of NPK through inorganic fertilizers resulted in higher yield over inorganically raised crop at Modipuram in northwestern plains. At Shimla, radio tracer studies revealed higher ³²P activity in potato leaves at critical growth stages with phosphorus-solubilizing bacteria.



Russet scab has emerged as an important disease of potato in recent years, disfiguring appearance of tubers. There was significant reduction in russet scab by cultivation of turmeric, inducing water stress, application of boric acid or sulphur and priming of seed tubers with FYM + *T.viride*.

Strains of *T.viride* efficient against control of *R. solani* identified and mass multiplication of antagonist standardized on cheap plant based solid media. The biogents B4 and B5, controled black scurf significantly at Gwalior

Potato aphids (*Myzus persicae*) indirectly affects potato as virus vector and thus leads to degeneration of seed stocks. Population of aphids crossed the critical level of 20 aphids/100 leaves in third week of December at Modipuram (northwestern plains), in third week of January at Patna and approached the critical level in third week of July at Kufri/Fagu. At Modipuram, *M. persicae* population showed tolerance to Metasystox 0.03% and Rogor, whereas tolerance to imidacloprid @ 0.03 and 0.005% was below 5%.

In country stored potatoes at Kangra, use of CIPC (grow stop) treatment @ 60 ml/ha reduced tuber damage by potato tuber moth larvae from 37.5 to 6% 60 days after of storage. The residue of CIPC in stored potatoes was much below the tolerance level of 30 mg/kg. Accessions, CP 3030 and CP 3109, were tolerant to potato tuber moths up to 60 days. A highly sensitive PCR technique was developed to detect potato apical leaf curl disease. The PCR amplification of coat protein gene (770 bp) of TLCNDV in 44 samples potato plants of different varieties and germplasm accessions using coat protein gene specific primers to amplify CP gene located on DNA-A of its biparrite genome.

Nine plant cultures designated as BP 1, BP 2, BP 3, BP 4, BP 5, BP 6, BP 7, BP 8 and BP 9 were found promising under both *in vitro* and in detached leaf experiments against *P. infestans*. Eight meiotic tetraploid cultivars, viz. HR 9-5, HR 5-2, HR 6-4, HR 9- 3, VMT2-3, VMT 2-10, VMT 5-3 and VMT 14-3, showed resistance to late blight but also yielded significantly higher yield.

Three new value-added products, viz. *Potato Salties*, *Potato Sweet Nuggets* and *Potato Sewia* were developed. Mixing of potato flour up to 50% with wheat flour improved taste and texture of *chapattis*. Of the total starch present in freshly harvested tubers, 39.8% was recovered during extraction, 11.8% remained in pulp and 18.2% was lost during extraction. The mean diameter of starch granules separated from tubers of Kufri Jyoti before storage was 15 µm and after 90 days of storage at 4, 8, 12 and 16°C, diameter 19, 22, 25 and 24 µm, respectively.

Fog application of CIPC @ 50 ml/tonne significantly reduced sprout index, weight and total losses up to 90 days of storage in heaps and tubers were acceptable for table purposes. Under heap storage, CIPC residues were higher in peels with spray application compared to fog treatment. Acceptable French fries were obtained from CIPC treated tubers up to 30 days of storage in tubers of Kufri Chandramukhi, up to 90 days of. Kufri Jyoti and up to 150 days of Kufri Surya, Kufri Chipsona 1 and Kufri Chipsona, 2 and Atlantic.

About 798 q of breeders' seed was produced both in hills and plains. A total of 18,588 quintal breeders' seed of 15 varieties from plains and 1,242 q of 3 varieties from hills was produced. About 546 q of quality seed in main crop and 224 q seed in autumn was produced at Ooty. A total of 38,947 microtubers of 10 Indian



Potato-maize intercropping at Shimla



Fallow-potato (control)

Turmeric-potato



Value-added product

varieties produced *in vitro* at Shimla, while 100,830 minitubers and 146,041 tubers were produced in nethouse/nursery-beds.

Tropical tuber crops

Two high starch, high-yielding triploid hybrids of cassava, Sree Athulya and Sree Apoorva were recommended for cultivation in industrial areas of Tamil Nadu. Clone MNga 1 (Sree Padmanabha) having consistently resistance to cassava mosaic has been proposed for release in Tamil Nadu plains. First *Amorphophallus* hybrid variety developed through intervarietal hybridization and selection, Sree Athira, is proposed for release in Kerala. Cassava lines, CMR 1, CMR 15 and CMR 21, with high starch content (25–28%) and high tuber yield (40–60 tonnes/ha) were found to be resistant to cassava mosaic. Two orange-fleshed clones of sweet potato, 362 - 7 and SV 98, with total carotene and β -carotene contents of 6–7 and 4–5 mg/100 g fresh weight, respectively were identified.

- A reproducible protocol in cassava was standardized
- Organic farming of elephant-foot yam was comparatively better than traditionally-growing one
- Cassava transformation protocol was standardized
- Coat protein gene of SPFMV has been cloned
- A technology for making light coloured chips from tubers was standardized
- Geriatric health drinks from cassava and arrowroot starches were made
- Two types of glubulators were made for sago-making
- Over 707 germplasm accessions of tuber crops were maintained
- About 276 new accessions were added
- Use of vermicompost along with NPK was recommended

A reproducible protocol for regeneration of plantlets through high efficiency somatic embryogenesis in cassava was standardized. It includes induction of primary embryogenic callus from immature leaf lobes and maturing of somatic embryos in MS medium with sucrose and growth regulators.

Application of Mg and B along with recommended dose of NPK+FYM resulted in highest tuber yield of 26.753 tonnes/ha, which was on a par with application of B and Zn (26.667 tonnes/ha), B alone (25.673 tonnes/ha) and Mg, Zn and B along with the recommended dose of NPK + FYM (24.773 tonnes/ha). The yields obtained from vermicompost (24.283 tonnes/ha), coir pith compost (22.933 tonnes/ha) and green manuring *in situ* with cowpea (22.143 tonnes/ha) were on a par with FYM @ 12.5 tonnes/ha (22.023 tonnes/ha). Application of vermicompost and coir pith compost, and B, Mg and Zn reduced cyanogenic glucoside content in tubers considerably.



Organic farming of elephant-foot yam gave significantly higher corm yield (70.625 tonnes/ha). Organically-grown plants produced significantly higher corm biomass as well as whole plant biomass. Cooking quality of both corms produced organically and traditional practices were equally good. The dry-matter and starch contents were slightly higher in corms grown organically.

Leaves of nine varieties of cassava were distilled and distillates were tested against *S. oryzae*, *Rhizopertha dominica* and *Callosobruchus maculatus*. The extracts of all varieties gave cent per cent mortality on *R. dominica* and *C. maculatus* 1 day after treatment, whereas mortality on *S. oryzae* ranged from 7.67% in Sree Rekha to 100% in H226. Since distillate from H226 was highly toxic, this variety was used for subsequent studies.

Cassava transformation protocol was standardized for the ruling H226 using pCAMBIA2301 vector through Agrobacterium mediated transformation. The incorporation of gene through GUS assay and PCR amplification using *npt II* primer was confirmed. *Amorphoballus* mosaic virus was detected and identified as a potyvirus using potyvirus specific primers under PCR. Coat protein gene of SPFMV has been cloned in pGEM-T vector and sequenced. Amplification was done with different SPLCV specific primers using DNA isolated from SPLCV infected sweet potato plants. Presence of *Dioscorea alata* Badna virus was detected in *Dioscorea alata* (Sree Keerthi) leaves and tubers which showed mosaic and distortion symptoms through PCR. Glucan and protein elicitors were purified from *Phytophthora colocasiae* mycelium and culture filtrate respectively.

Technology for making light coloured chips from taro, tannia and sweet potato was standardized. Pre-fermentation with yeast was found effective in taro and sweet potato. Cassava flour with low energy density was made through termamyl treatment and pre-fermentation with yeast. The resultant flour had low calorific value and was tried in biscuit making. Geriatric health drinks were made using cassava and arrowroot starches. Nutritional, rheological and functional evaluation of health drinks was made to identify best formulation. The formulae with whey protein concentrate as a partial substitute for milk powder had high protein content (13–15%). Cationic starch was prepared from cassava using four solvents. Wide variations in starch, vitamin C, phenolics and oxalates were observed in different cultivars of taro, indicating their potential use.

Two types of globulators, oscillatory and vibrating types, were made for mechanical globulation of cassava starch for sago-making. These were evaluated at different speeds. Texture profile studies on fried sago and wafers indicated that as the temperature and time of frying increased, oil content in fried products increased and moisture content decreased. Expansion ratio of fried products along thickness and diameter increased with increase in frying

temperatures and time. Hardness decreased as frying time and temperature increased.

The farmers' participatory varietal evaluation trials on yams revealed that promising accessions of greater yam, DA 68, Sree Keerthi, Sree Shilpa and USM 2 and white yam clones, Sree Priya, Sree Subhra and DR 164, were preferred most by farmers in Kerala. However, under laterite soil condition, white yam was opined to be unsuitable owing to its longer duration, long tuber shape and difficulty in harvesting and less market demand.

Over 707 germplasm accessions of different tuber crops were maintained at the Regional Centre, Bhubaneswar. Twenty-two *in vitro* sweet potato germplasm accessions received from CIP were maintained and multiplied. Ten germplasm samples of different tuber crops have been collected from Mizoram, Manipur, Tripura and West Bengal.

Studies using RAPD markers in sweet potato and taro revealed homology or uniformity between *in vitro* raised and source plants. *In vitro* cultures of different yam species, *D. alata*, *D. esculenta* and *D. rotundata* have been established through auxiliary shoot proliferation by culturing nodal explants, tuber sprouts in MS media supplemented with 0.25 mg/litre each of NAA, BA, 0.5 mg/litre GA₃ and ascorbic acid (1,000 mg/litre). Rate of multiplication could be enhanced by 20–30% in *D. alata* by using sprouts of aerial tubers as explant source and 2, 4-D as auxin source in medium. Regeneration through callusing and organogenesis was also achieved in *D. alata* by subsequent culture of nodal segments in media supplemented with 0.25 mg/litre 2, 4-D and 0.25 mg/litre each of NAA, BA and 0.5 mg/litre of GA₃. *In vitro* raised plants were hardened and transferred to field. A high frequency (76–84%) field establishment was achieved in *D. alata* and *D. esculenta*.

A total of 4,350 collections in 24 species of root and tuber crops consisting of sweet potato (2,020) with 175 new additions, cassava, 596 accessions, *Colocasia esculenta*, 900 accessions (taro, bunda and swamp taro types), elephant-foot yam, 195 accessions (33 newly added), yam bean, 205 collections are being maintained. During the period, 276 accessions were newly added to germplasm collections. Cassava accessions evaluated for starch content in tubers at Yethapur (Coimbatore) revealed that 67 accessions had more than 25% starch content.

Use of vermicompost (15 kg N) along with 45 : 40 : 60 kg NPK/ha was recommended for sweet potato. Two-thirds recommended dose of N with *Azospirillum* (2 kg as vine dipping and 10 kg/ha as soil application) was recommended for sweet potato which gave tuber yield of 29.3 tonnes/ha and 21.28 tonnes/ha in Bihar and Assam respectively. Similarly, biofertilizers with half the recommended dose of phosphorus was standardized for *Colocasia* in Hyderabad areas of Andhra Pradesh, which gave a cormel yield of 17.23 tonnes/ha and high cost : benefit ratio of 1 : 6.5.



In elephant-foot yam, straw mulching was recommended for weed management and enhanced yield in West Bengal (61.40 tonnes/ha), Andhra Pradesh (47.44 tonnes/ha) and Kerala, while sesamum leaf mulching or black polythene mulching was recommended for Bihar, with a corm yield of 41.6 tonnes/ha.

In Bihar, 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 1,26,000/ha. In Chhattisgarh, elephant-foot yam as intercrop in mango orchard gave highest corm yield of 9.52 tonnes/ha. In Konkan region, sweet potato was the best intercrop in pre-bearing cashew orchard with highest cost : benefit ratio of 1 : 1.36.

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 weevil damage. *Trichoderma* and *Pseudomonas* were found to be effective in controlling diseases of elephant-foot yam. Combined application of yam bean seed extract and soap nut seed extract checked the snail population in tuber crops. 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. Yam bean seed extract was toxic to third instar larvae of Bihar hairy caterpillar, *Spilosoma obliqua* at Dholi. Yam bean seed powder was effective against cockroach. Baiting prepared with yam bean seed powder + maize flour (1 : 8) with little sugar and mustard oil (a few drops) was an effective biopesticide against cockroach.

FLORICULTURE

Rose

Rose Pusa Gaurav was found to be best for cut flower production. Neelambari and Arunima were good roses for loose flower production, whereas Banjaran and Arunima for garden display. Basal dose of fertilizers, vermicompost and 3% manchurian tea gave better performance in respect of plant height, length of flowering shoot and number of flowering shoots/plant. The stems of rose showed considerable increase in keeping quality when held in a solution of $Al_2(SO_4)_3 \cdot 16 H_2O$ (300 ppm) during wet refrigerated storage. Holding solution comprising aluminium sulphate (300 ppm) + sucrose (1.5%) significantly increased the vase-life and final flower diameter.

Gladiolus

Gladiolus Urvashi and Neelima have been developed. Early-flowering was recorded in Bindiya, while it was late in Anjali at Hyderabad. Gladiolus White Prosperity when sprayed with 4% *panchagavya* + 4% *manchurian* tea performed better. Sucrose (4%) + calcium hypochlorite (bleaching powder), 50 ppm chlorine

- Pusa Gaurav rose was found best for cut flowers
- Aluminium sulphate along with sucrose increased vase-life of roses
- Gladiolus Urvashi and Neelima have been developed
- Bindinya gladiolus recorded early flowering
- Chrysanthemum Punjab Gold and Punjab Anuradha were suitable for pot culture
- The vase-life of Sonia 17 (*Dendrobium*) was maximum
- Highest flower stalk length was recorded in Ria Bamboo Red anthurium
- Cancan was best anthurium for flower production
- The packaging of cut spike of tuberose in polythene sleeves increased their keeping quality
- Calcutta Orange, Calcutta Pink and Cassava were promising gerberas for flower production

was found to be best in improving vase-life (7.67 days), florets opened (100%) and floret size (6.13 cm) compared to all other treatments used in White Prosperity. Four fungicides, Indofil M-45 (0.2%), Kavach (0.2%), Antracol (0.2%) and Quintal (0.2%) were recommended for reducing *Botrytis* blight in gladiolus Sancerre.

Carnation

Recommended dose of fertilizer (50%) + vermicompost 3% + manchurian tea 3% + *panchagavya* 3% increased number of flowers/plant/year and number of flowers/m².

Chrysanthemum

Chrysanthemum Chandrika and Yellow Gold were found suitable for loose and cut flower purposes, whereas Punjab Gold and Punjab Anuradha for pot culture. Early flowering was observed in Punjab Anuradha, while late-flowering was observed in Yellow Gold. Vase-life duration was significantly high when treated with bud opening solutions, sucrose 2% + biocide + BAP 25 ppm (2.85 days); sucrose (2%) + biocide (2.53) and Biocide + BAP (50 ppm) (1.75 days). The vase solution containing sucrose (2%) + biocide ($AgNO_3$, 25 ppm + citric acid, 75 ppm) + BAP, 50 ppm was rated the best for opening of immature buds in chrysanthemum, improving their longevity and preventing yellowing of leaves in the vase.

Orchids

Full dose of recommended fertilizers along with organic manures gave better response in vegetative characters compared to that with half dose, in two varieties (Shavin White and Earsakul) of *Dendrobium*. Recommended dose of fertilizer (50%) + vermicompost (3%) + *panchagavya* (3%) was most effective in influencing all characters. *Aerides multiflorum* produced highest number of flowers followed by *Rynchosstylis retusa* at Kalyani. The NPK @ 20 : 10 : 10 at 0.2% spray with VAM is best treatment combination for most of the characters. The vase-life of



Dendrobium Sonia 17 was found to be maximum in holding solution consisting of HQ 400 ppm + sucrose 5%. Maximum vase-life of 25.67 days was achieved when the stems were kept in a holding solution containing 25 ppm silver nitrate, 400 ppm hydroxy-quinone and 5% sucrose.

Anthurium

Highest flower stalk length (59.2 cm) was recorded in Ria Bamboo Red; maximum spathe length (12.3 cm) and width (11.6 cm) in Honduras and spadix length was maximum in Red Dragon. Cancan is best variety for flower production. However, Kalimpong Pink, was the best performer for flower size. The NPK @ 30 : 10 : 10 at 0.2% spray + GA₃ 200 ppm + *Azospirillum* + Phosphobacteria recorded highest stalk length. The NaOCl 50 ppm as well as Al₂(SO₄)₃ 16 H₂O along with sucrose 5% gave better vase-life in anthurium Tropical.

Tuberose

The NPK @ 200 : 100 : 100 kg/ha produced highest number of spikes of tuberose/plot during April and June. March planting of tuberose bulbs was proved profitable for production of flower spikes with more number of florets/spike at Kalyani, while at Kahikuchi, May planting was best for yield. The NPK @ 150 : 100 : 200 kg/ha in two split doses significantly increased yield at Kahikuchi, while at Kalyani NPK @ 100 : 150 : 150 kg/ha is recommended to enhance number of florets/spike. Vase solution containing sucrose (5%) + Al₂(SO₄)₃ 16H₂O, 300 ppm was most effective for improving vase-life of cut tuberose. The packaging of cut spikes in polyethylene sleeves significantly enhanced the keeping quality.

Gerbera

Gerbera Calcutta Orange, Calcutta Pink and Cassava were promising for flower production. About 25% shade is suitable for increasing plant height, stalk length and flower diameter, while 50% shade is suitable for number of leaves at Kalyani. Maximum vase-life of 7.6 days in gerbera was obtained in Al₂(SO₄)₃ at 100 ppm pulsing treatment in Sun Ray gerbera.

PLANTATION CROPS

Coconut

Coconut germplasm was strengthened by adding nine accessions. A total of 86 coconut germplasm types were collected from different regions for further evaluation. Cryopreservation of zygotic embryos of West Coast Tall (WCT) palms of coconut was achieved using the encapsulation-dehydration technique. Hybrid ECT × MYD performed better than all other hybrids in the last few years and has given uniformly around 100 nuts/palm/year.

Vetiver (*Vetiveria zizanoides*) crop established well in coconut

Digital Library

The Bioinformatics Centre and Library has developed digital library using D space software and made accessible through the library website <http://www.bioinfpcpri.org/>. In bioinformatics, two new databases on pest management and cocoa germplasm have been added.

garden, yielding 88 g of dry roots/plant and 780 kg of dry roots/acre. The net return obtained by growing vetiver was about Rs 28,000/acre of coconut garden. Among shrubs, growth of Karinkurinji (*Nilgiriantbus ciliatus*) performed well and yielded 27 g of fresh root and 532 g of fresh shoots/plant. The net return obtained by cultivating *Nilgiriantbus* in one acre of coconut garden was Rs 30,000 for one-and-a-half year.

Plant growth-promoting rhizobacteria, *Brevibacillus brevis* inoculation increased shoot elongation (up to 21%) and seedling girth (up to 18%), whereas combined inoculation of *B. brevis* and *B. coagulans* increased root elongation (up to 6%), shoot dry weight (up to 16%) and root dry weight (up to 21%) over the control. Root : shoot ratio was maximum in *Bacillus coagulans* treatment. Seedling quality index and PGPR inoculum efficiency were highest in combined inoculation of *Brevibacillus brevis* + *Bacillus coagulans* which was on a par with treatment having *B. coagulans* alone. The application of these inoculants stimulated the beneficial soil microflora in root region of coconut seedlings. Both *B. brevis* and *B. coagulans* were found to produce L-tryptophan-derived auxins *in vitro* and in field soil. The *Bacillus coagulans* either alone or in combination with *Brevibacillus brevis* can be used for inoculation of coconut seedlings for their growth promotion while raising them in nursery.

SUCCESS STORY

An Enterprising Vermicompost Man

Mr Jacob.K. Cheriyan, Kariyadil Puthenparambil, Kattanam, a retired geologist, is cultivating coconut, banana, mango, coffee and vegetables. After attending KVK training programme in vermicomposting, he constructed five vermicompost units with taps for collecting vermiwash, a tonic for plant growth. Now he is getting vermicompost (800–1,000 kg) worth Rs 3,500–4,000/month besides worms, vermiwash etc. Mature worms are used for feeding ducklings and fish fingerlings. He produces 50–60 bottles of vermiwash at bimonthly intervals, which is used for foliar spray. Vegetables produced by organic farming are much tastier than those produced inorganically' says Mr Jacob Cheriyan. Nowadays, he serves as a master farmer for farmer-to-farmer technology transfer.



The CGD × WCT hybrid, planted during 1991, recorded a ten-year cumulative average yield of 71 nuts/palm/year, even though 68% of hybrids recorded incidence of root (wilt) disease. Fifty-three progenies derived from root (wilt) resistant palm (WCT 421) were characterized with microsatellite markers. The recombination fraction based on classical estimate was highest between CNZ 13 F and CNZ 40 (0.722) followed by CNZ 13F and CNII E6 (0.614) and CNZ 43 and CNZ 13 F (0.611). The 'r' value was lowest between the locus CNZ A4 and CNZ 40 (0.294). Among seven primers used, locus CnCir C11, CNZ A4, CNZ 13F, CNZ E6 and CNZ 40 showed 1 : 1 segregation ratio among progenies. The LOD score was maximum between locus CNZ 13F and CNZ 40 (1.6). Here for all the 7 loci tested the LOD scores were less than 3, hence no linkage could be established. The SSR loci map showed the arrangement of SSR locus. The total map size obtained was 624.1 cM. The map distance between CNZ 42 and CNZ 40 were the lowest.

Induction of resistance/tolerance against root (wilt) pathogen using salicylic acid and triazol induced higher glucanase activity and digitonin induced higher peroxides and PPO activity. Higher peroxidase activity was also observed in *Pseudomonas fluorescens* and *Bacillus amyloliquefaciens* treated seedlings. The culture filtrate of *Trichoderma harzianum* showed 54% inhibition, while culture filtrates of *B. amyloliquefaciens* showed 80% inhibition of *Ganoderma*. An acaropathogenic fungus *Hirsutella thompsonii* was isolated from coconuts infested with eriophyid mites which is considered as the most important natural enemy of eriophyid mite throughout the world.

Wax moth (*Galleria mellonella*) could be used as an alternate host for mass rearing of larval parasitoids *Goniozus nepbantidis*, *Bracon brevicornis* and pupal parasitoid *Trichospilus pupivorus* of coconut black headed caterpillar, *Opisina arenosella*. Egg parasitoid *Chrysochalsicea indica* and predator *Endochus inornatus* were found to be natural enemies of coreid bug (*Paradasynus rostratus*).

Agro-processing Centre was established with all the proven technologies for plantation crops. A low-cost salinity sensor based on graphite electrode, shell fired copra dryer, coconut punch and cutter were the new gadgets developed. A technology for canning of coconut kernel and paste by boiling water bath method was perfected.

Arecanut

Seven accessions from Gujarat and two from Karnataka were collected. Arecanut Saigon is likely to be released. Shatavari, nilgiri antus, vetiver and brahmi were more remunerative with net returns of Rs 80,000; 42,000, 21,000 and 15,000/ha in arecanut garden, respectively. The lemon grass registered highest return of Rs 50,000/ha in arecanut plantation followed by patchouli (Rs 37,000) and davana (Rs 29,000).

Fertigation at 75% recommended NPK at 10 days intervals produced significantly higher chali yield (4,016 kg/ha) compared to other doses, indicating a saving of 25% fertilizer if supplied through microirrigation.

Arecanut based HDMSCS (arecanut, pepper, banana, clove, nutmeg and citrus) at Kahikuchi (Assam) under graded levels of fertilizers coupled with organic biomass recycling in the form of compost revealed higher yield of arecanut, pepper and citrus at two-thirds of the recommended dose of fertilizer. However, banana yield was higher under full dose of recommended fertilizer. The highest recovery of vermicompost from arecanut wastes was 80.2% in cement tank within 55 days during May–October when temperature and relative humidity were optimum.

Oil palm

Preliminary analysis of RAPD data of first set of germplasm showed that each genotype forms separate cluster. Uniformity among Costa Rican palms was more. Others have considerable divergence within genotypes. Molecular characterization of second set of germplasm showed that biochemical parameters were on a par in Palode and Cost Rican materials compared with African genotypes. Soluble and total carbohydrates were highest level in these two genotypes, indicating their superior performance in irrigation condition of Andhra Pradesh, which is yet to be correlated with yield.

Hybrid combination of 115 D × 291 P recorded highest yield of FFB, i.e. 121.75 kg/palm/year (17.4 tonnes/ha), whereas 109 D × 291 P recorded highest bunch weight (24.38 kg) at Mulde Centre in Maharashtra. Thirteen botanicals (extracted from fresh leaves)

- A total of 86 coconut germplasm types were collected
- Vetiver was good intercrop in coconut gardens
- Acecanut Saigon is likely to be released
- Aromatic crops in arecanut garden were more remunerative
- Lemon grass gave highest return in arecanut garden
- Old palm hybrid, 115 D × 291 P, gave highest yield of FFB
- Thirteen botanicals were evaluated against *Ganoderma* species
- A technology for making window shades from oil palm frond rachis has been standardized
- Oilp palm window shades were good for offices, residences, restaurants etc.
- Hand-made paper boards were made from shredded empty fruit bunches
- Oil palm EFB was used for making cooling pads.
- The 173 accessions of palmyrah palm are being maintained
- New cashew Bhaskara has been released



IMPROVEMENT AND MANAGEMENT OF HORTICULTURAL CROPS

were evaluated against *Ganoderma* sp. (Makinavarigudem isolate) and it was found that alcoholic and acetone extracts of *Vinca rosea*, *Aloe vera*, *Parthenium hysterophorus*, *Phyllanthus niruri* and *Tridax procumbens* showed 100% inhibition. Alcohol extracts

Palm Oil Mill

A mini palm oil mill with a capacity to process 1 tonne of fresh fruit bunches/hour was developed. The total cost of the mill including infrastructure is estimated about Rs 20 lakh. The mill operation is simple and can be managed by woman labourers also.

of *Cassia auriculata*, *Cassia occidentalis*, *Acyranthus aspera* and *Ocimum sanctum* also showed 100% inhibition. Aqueous extracts of *Acyranthus aspera* plant product exhibited 75% inhibition followed by 70% inhibition with *Parthenium hysterophorus* plant extract.

A technology to make window shades from oil palm frond rachis has been mechanized by employing a wood planer machine with modifications. A technology has also been evolved to make insect and fungal proof shades. Oil palm window shades proved to be suitable for use in offices, residences, restaurants etc. as a replacement of bamboo made window shades.

A mobile oil palm waste shredding unit was designed and developed to shred Empty Fruit Bunches and oil palm fronds. The mobile unit reduces collection and transportation cost of wastes scattered in plantation and factory premises. This is suitable for areas which are non-accessible to electrical power.

Oil palm EFB, which is cheap and available in bulk compared to other sources of natural fibres were used to make cooling pads and it was found that the room temperature was reduced by 3°C and humidity was increased by 20% by using cooling pad.

Palmyrah palm

The 173 accessions are maintained at Killikulam, while 176 accessions have been collected and maintained at Pandirimamidi.

Paper Boards from Oil Palm

Hand-made paper boards were made from shredded empty fruit bunches in a pilot paper plant. The effect of mixing cotton waste and paper waste pulps in different proportions on pulp quality was studied. Testing of paper boards prepared from these pulps indicated that Empty Fruit Bunches are suitable for making paper boards. Paper files, cartons and packaging material can be prepared from these boards. Addition of cotton wastes and paper wastes improved the finishing of boards.

Fourteen palmyrah local germplasm types collected from coastal region of Andhra Pradesh were added to germplasm.

Cashew

Bhaskara, a new cashew variety developed from a tree of seedling origin, was released during March 2006 for coastal region of Karnataka. Having mid-season flowering habit, it has a potential to escape from the attack of tea mosquito bug under low to moderate outbreak situation. This variety has yielded more than 1 tonne/ha from fourth harvest onwards, highest yield being 2,975 kg/ha (10.7 kg/tree) during 11th harvesting. A bold nut (9 g) and high-yielding cashew tree was identified in Andhra Pradesh which appears to be tolerant to flower and panicle drying malady.

So far, a total of 500 accessions have been conserved in National Cashew Field Gene Bank. Thirty-one cashew types having high yield, cluster bearing habit, bold nut type and maximum nut weight were identified, collected and conserved in Regional Cashew Field Gene Banks (RCFGBs) existing in Centres of AICRP on Cashew thereby increasing total germplasm accessions to 1,274.

The DNA extraction from dry leaves was also standardized. Diversity analysis and species relationship in 10 cashew accessions using RAPD and isozyme markers was done and *Anacardium pumilium* was found as most divergent. About 42 cashew varieties were characterized using RAPD and isozyme markers.

Pruned trees gave higher yield over un-pruned trees in third fruiting season after pruning. The limb pruned trees had an average of 9.64 kg/tree yield in four different varieties, while



Cashew Bhaskara



unpruned trees had 5.59 kg/tree. Modified crescent bund and staggered trenches with coconut husk burial between two rows of cashew conserved the maximum soil moisture.

Chlorpyrifos (0.4%) reduced significantly re-infestation of cashew stem-and root- borer followed by chlorpyrifos (0.2%). Phytosanitation also reduced infestation of the pest over years.

MEDICINAL AND AROMATIC PLANTS

Aloe

The flowers of aloe showed protandry. Major floral visitors, birds, honey bees and ants were observed in plant population and sun-bird (*Nectarinia asiatica* var. *asiatica*) played a major role in pollen-transfer. Pollen-grains remained viable even after 76 hours of storage in humidity chamber at both room temperature and refrigerated condition. Pollination experiments showed that selfing, crossing and open-pollination occur in *A. barbadensis*.

All accessions were of diploids with somatic chromosome number $2n = 2x = 14$. Total chromosome length (TCL) of diploid chromosome complement ranged from 84.58 to 197.5 μm , average chromosome length being 14.11–6.04 μm .

Isabgol

Downy disease is a major constraint in cultivation of isabgol. The downy mildew infection on bio-constituents of host leaf



Sunbird (*Nectarinia asiatica* var. *asiatica*) mediated pollen transfer in *Aloe barbadensis*

revealed that moisture content of leaves increased due to infection. Leaves at early stage of infection, showing slight chlorosis contained significantly higher amount of total and OD phenol (14.64 and 7.9 mg/g dry leaf, respectively).

A total of 80 lines of isabgol were evaluated for six characters at Mandsaur. The seed yield ranged from a minimum of 406 kg/ha (GI 2) to 1,364 kg/ha (Udaipur 1). At Mandsaur, maximum grain yield was obtained when sowing was done on 21 November (856 kg/ha) followed by 750 kg/ha from 14 November sowing. A maximum yield of 762 kg/ha was also obtained when three irrigations (at tillering, before ear head emergence and after ear head emergence) were given.

- A total of 500 accessions have been conserved
- A total of 80 lines of isabgol were evaluated for seed yield
- A total of 119 germplasm accessions of aswagandha were evaluated
- A number of genotypes were evaluated for different characters
- Saponin content and its yield were highest 24 months after planting
- Maximum latex yield was recorded in UO 1385.
- About 235 germplasm lines of opium poppy were evaluated
- A protocol for *in vitro* fleshy root formation in safed musli has been standardized
- Twenty-four lines of safed musli were tested
- A software package for identification of medicinal and aromatic plants has been developed

At Udaipur, 68 genotypes along with controls (RI 89, GI 2 and Sel 10) were evaluated for higher seed yield. Six genotypes gave higher seed yield over best control RI 89 (1,390 kg/ha).

Seventeen genotypes along with three controls, RI 89, GI 2 and selection 10, were evaluated for higher seed yield at Udaipur. Genotype RI 129 (1,728 kg/ha) recorded highest seed yield followed by PB 31 (1,312 kg/ha) and Palampur 2 (1,301 kg/ha).

Ashwagandha

A total of 119 germplasm accessions of aswagandha were evaluated for 13 different characters at Mandsaur. Among lines, a wide variability was observed. Mean dry root yield ranged from 100 kg/ha (MWS 325) to 1,166 kg/ha (RAS 34). Mean seed yield was 145 kg/ha (red berries) to 652 kg/ha (MWS 208).

Fifty-two genotypes along with three controls, Jawahar Aswagandhah 20, WS 90-127 and Jawahar Aswagandhah 134, were evaluated for higher dry root yield/plant and total alkaloid content at Udaipur. The dry root yield/plant was 2.7 g/plant (RAs 11) to 7 g/plant (WS-90-136). Maximum total alkaloid content, i.e. 0.40% was in WS 90-105, WS 90-136 and RAS 35.

Thirteen genotypes along with JA 134, WS 90-127 and JA 20 were evaluated at Udaipur. Eight genotypes, viz. WS 90-140 (1,190 kg/ha), RAs 10 (1,180 kg/ha), WS 90-101 (1,140 kg/ha), RAs 7 (1,119 kg/ha), RAs 15 (1,053 kg/ha), WS 90-124 (948 kg/ha), RAs 21 (910 kg/ha) and WS 90-141 (909 kg/ha) showed higher dry root yield over best control WS 90-127 (825 kg/ha).

At Mandsaur, vermicompost at 5 tonnes/ha + RD 50% recorded maximum dry root yield of 994 kg/ha followed by FYM + RD ($N_{20}P_{60}K_{40}$ kg/ha) 50% (973 kg/ha) and poultry manure + RD 50% (958 kg/ha) among 16 different treatments tried.

At Akola, a seed rate of 10 kg/ha produced significantly more root yield (546 kg/ha) which was on a par with 9 kg/ha (540 kg/



Digital Herbarium

A software package entitled "Digital Herbarium of Medicinal & Aromatic Plants in India" has been developed for authentic identification of medicinal and aromatic plants. The software package consists of three types of search engines, "simple search", "multiple search" and "advanced search".

ha). Application of 10 tonnes/ha of FYM recorded maximum dry root yield (567 kg/ha) which was at par with 5 (550 kg/ha) and 7.5 tonnes/ha FYM (562 kg/ha). Superiority of application of FYM was recorded over control (no FYM applied) and 2.5 tonnes/ha FYM. The alkaloid yield showed increasing trend from flower initiation reaching highest at 100% harvesting (3.47 kg/ha) and decreasing thereafter. The root yield was found significantly influenced by harvesting time. Early harvesting at flower initiation produced significantly low root yield (269 kg/ha).

At Hisar, dry root yield was recorded to be 2.37 and 2.95 kg/ha in JA 20 and JA 134, respectively. Seed rate at 12 kg/ha recorded maximum root yield and alkaloid content, resulting in higher alkaloid yield followed by 10, 8 and 6 kg/ha. Root length and root diameter were found to be significant, resulting in higher dry root weight and dry root yield. Quality of alkaloid was influenced by different dates of harvesting. Alkaloid yield was recorded to be maximum (4.16 kg/ha) 180 days after sowing. Among different rates of application of FYM, (7.5 tonnes/ha) recorded maximum dry root yield (3.85 tonnes/ha) and alkaloid yield (4.17 kg/ha).

Satavari

A spacing of 60 cm × 60 cm had significant effect on fresh (4,730 kg/ha) and dry fasciculated root yield (870 kg/ha) over 60 cm × 90 cm and 90 cm × 90 cm. Harvesting of crop (duration) 24 months after planting recorded significantly more fresh (3,610 kg/ha) and dry fasciculated root yield (680 kg/ha) as compared to harvesting 21 and 18 months after planting. Saponin content (5.68%) and saponin yield (49.61 kg/ha) were highest at 60 cm × 60 cm and crop harvested 24 months after planting recorded maximum saponin yield (38.48 kg/ha). Root moisture content was highly influenced by environmental conditions and it was significantly highest (9.76%) during July. The root samples contained 5.83% saponin. It became significantly lowest at the end of storage period (4.62%) which was on a par 10 months after storage, i.e. November sampling (4.85%).

Liquorice

Liquorice (mulhati) planted in at a spacing of 75 cm × 30 cm, 75 cm × 45 cm, 90 cm × 30 cm and 90 cm × 45 cm showed maximum sprouting when planted in January (71.2–79.3%) as compared to February and March planting. There was a drastic reduction in sprouting in March planting (18.1–33.3%). A spacing of 90 cm × 30 cm and 75 cm × 45 cm recorded maximum stolon yield of 7,428 and 6,836 kg/ha respectively as compared to other spacings. Variations were also found significant in stolon length (3'–10') and girth (2.0–5.2 cm).

Opium poppy

Maximum latex yield was recorded in UO 1385 (38.74 kg/ha)

and minimum in UOP 69 (1.45 kg/ha). Maximum seed yield was recorded in NDO3-4 and NC 57950 (790 kg/ha) and minimum in UO 221 and UOP 6 (420 kg/ha). Maximum husk yield was recorded in NC 57950 (982 kg/ha) and minimum in UO 1285, UO 37 and UOP 71 (124 kg/ha).

At Mandsaur, 235 germplasm lines were evaluated for different qualitative and quantitative characters. Latex yield ranged from 33.06 (MOP 1069) to 70.54 kg/ha (UOP 490) and seed yield from 87 (ND 16) to 1,102 kg/ha (ND 25). Similarly, morphine content ranged from 12.4 to 17.3%. Highest husk yield (986 kg/ha) could be obtained from the recommended dose ($N_{150}P_{75}K_{40}$ kg/ha) followed by 10 tonnes/ha vermicompost + RD 50% (928 kg/ha) and 10 tonnes/ha FYM + RD 50% (720 kg/ha). Highest seed yield of 1,160 kg/ha could be obtained from RD ($N_{150}P_{75}K_{40}$ kg/ha) followed by 10 tonnes/ha vermicompost + RD 50% (1,031 kg/ha) and 10 tonnes/ha FYM + RD 50% (948 kg/ha). Latex yield also followed same trend (55, 50 and 48 kg/ha).

A total of 152 genotypes along with control Chetak Aphim and IC 42 were evaluated for higher latex yield, seed yield and morphine content at Udaipur. Latex yield ranged from 11.59 (UOP 52) to 57.75 kg/ha (NC 57915). Seed yield ranged from 656.00 (UO 790) to 2,111 kg/ha (NC 57936). Maximum morphine content was found in ND 21 (12.79%) and minimum in UOP 55 (9.04%).

Ten crosses along with IC 42 and Chetak Aphim were evaluated. Two crosses, viz. UOP 86 × Chetak Aphim (32.63 kg/ha) and UO 1985 × IC 42 (30.88 kg/ha) recorded higher latex yield over the control IC 42 (30.39 kg/ha), while UOP 6 × JA 16 (1,504 kg/ha), UOP 86 × Chetak Aphim (1,474 kg/ha) and UOP 82 × JA 16 (1,395 kg/ha) showed higher seed yield over IC 42 (1,331 kg/ha). Highest morphine content was found in UOP 17 × Chetak Aphim (12.10%), UOP 85 × Chetak Aphim (11.95%) and IC 42 (11.92%).

At Faizabad, latex yield was recorded highest (27.39 kg/ha) in treatment applied as 25% FYM. Seed yield was recorded highest (701 kg/ha) in treatment applied as 25% vermicompost and lowest (312 kg/ha) in 100% vermicompost. Treatment with 25% vermicompost gave highest husk yield (486 kg/ha) and lowest being 263 kg/ha in 100% vermicompost.

At Udaipur, sowing on 25 October gave significantly maximum gum yield (4,393 kg/ha), seed yield (1,383 kg/ha) and husk yield



(1,268 kg/ha) as compared to 5 and 15 November sowing. Plant population (3.5 and 4 lakh plants/ha) on the other hand did not affect significantly. However, plant protection treatment significantly increased plant height, gum yield, seed yield and husk yield.

Plant height (91.64 cm), capsules/plant (1.65/plant), gum yield (57.61 kg/ha), seed yield (1,688 kg/ha) and husk yield (1,510 kg/ha) were highest with 8 irrigations at stem elongation 30 days after sowing, rosette 45 DAS, bud 58 DAS, flower initiation 70 DAS, 50% flowering 85 DAS, late capsule 98 DAS, capsule maturity 108 DAS and at after lancing 120 DAS were given at Udaipur.

Safed musli

The protocol for *in vitro* fleshy root formation of safed musli was standardized. Fibrous rooting of micropropagated shoots was readily achieved upon transferring shoots onto half-strength MS media containing IAA with sucrose within 8–10 days of culture. Twenty-four lines of germplasm were tested at Mandsaur. Fresh weight of fleshy root ranged from 375 kg/ha (MCB 420) to 3,150 kg/ha (MCB 409). Maximum mean yield of fresh fasciculated root yield (2,371 kg/ha) was in MCB 409.

Three genotypes, viz. Anand Safed Musli, Mandsaur Safed Musli 412, Mandsaur Safed Musli 414 and control Jawahar Safed Musli 405 were tested at Anand and Mandsaur. At Anand, ASMV II yielded significantly high fasciculated root, which was 81.37% higher than the control MCB 405.

At Mandsaur, maximum fasciculated root yield of 1,453 kg/ha was recorded by MCB 414 which was significantly superior to control (JSM 405) 1,315 kg/ha. MCB 414 recorded significantly higher fasciculated root yield (2,357 kg/ha) followed by MCB 412 (1,901 kg/ha) than control JSM 405 (1,796 kg/ha).

At Mandsaur, application of FYM at 20 and 10 tonnes/ha and vermicompost at 5 tonnes/ha along with control and spacing at 30

cm × 10 cm, 30 cm × 15 cm and 30 cm × 20 cm recorded a maximum yield of 1,843 kg/ha from 20 tonnes/ha FYM and 1,512 kg/ha from spacing of 30 cm × 10 cm. A lowest yield of 596 kg/ha was obtained from control (no organic manure).

At Akola, highest fresh root yield was recorded at 180 DAP (3,205 kg/ha), while lowest at 90 DAP (2,265 kg/ha). Significantly highest dry fleshy root yield was recorded at 240 DAP (695 kg/ha). The saponin content decreased successively with increase in harvesting time and significantly lowest content was recorded at 240 DAP (6.00%). Fleshy root harvested at 90 and 120 DAP contained highest saponins (7.45 and 7.35%, respectively). At Udaipur, lowest weight loss was recorded from wooden box containing 4² layer of musli + 4² layer of soil (27.73%) followed by wooden box containing 4² layer of musli + 4² layer of sand (28.77%), earthen pot containing 1 kg roots mixed with 1 kg sand and mud plastering (30.27%).

Valerian

At Solan, maximum fresh aerial biomass of 5.38, 9.68, 24.44, 65.42 and 98.64 g/plant was recorded when planted at ridges as compared to furrows, level beds and sloppy terrace at 6, 9, 12, 15 and 18 months respectively. Similarly, transplanting on 16 August recorded maximum fresh aerial biomass of 6.63, 12.86, 31.61, 65.73 and 108.91 g/plant compared to transplanting on 31 August and 15 September.



In vitro fasciculated root formation in safed musli



Inflorescence in valerian



Maximum aerial biomass (75.42 g/plant), fresh underground biomass (47.76 g/plant), fresh root yield (24.83 g/plant), and fresh rhizome yield (22.93 g/plant), could be obtained from a combination of Azotobacter + PSB + VAM followed by a combination of other biofertilizers. Valepotriate content was maximum (2.39) when applied with Azotobacter at 10 kg/ha followed by Azotobacter + PSB (2.35) and PSB at 10 kg/ha (2.34). The organic carbon (0.13%), N (361.96 kg/ha), P (38.2 kg/ha) and K (187.2 kg/ha) were also maximum in combination of Azotobacter + PSB + VAM. Similarly nutrient content and nutrient uptake were also found maximum.

- Over 350 accessions of betervine are being maintained
- The 155 accessions of betervine were catalogued

Different growth media had positive effect and use of vermicompost in site soil (1 : 1) gave maximum plant height (29.29 cm), fresh aerial biomass (198.05 g/plant) and fresh underground biomass (57.52 g/plant) 18 months after transplanting. Valepotriate content was maximum (2.80) when grown in soil + sawdust followed by soil + FYM (2.43) and soil + sand + FYM (2.39).

Betelvine

Over 350 accessions are being maintained at different centres and 255 were catalogued during the year. Hybrid evaluation trial indicated that only GN₁ Hybrid (Godi Bangla × Kapoori Nasik) showed normal vigour. Even for GN Hybrid, leaf yield was much below than local control variety.

Highest leaf yields was recorded with application of 200 kg N in the form of oil + urea or FYM with 100 kg each of phosphorus and K₂O/ha. Optimum plant population, replenishment of 100% pan evaporation soil moisture during dry periods along with recommended doses of manures and application of 4 drenches plus 8 sprays of Bordeaux mixture resulted in better quality yield as well as higher cost : benefit ratio at all centres compared to farmer's practices. Staggered lowering of betelvine influenced growth and yield. Leaf yield was found higher when July–November and February–June lowering of betelvine was carried out at BCKV, Kalyani.

The regression analysis of disease development with weather parameters, rate of evaporation contributed to 72.43% followed by maximum temperature (14.55%), morning relative humidity (5.98%) and bright sunshine hours (5.64%), whereas overall influence of all meteorological parameters contributed to 47% towards disease incidence besides other individual factors.

Maximum temperature, morning relative humidity and rainfall had significant negative correlation for anthracnose disease, while

minimum temperature, evening relative humidity and number of rainy days had positive correlation with incidence and spread of disease at Jorghat. Maximum temperature contributed to 25.89% disease development, whereas evapotranspiration contributing to 66.77%. The overall influence of climatic factors in disease development was recorded to be 70.7%.

At Jabalpur, maximum humidity was positively correlated with bacterial disease development in betelvine, whereas maximum temperature and rainfall are partially significant in development of bacterial infection. At Sirugamani, minimum temperature, relative humidity (evening) and rainfall had positive effect on disease incidence.

Integrated disease management of Phytophthora foot rot includes sanitation + one soil drenching of Bordeaux mixture + Trichoderma application (after one month) + one more soil drenching of Bordeaux mixture which significantly reduced the disease incidence and increased leaf yield.

Application of wettable sulphur 0.15% spray significantly reduced the population of red spider mites. The cost : benefit ratio is 1 : 13.94. The combination of wettable sulphur 0.15% + Azadirachtin 0.03% was found to be best treatment for effective management of mites thereby reducing number of damaged leaves. The cost : benefit ratio was highest (1 : 99.7) for treatment with wettable sulphur followed by wettable sulphur + Azadirachtin (1 : 77.1).

The incidence of major insect pests/mite pest was negligible (1.4–3.1%) in Bangla, Kali Bangla, Awami Pan, Black Leaf, Simarali Babna Local, Nov Bangla, SGM 1, Godi Bangla and Maghai. Bangla Bihar, Bangla Banarasi, Calcutta Bangla, Nava Cuttak, Dese Bangla, Bangla Mohoba, Maghai, Bangla Ghamela, and Bangla Ghaneghatte, remained uninfested, however, Dpb 6, K. Pacchaikodi, K. Valiaikodi, K. Telleku and K. Chittikavti were infested by betelvine bug. At Karpoori, Tellakku, Vellaikodi, Karapakku, Kuljedu, Sirugamani BV 2, Andhiyur, Tellakku Uttukar, Sarkarai Kodi and Halisagar Sanchi showed field tolerance to scale insect.

SPICES

Black pepper

Fifteen qualitative morphological characters of 16 wild species of black pepper in south India were studied and plotted the hierarchical cluster, using SPSS software. Bioclimatic analysis and prediction system (BIOCLIM) comparison of these clusters revealed rich diversity and 'niches' where *Piper* species occur predominantly. The highest richness grid was found to have 15–16 species, while highest diversity was 1.8–3. The *P. bababudani*, *P. schmidtii* and *P. wightii* were also related to *P. nigrum*. Variation in inter-microsatellite regions among cultivars was found to be low. A protocol for isolation of PCR amplifiable genomic DNA (modified



CTAB extraction step followed by purification and PEG precipitation of DNA) was developed.

Black pepper grafted on *P. colubrinum* rootstock (resistant to *P. capsici*), plants remained healthy even 7 years after planting. On an average, a yield of 0.65 kg (dry) pepper/vine was obtained in un-irrigated gardens. Evaluation of various formulations of endophytic bacteria, promising against nematodes indicated that chitin based formulation sustained bacterial population ($\times 10^7$ cfu/g) even after 90 days of storage. The portion of Open Reading Frame I (ORF I) and ORF III of badnavirus infecting black pepper was

- Sixteen wild species of black pepper were studied
- A protocol for isolation of PCR amplifiable genomic DNA of black pepper was developed
- Black peppers stored in vacuum showed good quality even 8 months of storage.
- Sequence analysis has confirmed the identity of virus
- Thirty-one hybrid samples of paprika were evaluated
- Two new accessions of seed spices were identified

amplified, cloned and sequenced. Sequence analysis and comparison with other known badnavirus indicated high levels of identity with Piper yellow mottle virus (PYMV) followed by Banana streak virus (BSV). A method for simultaneous isolation of RNA and DNA from infected black pepper plants and multiplex PCR for simultaneous detection of CMV and Badnavirus in a single reaction was standardized.

The transmission of cucumber mosaic virus by four species of aphids was confirmed by DAS-ELISA. Species-specific primers were developed for identification of *Radopholus similis* based on sequence information from ITS gene, and their use in identifying *R. similis* was proved in laboratory. The primer set generated a single PCR fragment of 398 bp in length that was specific to *R. similis*. The amplified product was cloned and sequenced to get partial sequence of ITS1 and 5.8S genes, which were submitted to EMBL, sequence database (Reference gil110321606|embl|AM286692.1| [110321606]). Sequencing of *R. similis* genome is done for the first time in India.

The yield level was markedly higher under organic system (1.7 kg/vine) compared to IPNM (0.96 kg/vine) and chemical (1.36 kg/vine) systems. The rainfall excess than normal from July to December-end was beneficial to crop and would help in enhancing the yield. The rainfall excess than normal beyond December would reduce yield of black pepper. Substituting sand with granite powder, a waste material obtained from stone quarries, in nursery black pepper mixture is more economical.

Black pepper samples stored in vacuum, showed good quality even after 8 months of storage. Essential oil constituents of

organically cultivated Panniyur 1 and Karimunda showed higher Caryophyllene (up to 30%) in Panniyur 1 and 24% in Karimunda.

Ginger and turmeric

Variations in curcuminoids were observed during growth stages in turmeric as determined by HPLC. Variations were observed for curcumin I (1.6–3.39%), curcumin II (0.39–1.08%) and curcumin III (0.48–1.1%) in Alleppey, Prabha, Prathibha, Suguna and Sudarsana.

The *Pythium myriotylum*, causing rhizome rot in ginger in Kerala, Karnataka, Uttar Pradesh and Sikkim, was identified. The

New Germplasm

The germplasm of black pepper (612), cardamom (273), ginger (633), turmeric (1,326), tree spices (230) and seed spices (4,117) was enriched.

pathogenicity trial further confirmed that this was highly aggressive on ginger. PCR based method was found suitable for identification of *P. myriotylum*. Primers specific for *P. myriotylum* were found to amplify 150 bp sequences in the genomic DNA of *P. myriotylum*. Mango ginger (*C. amada*) was found resistant to natural infection by *R. solanacearum*.

Mermithid nematode (*Hexameris* sp.) was recorded as a major natural enemy of shoot-borer larvae in field at Peruvannamuzhi and percentage of population of larvae parasitized by nematode was higher during August–September.

Tree spices

Cassia C1 (IC 370415) has been registered as INGR 05029 at NBPGR, New Delhi, for its high oleoresin content (10.5%). Molecular characterization of 10 elite accessions of nutmeg with 13 random primers was done and 75% polymorphism was observed.

Nutmug mace blanched for 2 minutes in boiling water showed better colour retention (Lycopene 49.9%) compared to 1 minute blanching (Lycopene 38.7%) and no blanching (Lycopene 9.98%) after storing in 300 g polypropylene covers.

Vanilla

A virus causing mild chlorotic mottle and streaks on leaves of vanilla was identified as a strain of Cymbidium mosaic virus (CymMV) based on coat protein gene sequence comparison and phylogenetic studies. The coat protein gene of virus was cloned and sequenced. Sequence analyses confirmed the identity of virus as a strain of CymMV. An identity of 92.3–97.3% was seen with different CymMV isolates infecting different orchids in India while with available partial CP sequences of CymMV isolates infecting vanilla identity ranged from 98.2 to 99.4%.



Paprika

Thirty-one hybrid samples and 30 germplasm samples were evaluated for colour value, oleoresin and capsaicin content. Accession 0107-7011 showed 308 ASTA units with 15.9% oleoresin and 1.02% capsaicin. MS-2X B-2 showed 308 ASTA units with 15.7% oleoresin and 1% capsaicin.

Seed spices

Two new varieties one each of anise, NRCSS Aani 1 and celery, NRCSS Cel 1 have been identified for release. These are first ever approved varieties in India. A total of 50 fungi were isolated in different stored spices. The fungi included *Aspergillus niger*, *A. flavus*, *Penicillium* spp. and *Mucor* spp. *A. flavus* and *A. parasiticus* have been isolated from a few samples especially nutmeg and ginger. These samples also possess lower content of essential oil and oleoresin.

PhyDisH, a new database on *Phytophthora* cultures conserved in the National Repository of *Phytophthora* at the institute and 'Spice Pat', a searchable database on patents related to spices were developed.

High-yielding varieties of cardamom (ICRI 5 and ICRI 6), coriander (RCr 480, Hisar Surabhi and Sudha), cumin (RZ 341 and Gujarat Cumin 4), fennel (RF 178), fenugreek (RMT 351 and Gujarat Methi 2) are ready for release. Cardamom ICRI 5 is first hybrid, which has high yield potential under intensive management. Cumin Gujarat Cumin 4 is identified as *Fusarium* wilt resistant and fenugreek RMT 351 resistant to powdery mildew and root-knot nematodes. Gujarat Methi 2 is resistant to root rot and downey mildew. Coriander Hisar Surabhi and fenugreek Gujarat Methi 2 are recommended for national/state release while others are recommended for state release.



Natural Resource Management

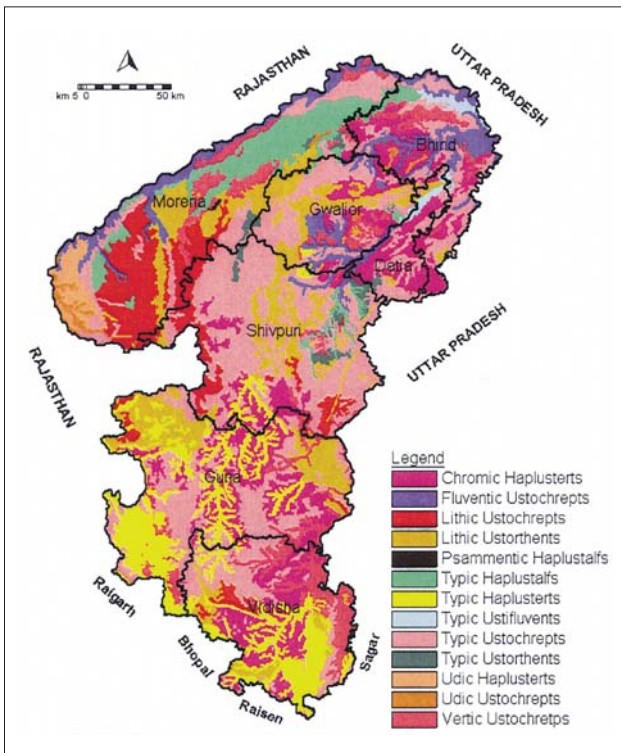
SOIL RESOURCE INVENTORY AND MANAGEMENT

Soil resource survey

Soil resource survey and mapping on 1 : 50,000 scale of 12 districts spread over Rajasthan, Jharkhand, West Bengal, Madhya Pradesh, Bihar, Orissa, Assam and Punjab, covering 5.17 million ha, has been done for the district-level land-use planning. And 254 divisional atlases for 22 districts in Andhra Pradesh, covering 275 lakh ha, have been generated. Besides, detailed soil surveys of 13 watersheds/farms on 1 : 10,000/1 : 5,000 scale have been completed, covering 112,904 ha, for soil-resource-based land-use planning in watershed-development programme. Sindh river basin-based inventory of soils has also been carried out.

Soil correlation: Soil series identified during reconnaissance, rapid reconnaissance, detailed surveys and soil-resource mapping

Soils of Sindh basin, Madhya Pradesh



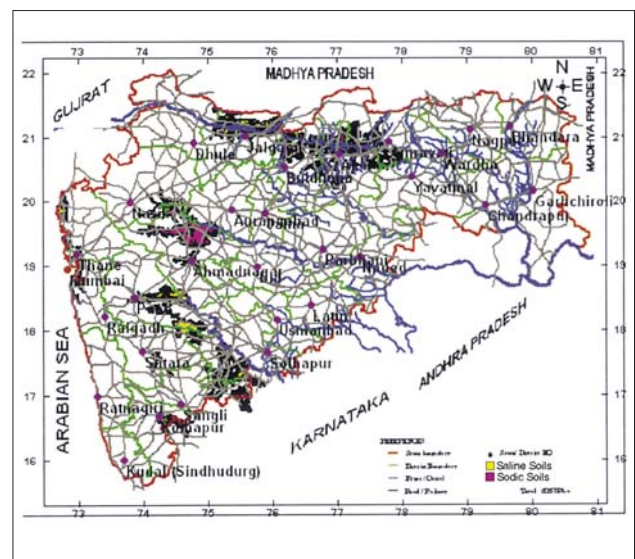
- On 1 : 50,000 scale, soil resource survey done of 12 districts spread over Rajasthan, Jharkhand, West Bengal, Madhya Pradesh, Bihar, Orissa, Assam and Punjab for district-level land-use planning
- Carried out inventory of soils of Sindh river basin
- Prepared computerized digital databases and state maps of alkali and saline soils of Karnataka, Maharashtra, Tamil Nadu and Kerala on 1 : 250,000 scale
- Soil erosion maps generated for Andhra Pradesh and Orissa
- Yield of rice increased significantly under Zero-Till Direct Seeded rice compared to conventional practice

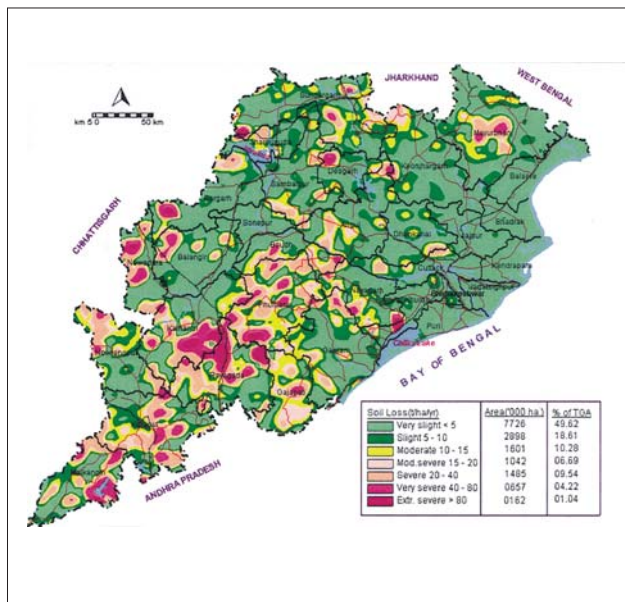
have been thoroughly reviewed and correlated, and finally 498 soil series comprising 121 in Bihar, 112 in Orissa, 155 in Gujarat, 45 in Medak district of Karnataka and 65 in Andhra Pradesh are retained.

Computerized database of salt-affected soils

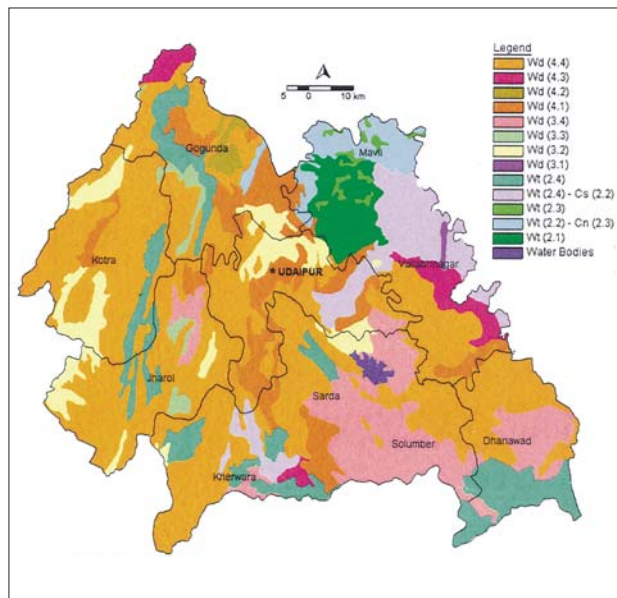
The computerized digital databases and state maps of alkali and saline soils of Karnataka, Maharashtra, Tamil Nadu and Kerala on 1 : 250,000 scale have been prepared.

Digitized map of salt-affected soils of Maharashtra

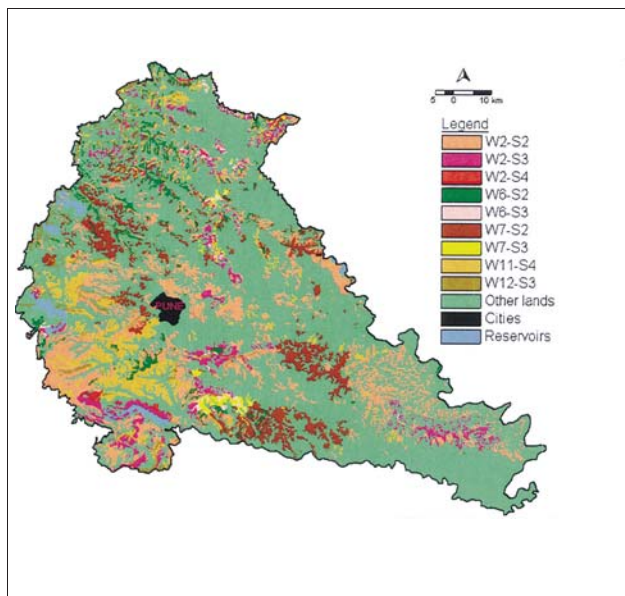




Soil erosion map of Orissa



Soil degradation map of Udaipur (Rajasthan)



Soil degradation map of Pune (Maharashtra)

Soil degradation/soil erosion

Based on the soil-resource data generated through soil-resource management project and grid observations (10 km × 10 km), soil-loss (tonnes/ha/year) maps have been generated for Andhra Pradesh and Orissa. In Andhra Pradesh, 37% and in Orissa 32% of the area suffer from soil loss of more than 15 tonnes/ha/year. Similarly, thematic map on wastelands and soil degradation of

Pune (Maharashtra) and soil degradation map of Udaipur (Rajasthan) have been prepared. These maps are useful for undertaking soil-conservation measures and for prioritizing implementation programme and resource allocation.

Resource conservation technologies to boost profitability of rice-wheat system

The average yield of rice under Zero-Till Direct Seeded Rice (ZTDSR) has been 6.1–6.7 tonnes/ha in comparison to 4.2–5.5 tonnes/ha in conventional practice. The farmer saved about 50–60% irrigation water too. Zero tillage wheat sown in the rice residue gave maximum yield of 3.55 tonnes/ha. The next higher yield of 3.19 tonnes/ha was with the normal ZT wheat in rice residue under double ZT system.

Management of agricultural resources in Garhok watershed, Dehra Dun

Cash crops, ginger, turmeric and colocasia introduced in the watershed performed excellently under rainfed conditions, and their yields were 11.5, 8.1, 12.5 tonnes/ha on an average. Under agri-horticulture and agroforestry, 3,772 fruit-plants and multipurpose trees could be planted with 70% survival. Mango, guava and citrus planted in 2002–03 have started bearing fruits. The co-efficient of improvement has showed productivity of watershed 1.3 to 1.7 times for *kharif* crops and 1.2 to 1.5 times for *rabi* crops, and this can be increased by adopting improved varieties with low-inputs under rainfed conditions.



Zero-Till Direct Seeded Rice for higher yields (6-7 tonnes/ha) compared to conventional practice



Brown manuring with *Sesbania* in rice, to save 35 kg N/ha

Soil-and-water conservation technologies

- Minimum tillage with crop residue treatment has been found beneficial for conserving natural resources, and this increased productivity under rainfed conditions in Doon valley. The treatment reduced runoff by 44 and 11%, and soil loss by 66 and 21% compared to cultivated fallow and conventional tillage. And this recorded 2,595 kg grain yield of maize/ha and 707 kg oilseed yield of *toria*/ha, which were higher by 15% and 12% over conventional tillage and were at a par with conventional tillage with crop residue treatment. The highest net returns of Rs 8,350/ha and B : C ratio of 1.48 were with minimum tillage with crop residue, followed by Rs 7,730/ha with conventional tillage.
- About 20–22% of cropping season rainfall in western Rajasthan used to be lost through surface runoff and nearly 1.5 to 2.0 tonnes of soil/ha due to water erosion. These losses could be reduced to 14 to 16% and 0.7 to 1.1 tonnes/ha with grass barriers of *Vetiveria zizanioides* (Khas)/*Saccharum munja* (Munj)/*Cenchrus ciliaris* (Dhaman)/*Dichanthium annulatum* (Karad grass). The filtering effect of these barriers promoted upstream deposition of soil and nutrients and *in-situ* moisture conservation. On an average, organic carbon, N, P and K was 3.8, 40, 5 and 12.8% higher in the upstream vicinity of grasses as compared to no barrier plots. About 15 to 24% increase in grain yield and 8 to 15% on straw yield of sorghum and soybean was observed in upstream vicinity of barriers.
- The runoff as percentage of rainfall was highest under traditional (28.3%) grazing, followed by rotational (22.6%) system and was least under cut-and-carry system (18% runoff). Trenching in combination with vegetative barriers allowed rainfall runoff of only 8.2% as compared to 41.5% under control (no measure).

Sesbania seeds at 20 kg/ha were broadcast 3 days after rice sowing. The crop when allowed to grow for 30 days and dried by spraying 2, 4-D ethyl ester could supply up to 35 kg N/ha.

WATER MANAGEMENT

Land and water productivity enhancement

To enhance productivity of seasonally waterlogged lands in canal commands, secondary reservoir fed by canal seepage and supplemented by tubewell, fish trenches-cum-raised bed for fish-horticulture production and rice-fish culture using nylon-pen under waterlogged area, were taken up. In secondary reservoir (SR) concept, two reservoirs (control and reservoir with water exchange due to routing of water) were constructed in the seasonal waterlogged area. Multiple uses of water by fish culture in reservoir, horticulture (two tiers: banana/guava/lemon and vegetables) on bunds, routing water to cereal crops, and duck-rearing were evaluated. Water was supplemented from tubewell to maintain minimum water level in the reservoir for fish production. Fish yield of 201 kg (2.52 tonnes/ha) was obtained by SR multiple use and 220 kg (2.75 tonnes/ha) from SR-Control through polyculture.

To utilize waterlogged lands having water depth 0.3–1.0 m, the

- Developed a low-energy water application technology specifically for small farm-holders and for close-growing crops
- Waterlogged wastelands could be reclaimed with *Acacia* and *Casuarina* species. *Acacia* performed better than *Casuarina*
- Earned net income of Rs 132,590/ha from fish in dug-out pond with horticulture on dykes; of this 56% was contributed by fruit-crops, 17% by vegetables and remaining 27% by fish



NATURAL RESOURCE MANAGEMENT



To enhance productivity of seasonally waterlogged lands in canal commands, multiple use of water by fish culture in reservoir, horticulture on bunds and routing water to cereal crops is being adopted (A) multiple-use system overview (B) rice+fish with centre refuge (C) fish trenches-cum-raised beds

concept of fish trenches was experimented with two types of layouts: (i) Meandering-type trenches simulating river flow in the fish trenches (Tr-R), and (ii) Island-type trenches simulating pond-type (Tr-P) conditions. Tr-R gave fish yields of 72.7 kg (1.66 tonnes/ha) and Tr-P of 80.9 kg (1.74 tonnes/ha). Banana was planted on the raised bed, which gave yield of 1.03 tonnes/ha.

Similarly, to enhance productivity of shallow waterlogged lands (20–50 cm) in the canal command, in an rice-fish integrated system, where fish was harvested after 120 days resulted in average fish yield of 1.13 tonnes/ha, which was slightly less as compared to

Component-wise net income from different multiple water-use systems

Water-use systems	Net income (Rs/ha)					% Increase over rice-wheat system (%)
	Rice and wheat	Fish	Fruit	Vegetables	Total	
Rice and wheat	27,965	0	0	0	27,965	0.00
	(100)				(100)	
Rice and wheat with fish refuge in the centre	26,392	3,302	0	0	29,694	6.18
	(88.88)	(11.12)			(100)	
Fish in sunken trenches, horticulture on raised beds	0	19,440	43,609	17,902	80,951	189.47
		(24.01)	(53.87)	(22.11)	(100)	
Fish in dug-out pond and horticulture on dykes	0	35,345	74,150	23,095	132,590	374.13
		(26.66)	(55.92)	(17.42)	(100)	
Fish in dug-out secondary reservoir	0	93,550	0	0	93,550	234.53
		(100)			(100)	

Note: Figures in the parentheses indicate percentage to their respective total



the yield of 1.42 tonnes/ha in 2004–05. Paddy yield enhanced, due to stocking of fish, by 7 to 13%. Stocking of stunted yearlings gave better fish yield as compared to fish-fry stocking. The system enhanced overall income by 11–32% as compared to sole rice-crop grown in the area.

Net income from the fish in dug-out pond with horticulture on dykes was Rs 132,590/ha. Out of this, 56% was contributed by fruit-crops, 17% by vegetables and the remaining 27% by fish. Net income gained from fish in dug-out secondary reservoir was Rs 93,550/ha/year and the amount came from fish production. Fish in sunken trenches with horticulture on raised beds gave net income of Rs 80,951/ha/year. Out of this, 54% was contributed by fruit-crops, 22% by vegetables and the remaining 24% by fish. Net income from rice-wheat system with fish refuge in the centre was Rs 29,694/ha/year. Out of this, 11% was contributed by fish and 89% by rice and wheat. These systems were compared with traditional rice-wheat system where net income was Rs 27,965/ha/year. Increase in net income was highest (374.13%) in fish in dug-out pond with horticulture on dykes. It was 6.18% in rice-wheat system with fish refuge in the centre, 189.47% for fish in sunken trenches with horticulture on raised beds, and 234.53% for fish in dug-out secondary reservoir.

Water productivity assessment in irrigated command

A study was initiated in three outlet commands of RP Channel V distributary of Patna Main Canal under Sone Canal System and two tubewell commands in Vaishalli Districts of Bihar to determine water productivity.

Crop water productivity (Rs/m³) considering applied water varied from 4.79 to 8.39 in the outlet commands. Considering water inflow, including rainfall, it ranged between 2.42 and 3.11. In tubewell commands, the crop water productivity for applied

water ranged from 14.03 to 29.61, and it was 2.81 to 2.39 with total water inflow, including rainfall. Total water productivity (Rs/m³) considering applied irrigation water varied from 5.28 to 10.66. Considering total water inflow, it ranged between 2.67 and 3.96 in outlet commands. In tubewell commands, the total water productivity ranged from 18.09 to 38.73 for applied water and 3.09 to 3.68 for total water inflow. Lower water productivity considering total water inflow (irrigation + rainfall) in tubewell commands may be attributed to higher proportion of rainfall in the total water used. Crop water productivity alone does not depict actual use of water in the command. Since total water productivity takes into account other water uses like trees, fodder, livestock, fish etc., and its value is higher and as such it gives the true picture of actual water use and productivity of water in an irrigated command.

Low-cost pressurized irrigation system

A low-energy water application (LEWA) technology specifically for small farm-holders and for close-growing crops has been



Treadle pressure pump operated with LEWA

Crop and total water productivities in canal outlet and tubewell commands

Item	Outlet head reach	Outlet middle reach	Outlet tail reach	Tubewell land consolidation	Tubewell land fragmentation
Area (ha)	30.61	43.68	4.65	18.74	13.21
Crop water productivity per unit of irrigation water applied (Rs/m ³)	4.79	4.95	8.39	29.61	14.03
Crop water productivity per unit of water inflow including rainfall (Rs/m ³)	2.42	2.73	3.11	2.81	2.39
Total WP per unit of irrigation water applied (Rs/m ³)	5.28	5.90	10.66	38.73	18.09
Total WP per unit of water inflow including rainfall (Rs/m ³)	2.67	3.25	3.96	3.68	3.09



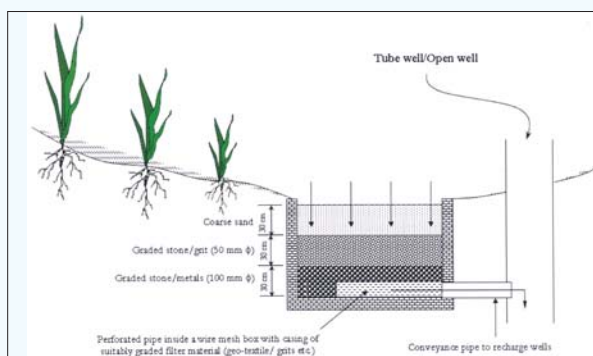
SUCCESS STORY

Impact of groundwater recharge in Antisar watershed, Vasad (Gujarat)

Scarcity of the water for drinking purpose as well as for the irrigation emerged as one of the major problems of the area. The conservation works for groundwater recharge included land levelling (132 ha), pond renovation (4 nos), repair of major dam (1 no.), construction of check-dams (16 nos) and well recharge filters (23 nos). Watershed development activities resulted in positive impact on the drought mitigation, crop improvement, and improvement in lives of beneficiaries. The recharge filter designed by the Central Soil and Water Conservation Research and Training Institute, Research Centre, Vasad,

groundwater table showed quantum of recharge resulting from the water-storage structures and recharge filters. Crop sowing, which was delayed by 25 to 30 days outside the watershed, could be done in time within the watershed. Likewise, the number of repeated sowings, which varied between two and three times outside the watershed, was done only once in the watershed. The fertilizer application in the watershed was double of the quantity used outside the watershed. The green and dry fodder consumption increased by 30 to 40% outside the watershed. The various *kharif* crops saved through

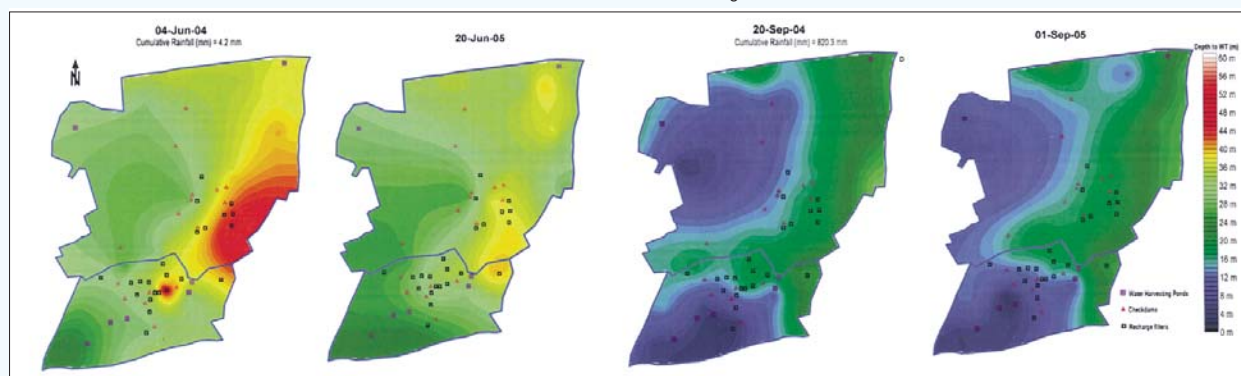
Antisar watershed (812 ha) is 100 km away from Vasad on Dakor-Pankhia road in taluka- Kapadvanj, District Kheda. About 500 families of 7 villages/hamlets of the watershed are engaged in agriculture and animal husbandry. The watershed is the part of Gujarat agro-ecological sub-region No. VI. Monsoon lasts for about three-and-a-half months (mid-June to September) in this with an average annual rainfall of 834 mm (1983–2005).



Schematic representation of groundwater recharge filter



Bumper harvest of drumstick pods with enhanced groundwater recharge in the watershed



Pre- and post-monsoon watertable regimes in water-harvesting structures (ponds, checkdams etc)

consists of porous filters to deliver a substantial quantum of storm-water runoff harnessed from agricultural fields and excess of drainage water from the catchment. A three-tier filter ensures sediment-free water delivery to a nearby open or tubewell through a buried pipe-line. Initially the artificial recharge filter was constructed in one of the community wells, which was dry since long. This resulted in water availability in this well in the same season. This visual impact motivated farmers to participate in this activity, particularly in drought years.

A comparison of pre- and post-monsoon (2004 and 2005)

supplemental irrigations from these recharged wells also yielded 50% higher in some cases. In addition, the available groundwater resulted in improved crop productivity.

The enhanced groundwater recharge had attracted farmers to diversify their cropping systems. In 2002–03, drumstick (*Moringa olifera*) hybrid type was introduced as block plantation (2 ha) in the watershed. Harvest of 6,906 kg of vegetable pods/ha was realized with gross returns of Rs 57,587/ha during the first year of plantation. In second year (2003–04), 30,000 kg of vegetable pods were harvested with gross returns of Rs 107,500/ha.



Low-energy water

Wild flooding or field to field irrigation is the most common on-farm water management practised by the majority of the farmers in the prevalent rice-wheat cropping system. And the major quantity of the water thus is lost in the system in conveyance and application, besides lots of wastage of energy.

Keeping in view the increasing pressure on water and energy resources in future, it was thought of to develop a low-cost water and energy-efficient device which can be used by resource-poor farmers possessing small and fragmented land holdings. This led to the development of low-energy water application, LEWA.

LEWA unit with rotating mechanism



Flow pattern of jet from the device



LEWA system laid down on farmer's field



A 1.5-hp prime mover pump (Electric) in operation



LEWA installed on underground PVC pipe to irrigate rice



application – at a glance

Salient features of LEWA

- Suitability: Provides irrigation to most of the field and row crops such as cereals, oilseeds, pulses, vegetables, flowers
- Energy efficient: Have an added advantage in saving of energy besides water
- Recommended operating pressure: 0.4–0.6 kg/cm²
- Throw diameter: 6–8 m
- Application rate: 2.6–3.1 cm/hr, (can be adjusted based on the crops and soil types)
- Riser height: 1 m
- Surface uniformity 60–70 % when operated at an operating pressure of 0.5 kg/cm² or above
- Sub-surface uniformity > 90%
- Higher discharge than infiltration rate, unlike sprinklers, just to keep soil surface wet
- Low pressure required by LEWA facilitates use of low-cost flexible flat-hose pipes, other system components, and low hp prime movers pumps leading to low-cost of system
- With flexible flat-hose pipes, a LEWA unit for 1,000 m² costs approximately Rs 8,100 (excluding prime mover and on shift basis)
- In most of the cases saving of water and energy by LEWA device has been to the tune of 30–50% over surface method whereas 10% saving of water and 30-50% saving in energy has been observed as compared to sprinklers without any reduction in yield.



Low-cost system components of LEWA irrigation system



Low-cost components of LEWA system for irrigating rice



Low-cost components of LEWA system for irrigating wheat



Bio-drainage for ameliorating waterlogged area

The water-table was found beyond 2.1 m in bio-drainage plots and it was within 0.5 m in the unmodified experimental plots in March 2006 in WTCER research farm. Successful establishment of trees and intercrops and their vigorous growth have revealed that bio-drainage species *Acacia* and *Casuarina* can be grown for reclamation of waterlogged wastelands. *Acacia* performed better than *Casuarina*. Average mortality of these bio-drainage plant species in such wastelands after one year was very low (< 6%). Pineapple, arrowroot and turmeric were also intercropped successfully.

Makhana—a profitable farming system component of eastern India

Makhana is being cultivated in lowland rice fields and also in natural ponds. In Purnea and Katihar districts, the cropping period of makhana is from March to September, where makhana-rice cropping system is followed, and the yield of makhana obtained is higher than ponds. In traditional ponds,



Makhana in lowland rice field

makhana seedlings germinate from left-out seeds of the previous season (January–February). This is common in Madhubani and Darbhanga districts.

Yield of makhana seeds ranged from 2.0 to 2.5 tonnes/ha in well-managed systems and 1.5 to 2.0 tonnes/ha in natural systems. Its cost of cultivation was approximately Rs 25,000 to Rs 40,000/ha. And net income from makhana cultivation was around Rs 17,500/ha.

developed. The modified nozzle of the LEWA replaces sprinklers and low-cost LDPE-flat-hose flexible pipe replaces low-cost fittings such as valves, tee, elbow, socket and riser. This has facilitated in lowering cost of the system to the existing overhead impact

sprinklers. A LEWA unit covering 1,000 m² per shift will cost Rs 8,000 approximately whereas the cost of the sprinkler unit for the same area is calculated nearly three times higher.

The performance of LEWA was compared with existing sprinklers (two low pressure spray nozzles, one impact sprinkler and another mini Wobbler). The tested sprinkler needed to be operated between 1.5 and 2.5 kg/cm² when spaced at 6–12 m, and mini Wobbler required at least an operating pressure of 1 kg/cm². The energy saving by the LEWA is to the tune of 3–5 times from sprinkler and approximately 2 times from mini Wobbler. Treadle pressure pump devised by the IDE has also been operated with LEWA. Considering the rate of discharge of the existing pump and capacity to generate head, four LEWA devices can be operated simultaneously when it is operated directly and water is lifted from the shallow depth.

NUTRIENT MANAGEMENT

Soil carbon stocks of Indo-Gangetic Plains

The soils in the IGP are formed by calcification, leaching, lessivage, salinization and alkalization, gleization and homogenization. The region is dominated by Entisols, Inceptisols, Alfisols, Mollisols and Aridisols. The total carbon in the region is estimated at 13.7 Pg (1 Pg = 10¹⁵ g); organic carbon (SOC) is 9.6 Pg and soil inorganic (SIC) is 4.1 Pg. In lower IGP, SOC stock under rice-wheat or rice-potato systems has stabilized. Intensification of cropping system towards triple cropping is likely to reduce SOC stock, which can be mitigated by adopting no tillage or reduced tillage operations and addition of organic substrates.

Granular borax (Granubor II)—a new boron source

Sodium tetraborate pentahydrate (Granubor II, 14.6% B), carrying five molecules of water of crystallization, less than borax deca hydrate, was evaluated for correcting boron deficiency in cauliflower in different regions.

The flower head yield response ranged from 2.1 tonnes/ha in acid soils of Kullu, Himachal Pradesh, to 7.5 tonnes/ha in Alfisols of Andhra Pradesh. The net profit derived from 1 to 1.25 kg B/ha application ranged from 6,181 to 22,228/ha. And net benefit per rupee spent on boron was Rs 5.60 to 35.80 with borax and was

- Developed a new sulphur fertilizer, Gromor sulphur benetonite pastille, containing 90% sulphur
- Sodium molybdate at 0.5/ha to maize in Mo-deficient soils of Andhra Pradesh increased crop yield



NATURAL RESOURCE MANAGEMENT



Granubor II effects on cauliflower. Granubor II has been found a cost-effective source of boron with returns of Rs 16 to Rs 60 per rupee invested

Rs 16.63 to Rs 59.91 with Granubor II (borax pentahydrate granular).

Gromor sulphur bentonite—a new sulphur source

Recently, a new sulphur fertilizer Gromor sulphur bentonite pastille, containing 90% sulphur, has been developed, and was tested in maize and mustard system on Inceptisol at Anand (Gujarat) and in



Gromor sulphur bentonite a new source of sulphur has proved as effective as gypsum or single superphosphate in improving the yield of mustard (Gujarat)

Mean effect of sulphur sources in correcting its deficiency in maize-mustard in Inceptisol, Anand, and rice-cowpea in Alfisol, Bangalore

S sources	Seed yield (kg/ha)			
	Maize-mustard		Rice-cowpea system	
	Direct maize	Residual mustard	Direct rice	Residual cowpea
Control (NPK only)	2,755	1,793	3,450	890
Bentonite-S	3,354	2,025	3,912	1,565
Gypsum	3,126	2,065	3,716	1,490
SSP	2,946	2,006	3,928	1,465
CD @ 5%	125	83	122	105

rice-cowpea sequence on Alfisol at Bangalore (Karnataka). The new sulphur source bentonite sulphur has been found as effective as gypsum or single superphosphate (SSP) in improving grain yield of maize, rice, cowpea and mustard over NPK without S.

Molybdenum for increasing crop productivity

Molybdenum at 0.5 kg/ha as sodium molybdate to maize in Srikakulam and Vizianagram districts of Andhra Pradesh, where 49% soils are deficient in molybdenum, increased crop yield from 45 tonnes/ha to 56 tonnes/ha.

CROPPING/FARMING SYSTEM RESEARCH

- In Bihar, wheat-elephant-yam and urdbean system provided maximum pigeonpea equivalent yield (8.16 tonnes/ha), followed by tobacco-summer maize-dhencha (GM) (6.96 tonnes/ha)
- Maximum yield equivalent in terms of rice was recorded in rice-tomato-bottle-gourd (48 tonnes/ha) in Bihar
- In red-gravelly soils of Dharwad, groundnut yielded higher in 20-cm wider spread teak alleys compared to 10-cm ones
- Using *subabul* leaves as fodder for feeding 70 lambs saved expenditure of Rs 20,660 on the concentrate feed
- *Amaranthus* GA 2 found as a good source of protein

CSR 36—A new rice variety for salt-affected areas

A new, high-yielding and salt-tolerant rice with long, slender grains was released by the CVRC for Haryana and Pondicherry in 2005. This variety performed well up to 11 dS/m in saline soils and up to pH 9.8 in alkali soils. This variety yielded more than 7 tonnes/ha in normal soils and above 4 tonnes/ha in the salt-affected soils.





Genetic transformation of mungbean (*Vigna radiata*) for enhancing drought tolerance

Mungbean contributes to 15% of the pulse production, and drought is the single-most important constraint affecting its productivity. Therefore, transgenic approach was tried with cultivar



In-vitro tissue culture via multiple shoots induction in mungbean using half cotyledonary node with intact cotyledon as explant

ML 267 by introducing *annexin bj* gene to impart tolerance to moisture stress by relieving oxidative stress.

Half-cotyledonary node with intact cotyledon as explant derived from 3-day-old seedlings germinated on the medium containing 2 mg/litre BAP has been found most suitable and effective, and it could produce a reasonably high number of multiple shoots when cultured on the medium containing 12.5 mM BAP. The shoots so developed were elongated on medium having 5 mM BAP and 0.05 mM NAA. These shoots were rooted on a NAA medium. On transfer to glasshouse, the plants could grow well and produced normal seeds.

Pre-rabi pigeonpea-based cropping systems

Wheat-elephant-yam + urdbean system provided maximum pigeonpea equivalent yield (8.16 tonnes/ha), followed by tobacco-summer maize-*dbencha* (GM) (6.96 tonnes/ha) in Bihar. The net returns also followed same pattern, and the highest returns of Rs 85,805/ha were obtained in the 1st system, followed by

Rs 71,737/ha by the second system. The cost: benefit ratio was highest under the Indian mustard-mungbean-urdbean cropping system (1.27), closely followed by wheat-summer maize-*dbencha* (GM) (1.25), wheat-elephant-yam + urdbean (1.24) and tobacco-summer maize-*dbencha* (GM) system (1.19).

Diversified cropping systems for irrigated ecosystem in Bihar

Maximum yield equivalent in terms of rice was recorded in rice-tomato-bottle-gourd (48 tonnes/ha). Minimum yield equivalent was recorded in rice-carrot-cowpea (7.62 tonnes/ha), rice-capsicum-cucumber (7.98 tonnes/ha) and rice-coriander-lady's finger (8.84 tonnes/ha). Rice-cabbage-Frenchbean (18.81 tonnes/ha) and rice-potato-onion (13.91 tonnes/ha), rice-mustard-tomato (12.88 tonnes/ha), rice-pea-green-chilli (11.43 tonnes/ha), rice-wheat-urdbean (11.25 tonnes/ha) and rice-lentil-sponge-gourd (10.34 tonnes/ha) recorded reasonable yields but they were



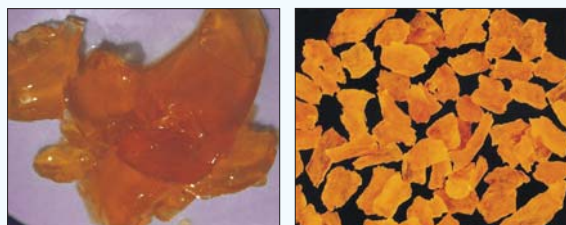
Diversified cropping systems for irrigated ecosystem in Bihar. Maximum net profit of Rs 83,253 has been recorded in rice-coriander-lady's finger



Edible candy and jelly from *Aloe vera*

A major problem of *Aloe vera* plant is its high perishability, even under refrigeration. A method has been developed for the preparation of 'Aloe Candy' in which active ingredient of the plant remains intact, and its shelf-life is reasonably high (> 6 months) at room temperature. The candy is made from freshly separated pulp of the leaves; by treating with sugar. Polysaccharides in *Aloe vera* leaves vary from 0.20 to 0.35%, and in the fresh juice from mature leaves ranges from 0.18 to 0.37% (w/v). Sugar is mixed as per taste requirement, but normally it should be 70–82%.

Prepared another product, 'Aloe jelly', from freshly prepared juice has polysaccharides content of 0.15–0.26% and sugar content of 9–50%.



Aloe candy and Aloe jelly from *Aloe vera*, a highly perishable plant, keep the active ingredient of the plant intact

CS 54—A new raya variety for saline/alkali soils

This variety yields significantly higher than other salt-tolerant and national high-yielding checks CS 52, Varuna and Kranti. Its average seed yield recorded was nearly 20, 22 and 20% more than CS 52, Varuna and Kranti.



found at a par. Maximum net profit was recorded in rice-tomato-bottle-guard (Rs 192,114), followed by rice-mustard-tomato (Rs 88,526) and rice-coriander-lady's finger (Rs 83,253).

Amaranthus—A new commercially viable option for arid Kachchh

At Kukma, application of nitrogenous fertilizer at 90 kg/ha and irrigation at 200 mm water at four growth stages to *Amaranthus* GA 2 in almost equal quantity, helped to produce 8,382 kg of dry biomass/ha and 1,206 kg of grains/ha with net economic returns of around Rs 20,000/ha, which were at a par with grain yield, biomass production and net returns obtained in the traditional *Amaranthus*-growing areas of Gujarat. The study indicates that cultivation of *Amaranthus*, which is a good source of protein, in Kachchh district is a commercially viable proposition.



Amaranthus GA2 at Kukma in Kachchh district

Agroforestry systems for different agroclimates

At Bhubaneswar, ragi, groundnut, sesame and urdbean were grown in alleys (8-m wide) of *Acacia mangium* and *Gmelina arborea* at 625 trees/ha. The highest benefit : cost ratio was obtained from sesame (1.82) under *A. mangium*, followed by sesame (1.54) under *Gmelina arborea*. Among two trees, growth in terms of height and diameter was greater in *A. mangium* (Ht. 10.4 m, DBH 14.2 cm).

In red-gravelly soils at Dharwad, groundnut yield was higher in wider (20 m) spaced teak alleys than closer (10 m) ones. Marketable wood value of teak has been higher in 10- m spaced teak alley (Rs 228,543/ha) compared to 20-m spaced alley (Rs 125,653/ha). The net income was three times higher (Rs 11,347/ha/year) in field crops + teak + papaya system as compared to sole field crops (Rs 3,983/ha/year).

At Kattupakam, *Leucaena leucocephala* (2 m × 2 m spacing) in Napier-*bajra* hybrid fodder production system yielded 12, 34 and 12% higher dry fodder biomass, digestible protein and total digestible nutrients compared to Napier-*bajra* hybrid alone.

If *subabul* leaves were used as fodder source instead of concentrate feed, 70 lambs weighing 18–20 kg mean body weight



SUCCESS STORY

Farming systems in and around Patna

- The technology of raising early vegetable seedlings for winter and summer vegetables was adopted by large number of farmers and farm-women. This increased their income from Rs 2,700 to Rs 6,000 in 0.20 acre of land.
- Landless families adopted mushroom cultivation as an alternative livelihood support system. More than 100 women that formed Self Help Groups (SHGs) have started mushroom production in south Bihar. Women are earning a minimum of Rs 50/kg of mushrooms by spending only Rs 8.
- Rice-fish system was popularized in lowland area. By adopting this technology farmers harvested 2–3 tonnes of fish and 3 tonnes of rice in Bikram block.
- Through raising of Divyan Red breed of poultry, for rearing in backyards, on an average a farmer earned Rs 593 from a single female bird by sale of eggs. Moreover, 4 farmers raised chicks from eggs and earned an additional amount of Rs 600/family/year. Khaki Campbell breed of ducks was distributed among 41 landless farmers and unemployed youth from 8 villages. On an average, a farmer earned Rs 480 from a single bird by sale of eggs. Moreover, 5 farmers raised ducklings from eggs and generated an additional income of Rs 700/family/year.
- Twelve farmers of 5 different villages raised bunds of their fields up to 20 to 30 cm from existing 5 to 7 cm height. A total of 50 plots were under this intervention comprising 9 ha that reported following benefits: Soil moisture prolonged for longer duration; this resulted in saving of 2 irrigations; Lesser incidence of diseases as well as existence of weed were reported, and additional benefit was also reported of growing arhar, okra on bunds, this provided additional income and compensated expenditure incurred for raising bund height.

could be maintained in one hectare of subabul + Napier-bajra hybrid fodder production system, and could save on concentrate feed expenditure of Rs 20,660.

Water hyacinth mulch to reduce weed infestation in potato

Water hyacinth mulch in potato (var. Kufri Chandramukhi) significantly decreased weed infestation (*Medicago*, *Chenopodium*, *Vicia*, *Chicorium* and *Physalis*), cost of earthing operation as well as cost of inorganic fertilizers by 50%. The plots which received mulch plus Metribuzin application showed minimum weed infestation and gave highest tuber yield.

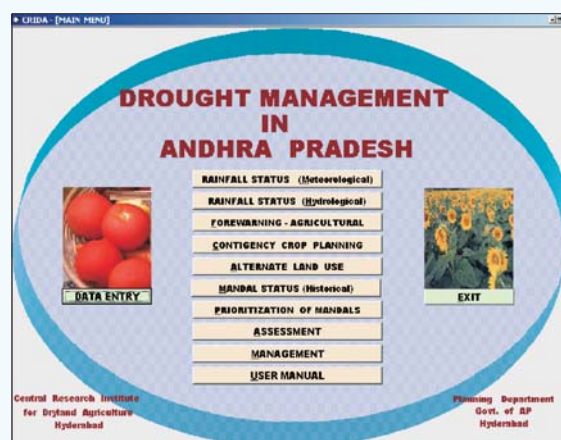
IPM for managing fruit fly in cucurbits in Western Ghats

During *kharif* 2005 and 2006, the ICAR Research Complex for

Goa demonstrated the technique of managing *Bactrocera cucurbitae* in hill cucurbits through on-farm trials using baits (10% banana/jaggery, 3% protein hydrolysate) laced with insecticide (0.1% Malathion 50 EC). These baits were applied in about 10 hectares in farmers' fields as fine splashes (squirts) once a week in a 7 m × 7 m grid (200 splashes/ha, 8 litres/ha, 40 ml/spot) on a 30-day-old crop (cucumber, ridge-gourd, bitter-gourd, snake-gourd) up to the end of commercial fruit production. Infestation levels were less than 10% in treated plots as compared

Drought Management Software for Andhra Pradesh Developed

Andhra Pradesh is the third most drought-prone state of India after Rajasthan and Karnataka. Rayalseema and southern parts of Telengana are considered as chronic drought-prone regions. The mandals prone to drought were assessed and prioritized using bio-physical and socio-economic parameters. Drought severity index was worked out for all mandals. A Drought Management Software (DMS) has been developed with several different modules dealing with drought assessment, mitigation and relief measures to reduce time-lag in collection, processing and transfer of data/information. Using information technology, a unique attempt has been made to bring planners and implementers on a single platform. In drought mitigation, stress has been laid on contingency crop planning and land-use diversification. Groundwater, surface water and livestock management have been given due attention as drought preparedness is much more cost-effective than relief measures. Relief measures have been focussed on developing a response plan by assigning roles and responsibilities to various departments including banks and insurance. Emphasis has been given to community-based participatory planning to improve effectiveness and transparency in various relief measures related to employment generation, public-health, food and fodder security.





Biofuel crops

- 892 CPTs (Candidate Plus Trees) of *Jatropha* and 323 CPTs of *Pongamia pinnata* (karanja) have been collected from 110 districts of India. The oil percentage in seeds ranged from 28 to 40%. All materials are in evaluation phase for growth, seed and oil yield.
- Vegetative propagation of *Jatropha* through stem-cuttings has been standardized. *Jatropha* cuttings in rooting medium containing equal proportions of sheep manure + red soil + black soil + vermicompost exhibited better overall growth. *Bacillus coagulans* (PD 7) and *B. lentus* (ALP 18) have been identified as potential strains to promote plant growth when administered through seed priming or as slurry treatment on cuttings.
- Two-year-old grafted *Pongamia* trees started fruiting whereas ungrafted seedlings are yet to flower.

to nearly 20% in plots that received no bait application. Managing fruit fly with this technique reduced insecticide load on the crops by nearly 90%.

MACHINERY AND IMPLEMENTS

Implements for reducing women's drudgery

Hand-drawn seed drill: To reduce drudgery and improve efficiency of farm-women in seeding operation, a two-row seeder with suitable attachments has been developed. The unit can be used either as a seed drill or as a weeder. The drill consists of 2



Hand-drawn seed drill. This two-row seeder developed with suitable attachments can be used as a seed drill or as a weeder

- Hand-drawn seed drill and hand-operated winnower developed to reduce drudgery of women

seed-hoppers of 22 cm × 18 cm × 26 cm, flow rate controls, conveying tubes, furrow openers with row-distance adjustment and 31-cm diameter drive-wheel and chain and sprockets. The main frame of the implement was fabricated with 25-mm pipe and 25 mm × 4 mm flat. The implement is suitable to sow dryland crops such as sorghum, *bajra*, chickpea etc. The implement has been tested in field to sow sorghum with 45-cm row spacing.

Hand-operated winnower: A simple, hand-operated winnowing machine has been developed. The machine consists of 55 cm × 75 cm × 115 cm frame on which a 12-kg capacity feed hopper with auger mechanism is fitted. A 180W 1425 rpm electric



Hand-operated winnower. For this machine, 2 women are required and they can winnow 0.25–0.3 tonne of grains per hour

motor with 15-inch fan are arranged on the frame. Two women are required to run the machine; one to operate the auger and the other to feed the material to be cleaned. Two women can winnow 0.25–0.3 tonne of grain per hour by this.



Livestock and Poultry Improvement and Management

ANIMAL GENETIC RESOURCES

Physical characterization and evaluation of animal genetic resources

Several indigenous breeds of livestock and poultry were physically characterized, and basic data on their production traits were generated during the year.

Gaolao cattle: This indigenous cattle breed is found in Amravati, Nagpur, Yeotmal and Wardh districts of Vidarbha region of Maharashtra. The Gaolao cattle is white, or grayish/black, and the muzzle and hooves are black. The average body length, height at withers and chest girth in adult females and males are 96.05, 113.99, 142.27 cm and 103.92, 128.46, 158.83 cm, respectively. Adult body weight is 219.72kg in females and 271.07kg in males. The age at first estrous (months), age at first mating (months), age at first calving (months), interval from calving to conception (days), number of services/conception, calving interval (days) were observed as 43.95, 44.83, 54.74, 150.94, 1.50, 430.26, respectively. The lactation milk yield (kg), lactation length (days), dry period (days), per day milk yield (kg), peak yield (kg) were recorded as 559.67, 249.18, 125.25, 2.43, 3.16 respectively. The highest milk yield was noticed in fifth lactation. The average fat content in milk was 4.32%.

Bonpala sheep: The Bonpala sheep also known as Gharpala, is distributed in all regions of Sikkim. The predominant body colour is black and white. The head is slightly convex, and ears are tubular in shape ranging from 2–8 cm. The horn is brownish-black with

Gaolao Cattle



- Kenkatha cattle is a valuable source of genetic material for meeting demands of future breeding programmes
- Jamunapari goats need appropriate genetic management to save the germplasm
- Ganjam and Marwari goats revealed highest genetic distance
- Indigenous poultry revealed high degree of gene diversity
- A model developed for conservation of cattle in *gaushalas*

tapering shape oriented slightly upward and backward, downward, and then twist forward and outward. The size of horn in adult male is 45.2 cm and in female is 11.69 cm. The body weight of adult male is 58.9 kg and female 51.20 kg. The chest girth, body length, height at withers measured 91.02, 81.33 and 74.6 ± 0.88 cm, respectively, in adult males, and 88.46, 77.84 and 72.95 cm, in adult females. Age at first mating ranged from 1 to 1½ years. Age at first oestrus and age at first lambing were recorded as 1 year and 2 years, respectively, with a lambing interval of 1 year. The litter size is single. The number of lambing in lifetime is 6 to 7. The average daily milk yield was 313.16 g, with 9.60% SNE, 3.12% protein and 6.14% fat. Wool production was 1 kg/annum (2 shearing per annum) with average wool length 9.86 cm and diameter 54.08 µ.

Zalawadi goat: The Zalawadi goat, a native of the Surendranagar district in Gujarat, is a large size, sturdy and dual-

Bonpala sheep





purpose breed. The coat colour is black. Horns are spiraled, straight and twisted (2–5 fold). Ears are long (19–25 cm), leafy, dropping with either white spot on black base or vice-versa. The nostrils are broad with slightly roman (convex) nose. Udder is symmetrical and capacious with long and outward teats. The average body weight of adult does is 34 ± 0.37 kg and of bucks 52 ± 3.12 kg. Zalawadi goats are high milk producers (1.13 ± 0.07 litre) with good lactation length (6.17 ± 0.06 months).

Ghagus poultry: Ghagus breed of indigenous poultry has its breeding tract in Kolar district, and adjoining locations of Karnataka and Andhra Pradesh. Ghagus birds are maintained largely for egg and or game purpose. The leading plumage colour is brown followed by black. The colour pattern is usually patchy in males and spotted in females. Shinning bluish black feathers exist



Ghagus poultry

on breast, tail and thighs of cocks. Neck is covered with golden feathers. Wattles are absent. Comb is red and pea or single type. Spur is short in cocks. Average adult body weight of the cock is 2.16 ± 0.25 kg and hens 1.43 ± 0.81 kg. Egg laying starts at the age of about 5–7 months, and hens lay about 15–20 eggs in one laying period of 20–26 days. Average annual egg yield is around 45–60. Average egg weight, albumin index, yolk index and Haugh units are 40.25 ± 2.39 g, 0.07, 0.39 and 76.79 ± 2.93 , respectively.

Danki poultry: Danki poultry is distributed in Vizinagram district and adjoining parts of Srikakulam and Visakhapatnam districts of Andhra Pradesh. The most frequent plumage colour is brown followed by black. Cocks have shining bluish black feathers on wings, breast, tail and thighs. Neck is fairly darker compared to the rest of body. Wattles are absent. Comb is red, pea type and compressed. Spur is long and sharp in cocks and small in hens. Average adult weight of cock is 3.12 ± 0.09 kg and hen 2.22 ± 0.06 kg. Egg laying starts at the age of about 6–8 months, and hens lay about 8–12 eggs in one laying period of around 15–20 days. Average annual egg production is only 25–35. Average egg



Dhanki poultry

weight, albumin index, yolk index and Haugh units are 46.16 ± 1.72 g, 0.06, 0.28 ± 0.01 and 66.81 ± 2.54 respectively.

Kalasthi poultry: This breed of indigenous poultry is seen in Chittoor district, and adjoining regions of Nellore district of Andhra Pradesh. The common plumage colour is bluish black but brown birds are also noticed. The colour pattern is generally patchy in males and spotted in females. Cocks possess shinning golden feathers on neck and wings. Legs are proportionately longer. Wings are dorsally set revealing thighs enveloped with smooth feathers.



Kalasthi poultry

Wattles are absent. Comb is red, pea type and compressed. Spur is small in size. Average adult weight of cocks and hens are 2.48 ± 0.13 kg and 1.85 ± 0.10 kg. Egg laying starts at the age of 6–8 months, and yield is 9–14 eggs in one laying period of 15–25 days. Average yearly egg production is 30–40. Average egg weight is 42.91 ± 1.94 g. Albumin index, yolk index and Haugh units are 0.05, 0.35 ± 0.02 and 68.81 ± 2.19 respectively. Kalasthi birds appear identical to those of Danki breed except that they are smaller in size, peacock type bluish in colour and have smaller spur.



***In-situ* conservation through Gaushalas**

Details collected from 76 Gaushalas in Haryana, Gujarat, Uttar Pradesh and Rajasthan revealed that more than half of the Gaushalas are directly or indirectly engaged in conservation of indigenous breeds. Based on the structure of cattle population in the Gaushalas, a new model, named as 10P Model, was developed for conservation of cattle in Gaushalas. Four Gaushalas have implemented the model by separating out the best cows in their herd and permitting controlled breeding by bulls of the same breed. These Gaushalas are: (i) Shri Bhadrariya Gaushala—Pokhran, Rajasthan, (ii) Murli Manohar Gaushala, Bhimasar, Rajasthan, (iii) Shri Kurukshetra Gaushala—Hisar, Haryana, and (iv) Shri Gaushala Trust, Bhiwani, Haryana.

Genetic and molecular genetic characterization

Cattle

Khillar: Genotypic data, generated across the 25 FAO prescribed microsatellite markers, was analyzed to assess the relative genetic variability. A total of 164 distinct alleles were detected across the 25 loci among the population screened. The allelic diversity per locus was 7.5. The effective number of alleles (3.8) was less than the observed values across all loci. Observed and expected heterozygosities ranged from 0.24 to 0.97 and from 0.30 to 0.89, respectively. Mean estimates of observed and expected heterozygosities were 0.58 and 0.67, respectively. High genetic diversity and absence of genetic bottleneck were observed in the Khillar breed.

Other cattle breeds: Comparative genetic analysis of cattle breeds, viz. Kangayam, Umblachery, Ongole, Amritmahal, Hallikar, Krishna Valley, was completed using 25 bovine-specific microsatellite markers. Gangatiri and Kenkatha cattle were also characterized. In Gangatiri cattle 138 alleles were detected with an average of 6.273 ± 2.394 alleles per locus. The number of observed alleles varied from 3 to 14 with an overall mean of 6.272 ± 2.394 . The observed number of alleles for all the loci exceeded the effective number of alleles, which varied from 2.007 to 6.238 with a mean of 3.356 ± 1.226 . The average PIC estimate was 0.625 ± 0.114 . The average observed heterozygosity was 0.464 ± 0.166 , which was lesser than the expected. The average expected heterozygosity varied from 0.502 to 0.839 with mean of 0.669 ± 0.097 . The *f*-estimates varied from -0.082 to 0.640 with an average of 0.318. Thus on an average a significant deficit (31.8%) of heterozygote exists in the Gangatiri population.

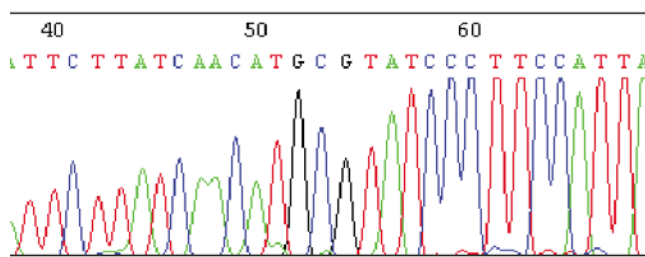
In Kenkatha cattle 125 distinct alleles were identified. The observed number of alleles varied from 2.10 to 4.75 depending on locus with a mean of 3.41 ± 1.09 . The average PIC estimate was

0.639 ± 0.101 . The average observed heterozygosity was 0.540 ± 0.171 , whereas, average expected heterozygosity ranged from 0.530 to 0.825 with an overall mean of 0.685 ± 0.100 . The *f*-estimates ranged between -0.179 and 0.572 with an average of 0.214. In conclusion, Kenkatha cattle still has sufficient genetic variability that can provide a valuable source of genetic material for meeting demands of future breeding programmes.

Buffalo

Jaffarabadi: Twenty-four heterologous bovine specific microsatellite markers, tested for buffalo genome diversity studies, were evaluated in 45 unrelated genomic DNA samples of Jaffarabadi buffaloes. Total number of alleles varied between 2 and 10 with mean of 5.04 and effective number of alleles ranged from 1.22 to 6.82 with mean 3.22. Observed heterozygosity ranged from 0.157 to 0.975 with mean of 0.554 and Nei's expected heterozygosity ranged between 0.185 and 0.853 with mean 0.604. Assessment of Jaffarabadi breed structure implied moderate extent of within breed genetic variability. Allelic frequency distribution (mode shift indicator) showed no recent bottleneck in the Jaffarabadi population.

Expressed sequence tags (ESTs) analysis and gene annotation: A beginning was made to establish an EST data base for Indian water buffaloes. For establishing the mammary gland specific ESTs, approximately 191,060 bases of cDNAs were generated from 466 clones of buffalo mammary gland. Summary of BLASTN



Sequence chromatogram showing mitochondrial D-loop region of buffalo

homology analysis indicated majority of clones from the two libraries (88.6%) showing significant sequence similarity to the gene sequences already registered in the NCBI database and only 11.4% sequences with no significant hits from the database. From the cumulative BLASTN and BLASTX searches a total of 402 ESTs could be assigned to the known genes in the database. The BLASTN and BLASTX analysis of buffalo mammary EST revealed that 329 ESTs from lactating and 120 ESTs from non-lactating library represented 62 and 44 unique genes/sequences respectively. Most of the ESTs that showed no homology to any known gene sequences in the database were thus classified as ESTs representing new or uncharacterized genes.



Molecular markers for wildlife identification

Species specific molecular markers will help in identifying the species from remnants of body parts or tissues that have relevance in wild life forensic and food adulteration investigations. Mitochondrial 12 S rRNA was used as a marker for species identification and differentiation from related domestic species using PCR-RFLP approach. Cloning and characterization of mitochondrial 12S rRNA gene of chital, blackbuck, thamin deer and jackal were carried out towards this objective. The differentiation of various Indian deer species namely, chittal, hog deer, musk deer, barking deer, sika deer and sambhar was done using this marker. Likewise, nilgai could be differentiated from cattle using PCR-RFLP. Methods were also standardized for forensic identification of hides of tiger and leopard and meat samples of hog deer based on morphological, chemical and/or DNA analysis.

Polymorphism of mitochondrial DNA D-loop region of buffalo breeds: Clustal alignment of the D-loop segment of mitochondrial DNA among Indian buffalo breeds, viz. Murrah, Jaffarabadi, Nili Ravi, Surti, Toda, Bhadawari Chilika, Mehsana, Kerala, Tarai, Nagpuri, and Pandharpuri, indicated 16 polymorphic nucleotide sites, which delineate into 20 mtDNA haplotypes. The bulk of animals grouped into majority consensus *IND- Buff* haplotype with frequency of 0.622. Frequency for other haplotypes ranged from 0.007 to 0.078 (*IND-Buff1*). Phylogenetic tree based on the mtDNA polymorphism, grouped these 20 haplotypes in different clusters close to buffaloes but distinct from *Bos* species.

Goats

Jamunapari: Estimates of genetic variability measures, viz. effective number of alleles and gene diversities revealed substantial genetic variation in Jamunapari goat population in its breeding tract. Average polymorphism and expected gene diversity in the population were 1.066 ± 0.510 and 0.528 ± 0.237 , respectively. Population significantly differentiated into different groups, and showed fairly high level of inbreeding ($f = 0.189 \pm 0.049$) and global heterozygote deficit. Bottleneck analysis indicated the introduction of unique/rare alleles by immigrants. The study revealed that Jamunapari, an improver goat breed throughout South Asia and now at risk, needs appropriate genetic management for its immediate conservation and improvement.

Osmanabadi: Genetic variation at 21 FAO approved microsatellite loci, population structure, and genetic bottleneck hypothesis were examined for Osmanabadi goat population from Maharashtra state. The observed and expected homozygosities ranged from 0.2609 to 0.9302 and 0.1148 to 0.8961, respectively, whereas heterozygosities ranged from 0.1087 to 0.7391 and 0.0999 to 0.9004 respectively. The Nei's heterozygosity was minimum

(0.0986) at locus ILSTS029 and maximum (0.8906) at ILSTS033. The average number of alleles was 6.85 with maximum (16) allele at ILSTS 033 and minimum (2) at ILSTS 065.

Sangamneri: Genetic diversity measures evaluated at 17 loci in Sangamneri goat population indicated the range of observed and expected homozygosities from 0.3478 to 0.9787 and from 0.1414 to 0.9787, respectively, and that of heterozygosities from 0.0213 to 0.6522 and 0.0213 to 0.8586 respectively. The Nei's heterozygosity was minimum (0.0211) at locus OarJMP29 and maximum (0.8495) at OarFCB304. The average number of allele was 6.70 with maximum alleles (13) at ILSTS 058 and minimum (2) at OarJMP29.

Sirohi: The observed and effective number of alleles at 25 microsatellite loci varied from 5 to 25 and from 2.05 to 14.07. The average observed and expected heterozygosity across the studied loci was 0.50 and 0.79 respectively. The allelic richness, observed independent of sample size, across the loci varied from 4.30 to 19.52. The population analysis based on microsatellite markers revealed substantial genetic variation in the population, which may be exploited for further improvement of the breed through appropriate breeding strategies.

Genetic diversity of indigenous sheep populations: Variation in the ovine intermediate filament type 1 (IF6) and high sulphur wool protein, (B2C) gene loci was investigated in Garole, Chokla, Kheri, Sonadi, Marwari, Chhotanagpuri and Jalauni sheep. Polymorphism at the IF6 loci revealed a biallelic pattern after cleavage with Msp1, whereas, Bsr1 RFLP analysis of amplified product of B2C locus exhibited three polymorphic patterns, one with 350 bp and 225 bp (XX genotype); second with 309 bp and 225 bp (YY genotype) and third with 350 bp, 309 bp and 225 bp (XY genotype). The 41 bp and 23 bp fragments were not visible on electrophoresis.

Single nucleotide polymorphism (SNPs) in sheep and goats: In 58 samples of Karnah sheep breed 9 distinct genotypes at GH-4 gene, viz. AA, AB, AC, AD, BB, BC, BD, CC and CD were identified with genotypic frequency of 0.447, 0.153, 0.121, 0.035, 0.121, 0.052, 0.035, 0.018 and 0.018 respectively. The alleles A, B, C and D showed frequency of 0.625, 0.222, 0.111 and 0.042 respectively. Alleles causing mutation in coding region of GH-4 were later named according to change in amino acid as per international norms; 135 M and 135 L alleles were observed and 135 L was more frequent. For GH-5 SSCP haplotypes A, B, C, D, E, F, G and H were found with 34, 20, 2, 6, 26, 4, 4 and 4% respectively.

In Black Bengal goats, GH-4 exon showed A, B, C, D, E and F haplotypes with 2.17, 10.87, 15.22, 6.50, 45.55 and 23.90%, respectively, whereas GH-5 exon showed A, B, C, D and E variants with 14.65, 77.00, 2.09, 2.09 and 4.17% respectively. Growth hormone, growth hormone receptor gene and beta lactoglobulin



gene were screened in Jamunapari and Jhakrana goats using PCR SSCP, and variants were sequenced. New DNA sequence variants were analyzed using DNASTar, and 65 NCBI accessions were obtained. Complete growth hormone gene was studied in Sangamneri goats. The sequences of 13-364, 345-693, 1011-1344, 1648-2012, 1993-2344 and 2325-2506 nucleotides were generated, and 6, 7, 9, 11, 6 and 5 SSCP variants were identified, respectively.

Milk protein diversity in Indian goats: Milk protein polymorphism was investigated in Ganjam, Marwari, Jamunapari, Jakhrana and Sirohi goats. In the studied population 13 different alleles were observed. The average number of alleles was lowest in Ganjam goats and highest in Sirohi goats. The effective number of alleles was observed in the range of 1.26 to 1.56, over all the breeds. The percentage of polymorphic loci varied from 50 to 100% over different genetic groups. The Shannon's weaver index over each locus showed highest diversity values for α_s1 and lowest for β -LG locus (0.01).

The highest genetic distance was observed between Ganjam and Marwari goats. Ganjam goats exhibited highest distance among all the breeds except local goats of Madhya Pradesh and Uttar Pradesh. The least genetic distance for milk protein gene was observed between Barbari-Jamunapari (0.994) and Jamunapari-Jakhrana (0.994). Four major clusters were observed in genetic tree indicating Marwari in one group, local MP in second cluster, Ganjam and local UP in third cluster, and Barbari, Beetal, Jakhrana, Sirohi, Jamunapari in fourth cluster. Jakhrana and Beetal were more similar in milk protein gene evolution than other goats. Jamunapari was more similar in milk protein evolution with Sirohi.

Horse

Zanskari: In Zanskari breed of Indian horse 145 alleles were observed across all the 25 loci evaluated with a mean of 5.8 ± 1.32 . The mean effective number of alleles were 4.95 ± 1.18 indicating high level of genetic variability within breed. This was also reflected in mean observed and expected heterozygosity of 0.61 ± 0.06 and 0.78 ± 0.05 , respectively. The polymorphism information content (PIC) varied from 0.65 for NVHEQ54 to 0.86 for HMS7 showing the suitability of these markers for studying within breed diversity. The within-population inbreeding estimates (F_{is}) indicated moderate levels of inbreeding. The analysis of these data revealed absence of any significant heterozygotic excess both in infinite allele model (IAM) and sequential allele model (SMM), demonstrating that the Zanskari horses have not faced any recent genetic bottleneck.

Marwari: Seminal plasma contains many proteins which may be used as a diagnostic tool/marker to select stallions of high breeding value. The heparin and gelatin binding proteins were isolated from the Marwari stallion seminal plasma. Five heparin binding proteins (17–83 kDa) and four gelatin binding proteins (18–83 kDa) were identified. The effect of these proteins in fertilizing potential is being evaluated.

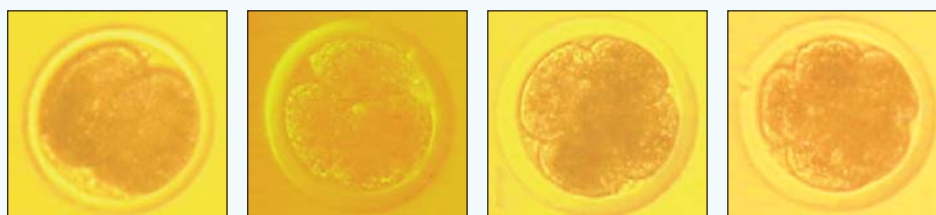
Yak

Studies were conducted to investigate the polymorphisms in the candidate genes, viz. growth hormone (GH) gene, growth hormone receptor gene and insulin like growth factor-I (IGF-I) gene. The polymorphism in IGF-1 is associated with birth weight. The

Production of cloned buffalo embryos through nuclear transfer (NT) of somatic cells

For the development of competent donor somatic cells, 8 cell lines BBM 16, BBM 31, BBM 32 and BBM 79 from male buffalo donors and BBF 22, BBF 33, BBF 37 and BBF 82 were cultured for 24 consecutive passages. The cell lines showed stable karyotype up to 12th passage in > 92% cells but subsequently, the 50 XX/XY normal chromosomal complement was reduced with the increase in passage number. At 24th passage, the percentage of normal cells ranged from 69.5 to 82.5% in different cell lines. The major chromosomal aberrations were

polyploidy and aneuploidy types. The cell lines showed decrease in average mitotic index of 17.85% in early passage cells to 12.3% in cells at 24th passage. The size of donor cell was also studied. The cells of 12–15 microns produced better cleavage rates in SCNT oocyte cell complexes. The oocytes showing uniform cytoplasm and organized polar body in the perivitelline space, showed better rates of enucleation and cleavage after activation of cell + oocyte complex. The NT derived 2-cell, 4-cell, 8-cell, 16-cell and 32-cell morula stage were obtained.



The NT derived morula at different cell stages



random amplified polymorphic DNA (RAPD) assay using 10 random decamer oligonucleotide primers indicated that all phenotypically different types of Indian yaks are genetically similar.

Poultry

The Dahlem Red and White Leghorns were genetically characterized using different molecular tools. On PCR-RAPD analysis, the halfsib and non-inbred groups showed higher genetic distance (0.76). The intra population genetic similarity was higher in the inbred groups. The genetic similarity between IWH and IWI lines of White Leghorn was highest (0.8) and between IWH and IWK the lowest (0.71). Line-specific RAPD markers were identified. The cluster analysis of these four populations indicated that IWH and IWI were genetically closer to each other, while, IWK was genetically distant from the other three populations.

Genetic diversity in indigenous poultry: Attempt was made to define all the 15 defined chicken breeds of India using microsatellite markers. The data generated was utilised to establish population parameters and genetic relationship among them. All the loci selected exhibited high polymorphic information content and gene diversity. All the breeds/populations also revealed high degree of gene diversity.

Disease resistance: HSRBC (771) and LSRBC (373) chicks of IWG divergent lines after third generation of selection based on humoral immune response to sheep red blood cells (SRBC) were evaluated for layer traits, viz. BW20, BW40, EW28, EW40 and EP40. The LS means of these traits in the HSRBC lines were 136.93 ± 0.96 day, 1340.96 ± 26.54 g, 1404.47 ± 30.76 g, 45.52 ± 0.29 g, 46.80 ± 0.51 g and 88.45 ± 1.66 , respectively. The corresponding values in the LSRBC line were 138.51 ± 1.77 day, 1407.66 ± 16 g, 1507.61 ± 19.09 g, 47.33 ± 0.59 g, 47.88 ± 0.83 g and 91.46 ± 1.90 . LSRBC line demonstrated higher BW20, BW40 and EW28.

In broiler, in F_3 generation, the overall mean for SRBC response (\log_2 of titre) in high and low responding lines were 9.100 ± 0.197 and 5.551 ± 0.203 . Corresponding CMI (% thickness) were 88.259 ± 4.610 and 37.205 ± 4.628 . Serum lysozyme (ig/ml) and IgG (mg/ml) levels were 7.59 ± 0.01 and 3.91 ± 0.084 in HIC line and, 6.23 ± 0.076 and 2.54 ± 0.071 , in LIC line. The candidate genes, viz. BL-bII, IFN-g and IL-2 promoters were analyzed by PCR-RFLP that exhibited gene and genotype frequency differences between immunodivergent lines.

Functional genomic studies of livestock

Gene analysis of milk performance traits in *Bos indicus* breeds: DNA samples of unrelated animals from 11 indigenous cattle breeds, viz. Sahiwal, Hariana, Tharparkar, Rathi, Nagori, Mewati, Kankrej, Red Kandhari, Deoni, Dangi, Gaolao, were evaluated by genotyping at two of the candidate loci, viz growth

hormone (b-GH) and kappa casein (κ -cas) affecting milk production/composition traits. Analysis revealed that AA genotype and A allele were most commonly distributed in Indian indigenous cattle populations, followed by AB genotype and B allele. No animal with homozygous BB genotype was observed in any of the studied population.

Genes involved in the immune response regulation: Nitric oxide synthetases are actively involved in the inflammatory process during the ensuing of the immune response against an infection. The promoter region of the NOS2 gene in *Bos indicus* breeds and the Holstein Friesian cattle was amplified and sequenced. An SNP was observed at nucleotide position 5,271 in the promoter region of the NOS2 gene in the *Bos indicus* cattle. The nucleotide sequence of the promoter region of the Sahiwal, Tharparkar, Hariana and Rathi cattle, showed the presence of both C and A at position 5,271 in certain animals in variance to *Bos taurus*, which had only C at this position.

Conservation of animal genetic resources

In-situ conservation

Beetal goat: Villages (55) from Beetal breeding tract in Gurdaspur district were identified. The herd size of adult goats ranged from 6 to 32 with the goat breeders and the entire feeding system is based on intensive grazing system. Elite goats (176) with goat breeders were identified and ear marked with brass tags. Their registration was made in record. All the selected goat breeders were given the part maintenance cost for elite goats.

Ex situ conservation

Krishna Valley cattle: About 170 Krishna Valley animals including breeding bulls, bullocks, lactating cows, calves of different ages and heifers were identified from Belgaum, Bagalkot and Bijapur districts and tested for diseases like brucellosis,

Krishna Valley bull





tuberculosis, John's diseases etc. In view of the endangered status of the breed only seven bull calves were brought to the Central Research Station (CRS), Uruli Kanchan, and are being monitored regularly.

Jaffarabadi buffalo: Jaffarabadi buffaloes are found mainly distributed in Junagadh, Amreli, Bhavnagar and Rajkot districts of Saurashtra region. Bull calves were kept for rearing at Nanodra



Jaffarabadi buffalo

farm in Gujarat State and subsequently brought to the Central Research Station, Uruli Kanchan.

Poultry: Multiplication of purebred Aseel (Peela), Kadakanath, Naked Neck, Frizzle fowl and CARI Red was continued and all these breeds were fully utilized for the production of commercial crosses of scavenging chicken, viz. CARI Nirbheek, CARI Shyama, Upcari and Hitcari. Aseel revealed much higher immunoresponsiveness to SRBC. Body weight of females at 20 and 40 week, age at sexual maturity, 40 week egg number and egg weight for Naked Neck line were 1,098 g, 1,485 g, 141.37 days, 97.69 eggs and 56.57 g, respectively, and the corresponding values for Frizzle line were 928 g, 1,350 g, 144.8 days, 89.19 eggs and 54.75 g. The attempts were initiated to develop the molecular standards for trueness of Red Jungle fowl. The eggs of Red Jungle fowl were collected from outside the protected areas of forest range in district Pilibhit (Uttar Pradesh) and hatched under captivity.

Adult Red Jungle fowl male and female (inset : eggs)



Genetic manipulation through introgression of major gene, transgenesis and reconstitution of poultry:

Two Naked Neck pure broiler populations having Naked Neck gene (NNWP and NNCP) have undergone specialized selection programmes over 11 generations and showed consistently relative superiority of Naked Neck birds over normal for economic broiler traits. The realised response for primary trait (5-week body weight) was statistically significant in both lines. The heritability estimates within generation for 5-week body weight ranged from moderate to high in both the lines.

Indirect selection for general immunocompetence using high HI titre method was initiated in two Naked Neck populations along with direct selection for high 5-week body weight. The dynamics of antibody response and the estimation of genetic and phenotypic response to ND vaccine were evaluated after 5-week post vaccination. The average HI titres in male and female progeny of NNCP were 4.09 ± 0.07 and 4.03 ± 0.06 . Among genotypes, homozygote birds showed highest 5 week body weight as 973 g followed by heterozygote (966 g) and normal birds (877 g). The HI titre was 4.04, 4.05 and 4.11 in homozygote, heterozygote and normal birds, respectively. Total birds were further classified as low, medium and high responders on the basis of HI titre. The respective mean values estimated in these classes were 1.11 (low), 4.62 (medium) and 6.47 (high). More or less similar results were obtained in NNWP population.

Molecular reproduction studies on bovines

- Use of simple media like mCR2aa and mSOFaa for *in vitro* culture of buffalo zygotes resulted in higher yields of day-8 morulae and blastocysts or day-9 blastocysts, even without serum supplementation and co-culture with somatic cells.
- Culture of inner cell mass cells on a homologous fetal fibroblast feeder layer was found to be a better choice than their culture on gelatin coated dishes for production of embryonic stem cells in buffaloes.
- Partial gene sequence (196 nucleotides) of buffalo ovary IGF I exhibited homology with cattle (99%), sheep (98%), goat (97%), pig (93%) and human (93%). Partial IGF II gene sequence (154 nucleotides) showed homology with cattle (100%), sheep (100%), pig (92%) and human (88%).
- Angiotensin II capacitated buffalo spermatozoa at nM concentration through AT 1 receptors on the sperm surface.
- Oviductin genes from oviductal tissues of buffalo and goat were cloned and sequenced.
- Lysozyme gene from abomassum and mammary gland tissue of buffalo was cloned and sequenced.
- Human lactoferrin cDNA from mammary gland tissue was cloned and sequenced.



ANIMAL BREEDING

Cattle

Frieswal: The synthetic breed development programme through crossbreeding continued during the current year also. The total population of Frieswal females at 43 Military Farms (MF) was 19,045 including 10,388 adult cows, 6,739 young stock and 1,918 calves. Presently, PDC has 305 doses of pure HF semen and 408,179 doses of Frieswal semen in the gene bank. The overall mean of age (AFC) and weight (WFC) at first calving in Frieswal cows was 978.8 days and 374.7 kg, respectively. The effects of farm and season and year of birth were significant on AFC and WFC. The overall least squares mean of 300 days milk yield (MY 300), total milk yield (TMY), peak yield (PY) and lactation length (LL) was 3,248.3 kg, 3,303.7 kg, 14.89 kg and 323.6 days. Estimates of heritability for all reproduction and production traits were low (0.003 ± 0.01 to 0.10 ± 0.01).

Indigenous Breed Project

Hariana: The overall conception rate in the herd was 53%. Average age at first calving, first lactation milk yield and peak yield were 1,538 days, 833 kg and 5.47 kg, respectively. First dry period, service period, lactation length and calving interval averaged 201, 147, 205 and 453 days, respectively. Young bulls were put to training for draught and took an average of 37.22 ± 2.1 days to be ready for draught purposes. The mean fatigue score for empty cart ranged between 2.16 to 2.33 after 2 h work and 2.44 to 2.66 after 3 h work. In a cart with 8 q load, the corresponding values were 3.05 to 3.55 and 3.72 to 4.22, respectively. Average carting ability (as per C K Thomas method) was 13.11.

Ongole: The female herd strength was 1,330. The breeding population contained 834 females and 9 breeding bulls. Forty-one bulls have so far been used under test mating in 5 sets. So far 2,179 daughters have been produced through 5 sets. The semen doses available on closing date at GP Unit were 134,189.

The per cent cows in milk, wet average per day per cow and herd average per day were 36.61%, 3,308 kg and 1.16 kg, respectively. The age at first calving averaged 53.53 months. The average lactation milk yield and peak yield was 439.9 and 3.01 kg. The overall average of service period and lactation length was 203.6 and 157.3 days, respectively. The dry period and calving interval averaged 350.9 and 515.1 days.

Draught studies were undertaken on animals by using single harness plough with digital dynamometer. Rectal temperature, respiration rate/min and pulse rate/min before work varied from 99.6° to 101.7°F , 18 to 28 and 40 to 52, and after work ranged from 100.6° to 103.2°F , 32 to 58 and 52 to 64, respectively. The results revealed that draught power varied from 0.70 to 0.92 HP among the bulls.

- Lactation length of 324 days was observed in Frieswal cows
- Elite herds of selected buffalo breeds were established under Network Project on Young Bull Production
- Barbari goats showed very high reproduction efficiency
- Survey on pig husbandry status was completed in eight states of North East
- Fertility, hatchability and survivability till lay improved over the preceding generation in IWH and IWI lines of poultry birds
- CARI Sonali secured second position in RSLT at Gurgaon
- Improvement of shank length was given emphasis in selection of Vanaraja male line
- Vanaraja female line was improved for egg production

Field progeny testing

At Ludhiana, 128 bulls have so far been used in six different batches. Overall conception rate was 41.4% on total inseminations basis and 46.2% on total AI's follow up basis since inception of the project. First lactation records were completed by 761 daughters from first four sets of bulls. The milk yield showed increasing trend among the progenies of different sets. The frozen semen of 20 bulls from sixth set and 25 crossbred bulls of seventh set was used for performing 4,430 artificial inseminations. The conception rate was 39% and during this year 1,736 pregnancies were confirmed. Female progenies from fourth batch completed their first lactation record. Their average milk yield was 2,285 kg and average age at first calving 1,200 days.

At BAIF, Pune, 104 bulls have so far been used in five batches since inception of the project. The overall conception rate was 41.2% on total inseminations basis. First lactation was completed by 1,525 daughters from first three sets of bulls. The average 305 days milk yield was observed to be 2,930.34, 2,821.75 and 3,050.94 kg, respectively, for three sets. The age at first calving indicated trend in desired direction as it decreased from 976.5 days for the progeny born from the bulls used in first set to 963 days for the progenies of fourth set. Fifth batch of bulls was used for genetic evaluation 2,461 inseminations were carried; and 733 pregnancies were confirmed. The cumulative conception rate of this batch was 44.6% (range 31.2 to 56.5%).

Buffalo

Buffalo improvement programme: Four genetically superior breeding buffalo bulls and 372 frozen semen doses from progeny tested bulls were disseminated to various buffalo breeding agencies involving village Panchayats, individual breeders and State Animal Husbandry Departments at Hisar.

Network project on buffalo improvement: Genetically



superior Murrah breeding bulls (129) were selected from various centers of the Project for Murrah Breed, and their semen was frozen for progeny testing programme. At present 488,555 doses of frozen semen from genetically superior bulls are in stock. Elite herds of Nili-Ravi, Surti, Jaffarabadi, Bhadawari, Pandharpuri, Godavari and Swamp buffaloes were established at the respective centres of Network Project for Young Bull Production.

Sheep

Meat purpose: Avikalin, Malpura, Garole × Malpura, Chokla, Bharat Merino, Marwari, Magra and Gaddi breeds of sheep were selected for improvement. Among these the Bharat Merino, Avikalin and Garole × Malpura have been developed at the Institute whereas the other indigenous breeds are being improved through selection. The survivability and culling in Avikalin flock was 92.70 and 4.91%, respectively. Topping per cent of the flock was 93.43%. Body weight indices for Avikalin and its crosses at birth, 3, 6, 9 and 12 months of age were 2.89, 14.15, 19.45, 20.61 and 24.30 kg, respectively. The corresponding indices for the pure Avikalin were 2.84, 13.61, 19.61, 21.00 and 24.76 kg, respectively.

Purebred stock of Malpura, the local mutton breed and, Garole, highly prolific breed are being maintained and crossed to enhance reproductive efficiency of the former. The targeted 6-month body weight in Malpura sheep was achieved. Least-squares means (LSM) of body weights at birth, 3, 6, 9 and 12 months were 3.17, 14.87, 21.55, 22.28 and 26.52 kg in Malpura; 1.86, 9.62, 13.40, 16.24 and 17.49 kg in Garole × Malpura (GM): 3.05, 13.70, 18.65, 21.69 and 24.583 kg in GM × Malpura; 2.24, 11.10, 15.87, 18.68, 22.04 kg Malpura × GM, respectively. Increase in body weight of (GM) M lambs was 64, 42, 39 and 40% at birth, weaning and 6-month of age, respectively.

Goat

Barbari: Genetic improvement of the Barbari goat is being carried out through selective breeding in the nucleus flock. Use of bucks selected on the basis of index value combining 9 month body weight and 90 day's milk yield of the dam indicated the improvement in both milk yield and body weight. The annual population growth in Barbari goat was 142%. The overall least squares means for body weight at birth, 3, 6, 9 and 12 months of age were $1.89 \pm .01$, 7.95 ± 0.06 , 12.51 ± 0.11 , 18.10 ± 0.13 and 22.02 ± 0.17 kg respectively.

The overall mean for lactation milk yield, milk yield 90 days, milk yield 140 days and average daily milk yield were 78.5 ± 2.4 , 69.0 ± 1.9 , 110.2 ± 4.4 and 0.673 ± 0.17 liter, respectively. Lactation length averaged 116.4 ± 1.4 days. The Barbari goat has very high reproduction efficiency. During the year the kidding rate was 1.62. The breeding efficiency on the basis of does available



Superior Barbari buck for breed improvement

and on the basis of does tugged were 139 and 80.5% respectively. There had been improvement in overall reproduction rates of the breed over years.

Jamunapari: Genetic improvement of the Jamunapari goat is being carried out through selective breeding in the nucleus flock. Use of bucks selected on the basis of index value combining 12 month body weight and 90 day's milk yield of dam indicated improvement in both milk yield and body weight. Mean body weights of kids at birth, 3, 6, 9 and 12 months of age were 3.29 ± 0.03 , 11.51 ± 0.11 , 15.08 ± 0.18 , 21.81 ± 0.34 and 25.01 ± 0.39 kg, respectively, during the year. Average milk yield (kg) in 90 days, 140 days and total lactation yield were 92.32 ± 0.85 , 129.96 ± 1.30 and 156.78 ± 2.94 , respectively. Significantly longer lactation length was recorded in does which kidded during autumn. Multiple births were 37.5% and kidding rate on the basis

Superior Jamunapari buck for breed improvement





of does available was 86.7% respectively. The ranking of sires on the basis of sire indices was computed by combining 9 months body weight and 90 days milk yield of their dams. Ten top ranking bucks were selected and allocated for breeding. More than 230 goats (128 males and 102 females) were supplied to farmers, SAUs, NGOs and other research institutions for improvement and conservation of Jamunapari goats under field conditions.

Rabbit

Meat and fur production: In broiler rabbits, the 12-week weights were 1.57, 1.45, 1.39, 1.47, 1.39 and 1.50 kg in New Zealand White (NZW), White Giant (WG), Gray Giant (GG), Soviet Chinchila (SC), Dutch and Black Brown (BB) breeds respectively. Litter size at birth were 4.75, 6.00, 6.76, 5.50, 3.00 and 3.33, respectively, in NZW, WG, GG, SC Dutch and BB breed.

Angora hair production: German Angora rabbits (breeding flock) had average pooled wool yield in first, second, third, fourth and fifth clips, respectively, 212.36, 189.83, 184.30, 184.49 and 185.74 g. The pooled wool yields of British Angora (BA), Russian Angora (RA) and A-1 crosses were 144.85, 147.47 and 135.52 in first clip, 129.42, 136.08 and 117.45 in second clip, 127.30, 136.18 and 129.75 in third clip and 128.0, 136.66 and 114 in fourth clip, respectively. The overall equivalent average death rate (EADR) in Angora rabbits was 0.43/1,000 rabbit days at risk.

Pig

Survey on status of pig husbandry practices regarding housing, nutrition, health coverage and product utilization by farmers in all the eight states of North East was completed. Data on haemato-biochemical parameters of pigs in respect of variation in altitude were also recorded.

AICRP on Pigs: Genetic stability in terms of litter size at birth through *inter se* mating in 50% Hampshire (11th generation) and 75% Hampshire (10th generation) at Khanapara, Assam was recorded as 6.67 and 6.91 respectively, in the first crop and 8.69 and 8.1, respectively, in second crop i.e. from the tried sows. With LWY after *inter se* mating in 50 and 75% crossbred, the litter size at birth was recorded, respectively, as 8.75 and 7.45, at Jabalpur; 6.87 and 7.06 at Tirupati; 5.70 and 7.19 at Kattupakakam; and 5.1 and 5.2 at Mannuthy. Due to inbreeding depression, litter size at birth at IVRI, Izatnagar, was recorded as 5 in Landrace breed of pigs. Litter size at birth at Ranchi and Goa was recorded as 5.28 and 8.25, respectively, in indigenous pigs.

Poultry

Poultry for egg

High producing commercial layer: Six strains of White Leghorn were improved under the AICRP on Poultry Breeding using selective breeding through intra-population selection for egg



Laying birds were improved for production

production up to 64 weeks of age superimposed with independent culling level for egg weight at 28 weeks of age and layer house viability. The genetic response was positive and significant in both the strains for egg production and egg weight. The age at sexual maturity decreased in IWN and remained unchanged in IWP strain.

The S-27 generation of IWH and IWI lines was evaluated at the CARI, Izatnagar. The egg production up to 64 weeks of age increased over the last generation. The genetic response to selection for 64-week egg production/generation was positive and significant in both IWH (1.105 eggs/generation) and IWI (1.06 eggs/generation) in the last two generations. Subsequently, the S-28 generation of these populations was regenerated. The fertility, hatchability and survivability till lay of both the lines increased over the preceding generation. The strain cross HI showed marked improvement in 64-week egg production.

At the PD on Poultry, Hyderabad, White Leghorn pureline populations, viz. IWH, IWI and IWK were improved for egg production and egg mass up to 64 weeks. In the S-5 generation, the egg production and egg weight at 72 weeks were 238 and 56.6 g in IWH, 244 and 57.8 g in IWI, 222 and 60.8 g in IWK, respectively. The egg mass up to 64 weeks was 10.56 kg in IWK. The egg production increased over the previous generation by 5.2 and 3.9 eggs in IWH and IWI, respectively. Six strain crosses of a diallele cross were evaluated. The egg production up to 40 weeks was higher in the crosses, IWH × IWK (103 eggs), IWI × IWK (105.5 eggs) and IWH × IWI (104.9 eggs) than others. Egg weight and body weight did not differ significantly.

The main White Leghorn strains i.e. WLH and IWI completed S₂₇ generation of selection. The reproductive performance showed an increasing trend with fertility (%) ranging from 91.36 to 92.41% in the pure strains and 93.36% in HI strain cross (S₂₈); the hatchability (%) on fertile eggs transferred basis ranged from 73.02 to 83.41% (S₂₈). An overview of the comparative performance for various economically important traits also reflected an



Random Sample Poultry Performance Test (RSPPT)

The broiler crosses from four AICRP centres on Poultry Breeding participated in the 24th and 25th Random Sample Poultry Performance Tests (RSPPT), held at Gurgaon. The body weight of different commercial crosses of AICRP strains at 6 and 7 weeks varied from 1,262 to 1,436 g and 1,692 to 1,924 g, respectively. The feed conversion ratio (FCR) up to 6 weeks was around 2.0. The cross Krishibro ranked third in overall performance among all the entries in the 24th RSPPT.

improvement over preceding generation ($S_{27} > S_{26}$). The main trait under selection (64 week EP) improved to the tune of 25 to 37 eggs in the pure strain and 42 eggs in HI strain cross ($191.48 < 216.43$ in IWH; $172 < 209$ in IWI; $184 < 225$ in HI). The average genetic responses per generation for 64th week of egg production were significant (1.11 and 1.36 eggs in IWH and IWI strain, respectively).

In HR (crossbred) the average egg production up to 64 weeks of age was 213.67 eggs with 51.77 g of egg weight. The corresponding figures for CD cross were 167.21 eggs and 55.30 g. The body weight and egg weight at 64 weeks of age in HI (strain cross) were 1,437 g and 52 g respectively. The egg production up to 64-weeks of age on HH and HD basis were observed as 221 and 225.25 eggs respectively.

The mean performance of RIR (S_{24}) for 40-week egg production was 101.63 eggs with 52.20 g of egg weight and 5,296.31 g of egg mass. The CARI Sonali (brown egg commercial layer), secured second position in RSLT at Gurgaon.

Poultry for meat

Under the AICRP on Poultry Breeding, six broiler pure lines were improved, with mass selection for 5-week body weight giving due weightage for conformation traits in the male line, and 5-week body weight, egg production and hatchability in the female

Colour broiler male line



lines with the ultimate objective of developing colour broiler crosses for commercial farming. The females matured at 180 days of age and laid 71.0 eggs till 40 weeks. Body weight at 5 weeks of age was 920 g and FCR was 1.93. The S-30 generation of PB-2 population was also evaluated. The fertility and hatchability on total eggs set were 94.2 and 88.8%, respectively. In comparison to the previous generation, body weight at 5 weeks (872 g) improved by 48 g and egg production (121 eggs) was higher by 4 eggs up to 52 weeks in the line. The S-10 generation of SDL population was evaluated at Bhubaneswar. The intensity of selection was 1.09 σ for males and 1.01 σ for females. The fifth week body weight of this population in the current generation was 1,123 g. The feed conversion ratio up to 5 weeks was 1.92. The SDL population matured 2 days earlier than the previous generation.

In the current generation, intensity of selection was 1.59 σ in CSML (Colour synthetic male line) and 1.53 σ in CSFL (colour synthetic female lines). The fertility was 82.2 and 79.8% in CSML and CSFL, respectively. The fifth week body weight of CSML and CSFL in the current generation was 1,069 and 1,056 g, respectively. The phenotypic response per generation for 5-week body weight was 30.2 and 34 g, and the corresponding genetic response was 20.4 g and 24.2 g, respectively, in CSML and CSFL in the last five generations. The females of CSFL line matured 10 days early and produced two eggs more over previous generation. At the JNKVV, Jabalpur, development of purebred dwarf dam line (white and colour lines) (G-7 generation) was undertaken. Body weight at 6 weeks, egg production and hatchability were considered for improvement. The intensity of selection was 1.09 σ . The per cent fertility was 89-90%. Hatchability on total eggs set increased and body weight at 6 weeks of age (679 and 856 g in colour and white lines, respectively) improved by 74 g over previous generation.

Synthetic colour broiler breeder populations (PB-1 and PB-2) were improved for traits of economic importance in broiler production. The cross of the two lines, a multi-colour commercial broiler, named as Krishibro, has become popular for intensive farming on low input requirement in areas having special market demand for colour broilers. The selection differential for 5 week body weight was 113 and 117.4 g in male and female lines, while the intensity of selection was 1.30 and 1.41 σ , respectively. The fertility and hatchability on fertile eggs set were 73.1 and 87.4%, respectively, in male line, while the corresponding data for the female line were 71.5% for both the traits. The control population maintained simultaneously was stable for the important traits.

Tropical broiler production: The naked neck and dwarf gene populations, developed on broiler background, were maintained at the PD on Poultry, for use as resource populations for use in tropical broiler breeding programmes. Both the lines were evaluated for juvenile and early production traits in S-4 generation.



Economic gain in tribal areas

Backyard poultry is popular with the tribal community, but they never bother for the loss or gain from such poultry farming. The economic aspect of backyard poultry farming were assessed at their doorstep and following data were recorded:

- The sale of the eggs is restricted even though the price is higher as compared to the commercial eggs available in the market as these eggs are utilized for multiplication.
- The cock and pullet are sold @ Rs 75 to Rs 120/kg live weight, when they need money to purchase their daily ration and to meet their emergency.
- The average income from single hen accounts about Rs 600/year.



In naked neck gene line, fertility was 84.2% and hatchability on total and fertile eggs set was 67.1 and 79.7%, respectively. The body weight at 6 weeks was 877.6 g. The production traits like age at sexual maturity (ASM), body weight at 20 and 40 weeks, egg weight at 40 weeks and egg production up to 40 weeks were 175.8 days, 2,349 g, 3,158 g, 61.5 g and 62.6 eggs, respectively. In dwarf gene line, fertility was 76.6% and hatchability on total eggs set was 69.7%. The body weight at 6 weeks was 607.3 g. The ASM, body weight at 20 and 40 weeks, egg weight at 40 weeks and egg production up to 40 weeks in dwarf line were 151.5 days, 2,104 g, 2,563 g, 56.6 g and 59.3 eggs, respectively.

Among synthetic broiler male lines, fertility percentage was 89.20, 88.11 and 74.13 in CSML, SML and control lines respectively. Percentages of hatchability were 86.75, 86.51 and 84.70, respectively, in CSML, SML and control lines. The overall average of body weight at 3 and 5 weeks in corresponding lines were 580.18 \pm 0.97 and 1,068.77 \pm 2.78 g, 521.31 \pm 3.45 and 1,060.34 \pm 6.58 g and 387.54 \pm 2.94 and 751.57 \pm 5.25 g, respectively. The overall average of body weight at 3 and 5 weeks in CSFL were 553.10 \pm 1.54 and 1,056.28 \pm 2.96 g, respectively. The average egg production up to 40 week were 61.2 eggs in CSFL and 62.8 eggs per bird in SDL. Fertility percentage in IC3, IR3 and CARIBRO Tropicana were 77.70, 89.54 and 84.69, respectively.

Development of germplasm for rural poultry farming

Specialized male and female lines with colour plumage were developed for production of varieties, Vanaraja (dual purpose) and Gramapriya (egg type) for rural poultry farming. In Vanaraja male line, emphasis was given for improvement of shank length, while no intentional selection was practiced for juvenile body weight. In S-7 generation, the body weight, shank length and SRBC titre of this line at 6 weeks of age were 595 g, 71.3 mm and 6.7 log₂, respectively. The production traits like ASM, body weight at 20 and 40 weeks of age, egg weight at 40 weeks and egg production up to 40 weeks were 178.4 days, 1,881 g, 2,789 g, 56.1 g and 42.2 eggs, respectively.

The Vanaraja female line was improved for egg production. In S-5 generation, ASM, body weight at 20 and 40 weeks of age, egg weight at 40 weeks and egg production up to 40 weeks were 170.1 days, 2,141 g, 2,512 g, 53.8 g and 63.4 eggs, respectively. In S-6 generation, body weight, shank length and



Vanaraja male line



Dwarf Gene and Naked Neck lines were used for tropical broiler production



Vanaraja female line



Dahlem Red line

SRBC titre at 6 weeks were 723 g, 76.2 mm and 6.5 log₂ units, respectively.

Dahlem Red population was developed as a female line for production of Gramapriya, for backyard poultry production. The age at sexual maturity, egg weight, egg production and egg mass to 40 weeks were 175 days, 56.2 g, 75.1 eggs and 4.45 kg, respectively.

New promising crosses for rural poultry production: The performance of two new crosses, C1 and C2 was evaluated along with Vanaraja and Gramapriya under intensive system. Both the crosses excelled over Vanaraja on all the growth and production parameters up to 40 weeks of age. The C1 cross excelled over Gramapriya and Vanaraja both in body weight and egg production. Moreover, the C1 cross recorded optimum juvenile body weight (about 600 g at 6 weeks), shank length (71.14 mm), better egg weight and production, which are suitable for backyard dual purpose variety. However, C2 cross was superior in body weight at 6 weeks of age and age at sexual maturity.

Duck

Native ducks: The morphological and production traits of ducks were recorded. The body weights of native ducks were 150–200 g less compared to Khaki Campbell. The mature body weights

White quail

A recessive auto sexing white-feathered quail line was developed. The broiler quail line CARI Uttam achieved fifth week body weight of 196.67 ± 2.84 and 204.88 ± 2.89 g, for males and females, respectively. The layer quail line CARI Pearl recorded fifth week body weight of 121.34 ± 2.41 and 128.17 ± 2.86 g for males and females, respectively. The base populations of CARI-Brown have been established. The fifth week body weight in this line in male was 170.18 ± 2.86 g while the corresponding value from female was 186.28 ± 2.89 g.

of male and females are 1,400–1,500 and 1,200–1,300 g. The recorded egg weight was 65–75 g. They usually lay 200–220 eggs/year in intensive and free-range system of management.

Evaluation of native, exotic ducks and their crossbred:

The hatchability percentage on total egg set basis in Khaki Campbell, *desi*, White Pekin, KD and DK were 66.01, 52.22, 65.31, 48.20 and 48.02%, respectively.

Body weight of White Pekin replacement ducklings at seventh and eighth week of age in male and female were $2,010 \pm 20.17$, $2,107 \pm 21.33$ g and $1,996 \pm 19.76$, $2,019 \pm 18.3$ g, respectively. Mortality per cent in combined sex from 0–8 week of age was 4.62%. Body weights of female at 16 and 20 weeks of age were $3,038 \pm 26.45$ and $3,114 \pm 25.95$ g, respectively. The HD egg production per bird up to 36th week of age was 41.06 eggs. The egg weight at 36th week of age was 75.81 ± 0.58 g. The HD egg production up to 72 week of age in the old stock of White Pekin was 172.06 eggs. The HD egg production per bird in Khaki Campbell up to 72 weeks of age was 239 eggs.

Comparative evaluation of Khaki Campbell (K), *desi* (D), KD and DK crossbred: Statistically significant differences were observed between different genetic groups for body weight at different ages. The 16th week body weight in K, D, KD and DK were $1,373 \pm 7.94$, $1,450 \pm 8.70$, $1,292 \pm 14.55$ and $1,288 \pm 15.27$ g, respectively. The best FCR up to sixth week of age was obtained in K (2.923) followed by KD (3.315), DK (3.350) and D (3.664). The hen day egg



Moti (Malkangiri) ducks



The fawn type runners



Ducklings



production up to 36th week of age was highest in DK (64.35 eggs) followed by KD (52.95 eggs), D (50.90 eggs) and K (49.52 eggs). Eggs weight at 36th week in K, D, KD and DK were 63.97 ± 0.14 , 67.38 ± 0.43 , 68.76 ± 0.59 and 68.24 ± 0.45 g, respectively.

ANIMAL HEALTH

Foot and mouth disease

During the year 2,852 FMD field outbreaks were recorded in the country and 2,257 samples were analyzed for serotyping by sandwich ELISA. Type identification could be made in 653 samples comprising 532 type O, 63 type A and 58 type Asia1. No virus could be detected in about 51% of the samples. Like the previous years outbreak due to type O predominated, and outbreaks due to type O, A and Asia1 virus were recorded in 19, 8 and 8 states, respectively.

Large majority of field isolates of types O and all the isolates of Asia 1 are antigenically related to the vaccine strains currently in use, indicating that the vaccine strains are good enough to cover the circulating field isolates. However the data generated for type A for this year also corroborates our earlier observation that in type A the field situation demands a change of vaccine strains. Different field strains are being characterized as a candidate vaccine strain replacement for type A.

Molecular epidemiological analysis of type O virus indicated continued dominance of Pan Asia III strains during this year also. However in Asia 1, lineage CII takes the center part after a gap of 4 years. The lineage VII which had been the major force behind type A outbreaks in the recent years continues to retain the prime position. One of the major observations of the year is that FMD returned to Andaman and Nicobar islands after 16 years of absence. Investigation revealed that infection had gone from the mainland and Pan Asia lineage of type O virus that circulated southern India during 1998–2002 was responsible for this outbreak.

A study undertaken to shortlist few more candidate vaccine strains in type O, indicated that isolates IND 271/01 and IND 120/02 could be ideal substitutes to current vaccine strain IND R2/75. Complete nucleotide sequence of all the short listed strains were generated, similarly, the complete nucleotide sequence of several field isolates of type Asia 1 was determined. The tree topology and

- FMD was reported from Andaman and Nicobar islands
- PCR developed for determination of lineage of the type Asia 1 field isolates
- PD_ADMAS detected BHV-1 genome in peripheral blood leucocytes, aborted materials etc.
- Blue tongue virus vaccine yielded promising results in local and Bharat Merino sheep
- A project on Development of Economic Analysis of animal diseases and their control was initiated
- H5N1 strain of influenza A virus was detected in poultry for the first time in country
- RT-PCR developed for diagnosis of border disease virus infection
- Herbal medicine found effective in clinical case of diarrhea
- *In ovo* vaccination in broiler chickens was standardized
- Seroprevalence of rotavirus antibody was studied in mithuns

clustering pattern was similar when complete coding region or primary poly-protein cleavage products in isolation were used for analysis. The identification of residues under positive selection, of which some are antigenically critical, made a beginning in the understanding of antigenic features of this serotype.

A PCR was developed to determine the lineage of the type Asia 1 field isolates involved in the outbreaks. This PCR gives a fast preliminary indication on the genetic lineage before proceeding with nucleotide sequencing of the 1D region of the viral genome, which definitely continues to be the confirmatory method to assign lineages by phylogenetic analysis. This assay promises to be an effective tool in molecular epidemiological investigation of FMD in the country.

Detection of foot-and-mouth disease virus (FMDV) from clinical specimens by conventional sandwich enzyme-linked immunosorbent assay (ELISA) and virus isolation in cell culture is often compromised owing to limited sensitivity and sample deterioration during transit. An RT-PCR (oligoprobing) ELISA in both solid and liquid phase hybridization formats targeting an across serotype conserved site at 3C–3D region was developed and its effectiveness was compared with that of the known targets at the IRES region. A non-isotopic RNA dot hybridization assay with colorimetric detection targeting both the IRES and the 3D region, was also validated, which is capable of handling high throughput samples with ease. RT-PCR (oligoprobing) ELISA and dot hybridization assay showed 1,000- and 10-fold greater sensitivity than the sandwich ELISA, respectively.

Evaluation of various extraction protocols for RNA isolation revealed that sample preparation in DEPC-water/PBS may not be ideal for it as compared to their preparation in lysis buffer prior to RNA extraction. Virus specific primer for reverse transcription of the RNA was more efficient compared to oligo dT or random primers.

PCR protocol for *Brucella* detection

PCR protocol to detect *Brucella abortus* and *B. melitensis* directly from the aborted material, foetal contents and vaginal discharges was standardized. The direct detection of *Brucella* using sensitive PCR is advantageous over isolation and serological tests and risk of laboratory acquired infection can be avoided. The standardized protocol can be used to screen suspected herds for confirmatory diagnosis.



Databases to study epidemiology of animal diseases

To study the national epidemiological status of economically important animal diseases, the following databases were collected, updated and formatted.

- Livestock demography at district level
- Livestock disease profile at district level
- Comprehensive district level censuses data 2003 developed as RDBMS
- National meteorological database
- Agro-ecological data—The country has been classified into 20 macro zones for the convenience of epidemiological analysis
- Development of GIS Admin level I and II level polygon and development of point projection maps
- National sampling frame of villages (epi_units) for epidemiological studies updated as on 2006

Functional livestock disease relational database software supported by GIS NADRES is made available on the internet. This website is available to general users such as administrators, planners and farmers. It is an interactive website through which animal disease forecasting, veterinary web pages on important animal diseases, epidemiological reports and maps are available. The disease forecasting module is updated regularly and with this the probability of outbreak of a specific disease at district level can be predicted two months ahead.

Plasmid vector, expressing short hairpin RNAs (shRNA) under mouse U6 and CMV promoters directed against a highly conserved sequence in the 2B-2C nonstructural protein-coding region of FMDV RNA identified earlier, were transfected to BHK-21 cells. At different quantum of infection (10 to 1,000 TCID₅₀), these cells showed a decrease in virus yield as observed in ELISA and virus titration when compared to control cells. The level of inhibition varied among the serotypes of virus, between the promoters used and the time of infection.

The virus repository is one of the big collections of cell culture revived field strains. The National repository contained 1,250 (800-O, 235-Asia 1, 200-A, 15-C) field isolates.

Animal disease monitoring and surveillance

National sero-epidemiological surveys conducted for brucellosis and infectious bovine rhinotracheitis (IBR) revealed that overall incidence was 22.4% in 14 states 37% in nine states.

Epidemiological studies

Brucellosis: Standardizations of latex based agglutination (LTA) for the detection of brucella antibodies in cattle, sheep and goat was standardized using sLPS, heat killed and sonicated antigens of *Brucella abortus* S₉₉ strain. Sensitivity and specificity of the test are being evaluated in comparison with other tests.

Indirect-ELISA protocol for brucellosis was standardized for small ruminants. Screening for *Brucella* antibodies from sera samples from small ruminants by RBPT, STAT and iELISA revealed higher seroprevalence of brucellosis in sheep (13.41%, 8.23%, and 9.14%) than in goats (8.27%, 4.43%, and 6.49%), and prevalence was the highest in Gujarat (26.08%, 17.30%, and 22.6%) followed by Karnataka (14.93%, 7.23%, and 7.23%) and lowest in Rajasthan (5.53%, 4.11%, and 4.78%). Seropositivity was found the highest by RBPT (9.95%) followed by iELISA (7.36%) and least in STAT (5.67%). The brucellosis prevalence rate by all the three serological tests was more than 5%. The test appears to be promising for large scale screening of sera samples.

Molecular epidemiology of *Brucella* strains: *alk B* gene in chromosome II region of *B. abortus* (498 bp) was cloned and sequenced. Comparison of this nucleotide sequence of *B. abortus* S₉₉ strain with those of reference sequences from USA (GenBank No. AE017224, AM040265 and AF148682), revealed 100% homology with all the three sequences. Similarly, the PCR amplified product of hypothetical protein in chromosome I of *B. melitensis* 16 M strain (731 bp) was also sequenced and nucleotide sequences were aligned with two reference sequences from USA (GenBank No. AE 009614 and AE009540) and one from Belgium (AF047478). There was 98.8% homology with all the three sequences.

Infectious bovine rhino-tracheitis (IBR): Screening of serum samples of bovine population from nine states of India by using AB-ELISA kit, revealed an overall antibody prevalence of 36.66% against BHV 1. The highest prevalence was in Meghalaya (59.09%) and lowest in Tamil Nadu (24.57%). The main means of control is elimination of carrier bulls. BHV 1 genome detection in peripheral blood leucocytes, aborted materials, semen samples etc. have already been undertaken.

BHV 1 infection in bulls is epidemiologically important as the virus is excreted intermittently in the semen and may cause spread of infection to all other cattle who receive semen from such breeding bulls. Identification and elimination of the bulls positive for BHV 1 antibodies and antigens by serological tests and PCR assays, respectively, would help in formulating the control strategies. An initiative to develop a PCR based detection of BHV 1 genome/antigen in the semen samples of all bulls in the breeding farms on regular basis, was initiated.

Molecular epidemiology of BHV 1 in India: The long term serological studies showed evidence of the disease all over the country, although there are only limited reports of isolation of virus mainly from Karnataka, Punjab and Uttar Pradesh. Pilot studies are being carried out using blood in EDTA collected from different cattle showing the symptoms of repeat breeding, abortions etc. The total DNA was extracted from PBL and was subjected to PCR using different primers specific for gB, gC, gD of BHV 1.



Serum based IBR AB-ELISA kit

Ever since the release of indigenously developed, software based AB-ELISA kit, there has been a growing demand for this kit from all over the country. The sale of kits also includes hands-on-training and help in times of troubleshooting. The kit is user friendly, economical and provides high levels of specificity and sensitivity. The sale of kits priced at Rs 25/test sample and supplied in 500 test capacity generated an appreciable income.

Comparison of the gB sequence of Indian isolates with those of reference sequences (one from Switzerland and two from Brazil), revealed that there was 100% homology with the sequence of AJ 004801 (Switzerland), 98.3% homology with AY 58382 and 98.7% homology with AY 330349 (both from Brazil). In clustering (rooted phylogenetic tree), Indian isolate was closer to the sequence AJ 004801 (Switzerland) and AY 330349 (Brazil).

Trypanosomiasis: The detection of carrier status of *Trypanosoma evansi* is a challenge in field condition as the carrier animals became nuclei for propagation of the disease in a particular area. Variable surface glycoprotein (VSG) which possesses diagnostic importance is having tremendous antigenic diversity, hence conventional polyclonal ELISA is not sufficient enough to detect the infection (carrier status). PCR technique was developed to detect the carrier status (latent infection) in domesticated animals. A pair of primers specific to VSG gene of *T. evansi* was developed.

Peste des petits ruminants (PPR): A national survey mainly comprising the states of Southern peninsular India and western states was conducted for seroprevalence. Screening of serum samples from sheep (1,492) and goats (2,423) from seven states revealed 41% seroprevalence in sheep and 32% in goat.

Leptospirosis: *Leptospira* species could be isolated from 15 (25%) out of 62 cases of bovine abortions. *Leptospira* staining kit is ready for commercial use.

Demographic studies on animal diseases of economic importance

Based on the reported incidence of the diseases over past 15 years, an epidemiological analysis of bacterial, viral and parasitic diseases of economic importance was worked out. Among the bacterial diseases, haemorrhagic septicaemia tops the list and the occurrence of the disease is throughout the country.

Blue tongue disease: Isolates of bluetongue virus types 1 (from Hisar and Chennai), 2 (from Hyderabad), 9 (from Hyderabad), 15 (from Hyderabad and Kolkata), 18 (from Parbhani and Bangalore) and 23 (from Izatnagar, Bangalore and Chennai) were confirmed and submitted to virus repository at IVRI,

Mukteswar. Fifteen BTV isolates (6 from Izatnagar, 4 from Hyderabad, 2 from Hisar, 1 from Parbhani and 1 from Bangalore) were deposited in the repository and are being maintained. The epidemiology of the last 5-6 years information revealed no outbreak of bluetongue in Rajasthan except in the year 2001–2002, which may be attributed to prolonged drought in the state. Andhra Pradesh, recorded most severe outbreak only during 2005 with 880 outbreaks with maximum attacks and deaths whereas outbreaks are being reported regularly from Karnataka and Tamil Nadu.

Seroepidemiology revealed an incidence as high as 70% in sheep, 85.33% in goat and 66.12% in bovine in Rajasthan. In Gujarat also higher percentage of seroprevalence of BT in goats (45.32), cattle (48.39) and buffaloes (44.67) than in sheep (36.12) and camel (35.63), was observed. Out of 433 serum samples from 6 districts of Madhya Pradesh tested, goat (24.5%), cattle (20.43%) and buffalo (19.35%) samples revealed the presence of BT antibodies. None of the sheep (21) or *cheetal* (38) sera was positive for antibodies. Andhra Pradesh showed per cent seropositivity of 35.39, 33.47, 9.09, and 8.25 in sheep, goats, cattle and buffaloes, respectively. Maharashtra had an incidence of 41.95% in sheep, 42.91% in goats, 42.85% in cattle and 84.61% in buffaloes. Karnataka had incidence of 42.39% in sheep, 27.48% in goats and 18% in cattle, whereas West Bengal showed an incidence of 31.12% in sheep, 22.28% in goats and 15.97% cattle.

Monoclonal antibodies produced against BTV reacted well with BTV r-Ag and purified BTV antigen. In indirect ELISA 9 out of 23 clones gave maximum absorbance.

Vaccine development: BTV vaccine using BEI inactivated bluetongue virus serotype 1 adjuvanted with saponin or seppic oil yielded promising results in local and Bharat Merino breeds of sheep.

Identification of vector species: Samples of midges from Uttar Pradesh, Uttarakhand, Gujarat, West Bengal, Haryana, and Rajasthan were identified as *Culicoides oxystoma*, *C. clavipalpis*, *C. actoni*, *C. anophelis*, *C. orientalis*, *C. similis* and *C. imicola*.

Typing of new isolates: Type specific primer designing for typing of new isolates of BTV, development of multiplex RT-PCR for differential diagnosis of BTV and PPRV, RNA-PAGE of the

National Serum Bank

The PD_ADMAS has established a National Serum Bank Facility with 166,037 serum samples collected from different States and Union Territories including 70,904 samples from cattle, 32,599 from buffaloes, 10,972 from sheep, 51,491 from goat and 71 from pigs. The serum samples were computer catalogued, stored at -20°C to -80°C and used for testing the presence of antibodies against different diseases like RP, PPR, IBR and brucellosis.



isolates, nucleotide sequence studies to determine the relationship of Indian isolates with other global isolates, were done. BTV-2 isolate from Hyderabad was found more closely related to European and Chinese isolate than to American isolate. Homology among Indian and Australian isolates ranged from 95.7 to 99.4%. Indian BTV types are closely related to each other forming monophyletic group.

A panel of 23 hybridoma clones reacting to purified BTV 23 antigen in indirect ELISA was produced. Out of 23 clones, 11 clones showed reactants with purified recombinant VP7 protein of BTV.

Gastro-intestinal parasitism: Epidemiological studies conducted in different agro-climatic zones of different states revealed various parasitic infections. In goat the infection rate was 56 to 70% with highest percentage in Madhya Pradesh followed by West Bengal and Sikkim. In sheep the rate of infection was 49.5 to 80% with highest rate in Madhya Pradesh than West Bengal (56%) followed by Meghalaya (55.00%) and Tamil Nadu (27.3-34.9%) however, in Uttarakhand comparatively a lower rate was recorded (12.43%) in cattle. In buffaloes a similar trend of infection was recorded. In Sikkim the infection rate ranged between 9.72 to 28% in yak. In Meghalaya the infection rate in pig was 33.5%. It was observed that both young and adult animals are infected with GI nematodes. In all the states of the country *Haemonchus contortus* was found to be the predominant infection in all the ruminant species. Bioclimatograph has been prepared for the semi arid and arid regions in Rajasthan. A software 'FROGIN' has been developed for forecasting the intensity of infection in sheep particularly *H. contortus* for semi arid region. The performance of FROGIN programme was evaluated in both the agro-climatic zones of Rajasthan, which gave precise prediction for gastro-intestinal nematode infection. In dot-ELISA affinity purified fraction of ES antigen recognized *H. contortus* infection at 4 day PI indicating diagnosis of preclinical infection. In western blotting, 60 and 120 kDa polypeptides of ES antigen were recognized as early as 4 day PI by the experimental sera indicating these to be immunodominant polypeptides. Immunoaffinity purified fraction of ES antigen also recognized 120 kDa polypeptide as early as 4 day PI. In the larval antigen 60, 120 and 170 kDa polypeptide have been recognized by 4 day experimental sera of sheep in western blotting indicating diagnostic value. In ELISA, dot-ELISA and western blotting cross antigenicity was recorded between *H. contortus* and *Oesophagostomum* spp. 60 kDa polypeptide has been determined to be glutamate dehydrogenase biochemically. In *Oesophagostomum*, 31 kDa and in *Bunostomum*, 152 kDa polypeptide have been found to be immunodominant in western blotting. Work on the production of recombinant antigen H-gal-GP and H-11 are under progress for immunoprophylaxis. PCR based technique was developed for detection of benzimidazole resistance in *H. contortus* in farm and

Quality control and production of veterinary biologicals

A total of 178,000 doses of RD 'F' strain vaccine, 550,000 doses of RD 'Mukteshwar' strain vaccine, 110,000 doses of fowl pox vaccine, 55,550 doses of lapinized swine fever vaccine, 99,100 doses tissue culture sheep pox vaccine, 11,280 ml of H.S. oil adjuvant vaccine, 2,630 doses of *Brucella abortus* strain-19 (live) vaccine, 500 doses of *Brucella melitensis* Rev-1 vaccine, 600 doses enterotoxaemia vaccine, 100,000 doses of tuberculin PPD, 3,500 doses of avian PPD, 96,500 ml of *Brucella* agglutination test antigen, 7,080 ml of *Brucella abortus* Bang Ring antigen, 13,780 ml of Rose Bengal Plate Test antigen, 150 ml of *Brucella* positive serum, 2,500 ml of *Salmonella Abortus equi* 'H' antigen, 57 ml of *Salmonella* poly 'O' sera, 3,500 ml of *S. Pullorum* plain antigen and 6,220 ml of *S. Pullorum* coloured antigen, were produced and quality tested. A total of 143,100 doses of tissue culture sheep pox vaccine was tested for infectivity titre. A total of 59.9 lakh doses of PPR vaccine were produced and supplied to the Uttar Pradesh, Animal Husbandry Department. Using FMD vaccine production technology in BHK 21 cell culture, a total of 13.97 million doses of monovalent FMD vaccine were produced.

field samples. *Duddingtonia flagrans*, a nematophagous fungi has been evaluated for biological control of GI nematodes and predatory activity of the fungi and its gut passage survival was also determined.

Haemorrhagic septicaemia: A total of 58 *Pasteurella multocida* isolates from various animal species and birds were characterized using morphological, cultural, biochemicals studies. All the isolates were found pathogenic to mice. Most of the isolates were sensitive to chloramphenicol, cloxacillin, ceftioxone and resistant to co-trimoxazole, oxytetracycline and erythromycin. Molecular studies were conducted for identification, characterization of *Pasteurella multocida* isolates from various animals and avian species by PM-PCR, HSB-PCR, Multiplex-PCR, RAPD-PCR and REP-PCR. All the isolates of *Pasteurella multocida* were typed as capsular group B. Cloning and sequencing of 16S RNA gene from different isolates of *Pasteurella multocida* B : 2 recovered from various animal species revealed 99.9% homology among the isolates of cattle, pig and sheep whereas, goat isolates shared 99.8% homology. Outer membrane protein from *Pasteurella multocida* B : 2 serotype were isolated and characterized by SDS-PAGE and western blotting. Two major proteins of 32 kDa and 38 kDa were observed and found to be immunogenic in rabbits. Low volume saponified HS vaccine gave 100% and 80% protection in cow calves at 9 and 12 months post vaccination, respectively, on direct challenge test. A preliminary trial of combined HS and FMD vaccine (virus type A, O and Asia 1) with a new adjuvant (seppic)



Technology assessment, refinement and transfer

A simple dot-ELISA using nitrocellulose membrane as solid support was developed for detection of PPR viral antigen in caprine and ovine clinical materials for easy and early diagnosis. Standardization of dot-ELISA using cell culture adapted PPR vaccine virus at different temperatures (37°, 42° and 45°C) of incubation, revealed that there was no difference in the detection of PPR viral antigen in relation to the incubation temperatures. The standardized dot-ELISA with known virus was well adapted for the detection of the known positive and negative clinical samples, unequivocally indicating that the test can be used for diagnosis of PPR in field at different temperatures. The validation of the assay was assessed with a variety of field clinical materials obtained from sheep and goats from various geographical locations of the country. The dot-ELISA detected PPR virus antigen in 149 out of 320 caprine materials giving a percentage positivity of 47, and the S-ELISA detected 154 out of 320 samples with percentage positivity of 48. The diagnostic sensitivity and specificity of dot-ELISA were found 82% and 91%, respectively, as compared to S-ELISA. However, the S-ELISA could not detect the viral antigen in all the positive samples, as the detection limit was about 500 TCID₅₀/ml. There was agreement between dot-ELISA and S-ELISA. Dot-ELISA has the advantages of being simple, easy to assay the results and perform under field conditions at various temperatures of incubation thereby fulfilling the criteria of an ideal pen side test for the diagnosis of PPR.

was carried out at IVRI Bangalore campus, Immune response of this combined vaccine was observed on 28th day post vaccination by direct challenge and the animals withstood the challenge test.

Exotic and emerging diseases

H5N1 strain of influenza A virus was detected in poultry for the first time in the country as a result of comprehensive field and laboratory investigations of clinical samples collected/received from Nandurbar, Jalgaon districts of Maharashtra, Uchchal of Gujarat and Burhanpur district of Madhya Pradesh. Four H9N2 and one H9N1 viruses were isolated. Porcine parvo and circovirus-1 genomic sequences were detected in the tonsillar epithelium of Indian pigs. Prevalence of antibodies to pestiviruses (border disease virus and bovine viral diarrhoea virus) was found in sheep and goats for the first time in India. More than 40 pestiviruses were isolated from sheep and goats and BVDV type 2 were detected in goats. Real-time PCR assays were standardized for typing H5 sub-typing of avian influenza virus. An anti-BIV gag recombinant phage library was developed as an alternative to monoclonal antibodies produced by hybridoma technology. An RT-PCR for diagnosis of border disease virus infection in small ruminants and a nested PCR were developed for differentiation of BDV, BVDV type 1 and BVDV type 2.

Disease diagnosis

Two Indian Orf virus isolates, one each from ovine and caprine, isolated in primary/secondary lamb testes cell culture for the first time were confirmed by using EM and semi-nested diagnostic PCR. Presence of G2 genotype of *Ecchinoscoccus granulosis* in Indian water buffalo is the first report from India.

Vaccines

Field trial of live attenuated **goat-pox vaccine** carried out in Maharashtra, Tamil Nadu, Karnataka, Orissa and West Bengal, showed complete protection for two years upon challenge. Sandwich ELISA evaluated for its usefulness as a quality control test for **PPR vaccine** was found suitable for rapid screening of vaccine batches for field use, showing good correlation with the conventional virus titration assays. Incorporation of groundnut oil with **ND vaccine** and its combination with sunflower oil administered with rabies DNA vaccine enhanced immunogenicity of these vaccines. Inactivated oil emulsified vaccine prepared from concentrated **CIA virus** induced good immunity. **Turkey pox virus** attenuated by passaging in chicken embryos provided better protection in comparison to tissue culture passaged virus. The 39 KDa gene was found useful in detecting vaccination among **avian pox virus**. The field trials of live **Salmonella Abortus equi vaccine** in young mares revealed that the vaccine is safe for use in young animals. The recombinant L7/L12 ribosomal protein of **Brucella abortus and its DNA** vaccine were found completely safe in pregnant guinea pigs.

Diagnostics

The recombinant “H” protein of PPR virus expressed constitutively in vero cells can serve as virus antigen in **PPR** competitive ELISA and may replace the whole virus antigen in use currently. An ELISA was standardized using recombinant protein coded by VP2 gene for detection of antibodies in chickens against **IBD virus**. A multiplex PCR was standardized targeted to four virulence genes, viz. *hlyA*, *actA*, *plcA* and *iapA* of **Listeria monocytogenes** and used for studying profiles of the isolates from human spontaneous abortion cases. PCR assays were standardized and used for detection of genus **Campylobacter** from faeces, semen and preputal washings, and **Campylobacter fetus** from semen and preputal washings. An outer membrane protein (OMP) based tube agglutination test was developed for the identification of **Aeromonas** cultures. PCR based method to differentiate cattle and buffalo tissues was standardized for **forensic application**. A PCR test was optimized for the **genus level diagnosis** and molecular identification of **Haemonchus contortus**. Cadherin and fibronectin, immunohistochemical molecular markers, caused different labeling and expression in



benign and malignant **tumours** of animals, suggesting their application in characterization of these tumours.

Herbal medicines

The modified DS formulation was highly effective in clinical cases of diarrhoea. The formulation given twice daily for 3 days afforded complete cure from severe **diarrhoea** in male cattle and buffalo. Oral electrolyte solution with high energy and glutamine was most effective supportive therapy in mild to moderate **calf diarrhoea** closely followed in terms of efficacy by oral formulation containing powder of *bael* fruit, *shisham* leaves, glucose and glutamine. In decreasing order of efficacy are two combinations (i) powder of *bael* fruit, *shisham* leaves and glucose, (ii) powder of *bael* fruit and *shisham* leaves. Zn, Se and vitamin E supplementation reduced **oxidative damage** by scavenging free radicals and proved beneficial against **stress due to diarrhoea**. Zinc @ 10.5 mg/kg body weight once daily for 5 days along with standard antibiotic was the best **antioxidant** in diarrhoea in farm animals. *Curcuma longa* @ 1.5 g/kg b.wt. administered orally for 3 days along with Zn as an antioxidant was found highly effective in **diarrhoea** in calves. Mixture of oil of *Jatropha curcas* along with zinc, selenium and *Curcuma longa* showed high therapeutic efficacy on local application against **canine demodicosis**. These adjunct therapies enhanced recovery rate from oxidative stress in infected canines. *Phyllanthus emblica* and *Curcuma longa* mixed extract therapy was found better immunoenhancer than *Allium sativum* in treatment of **mastitis** in cattle. Cystic irrigation with ammonium chloride was found to be a good technique for **dissolution of urethral calculi** and the combination of *Pasanbhed* and *Gokbru* has the potential for dissolution of urethral calculi. Various essential oils from plants namely, EOIVR-2&3 and EOIVR-6&7 completely **paralyzed *Gastrothylax crumenifer*** and *Haemonchus contortus* and *Fasciola hepatica* and *Gigantocotyle explanatum*, respectively, *in-vitro*.

Surgical and clinical interventions

Techniques for the correction of **ante bracheal deformities** in growing dogs affected with skeletal diseases were developed. Surgical excision followed by chemotherapy with vincristine sulphate and cinnoline proved to be an effective method for the treatment of **canine mammary tumours**. A modified technique of interlocking nailing was successfully used for the **management of fractures** in osteopenic bones in small animals. The clinical and laboratory investigation revealed that oral administration of **meloxicam** was safe for vultures and four other species of scavenging birds. Gestational stages had a significant influence on both myometrial and placental COX-1 and COX-2 activities.

Immunogenicity of IVRI FMD vaccine under field conditions in Karnataka

Serum samples collected from the previously vaccinated animals in various villages were tested for the serum neutralizing antibody titers against type 'O' and 'A' and type 'Asia 1'. The data on SN antibody titers revealed that a minimum of four FMD vaccinations are required for developing the herd immunity, as less number of vaccinations did not maintain significant SN antibody titers (SN log₁₀ titers of less than 1.5).

Especially, the changes in uterine enzyme activity may have an influence on the **myometrial contractility** during different stages of gestation through altered prostaglandin synthesis. The **non-steroidal anti-inflammatory** drug nimesulide exhibited favourable pharmacokinetic properties including long elimination half-life and mean residence time and better bioavailability following intramuscular administration and thus, the drug has therapeutic potential for use by intramuscular route in goats.

Animal health research in livestock and poultry

Goats: Johne's disease in goats is caused by *Mycobacterium avium* ssp *paratuberculosis*. A IS900 based PCR was developed for rapid identification of this bacteria. For serological diagnosis of Johne's disease, an ELISA test was also developed. This test is useful for the screening of the goat flocks. Healthy ruminants transiently harbor the human pathogen *Escherichia coli* O157: H7 and other STEC in their gastrointestinal tract. However, prevalence of pathogenic *E. coli* is not clearly understood in goats in Indian sub-continent. Samples were drawn from goat faeces, meat, milk and other sources for isolation of the pathogen, and 38 isolates were biochemically characterized as *E. coli*. Rest of the 138 isolates belonged to *Klebsiella*, *Proteus*, *Enterobacter* and *Micrococcus* spp.

Neonatal diarrhoea is predominantly caused by *E.coli* in young animals of all species, causing 20–40% mortality and other indirect losses. Eight medicinal plants were identified on the basis of their

Technologies commercialized

- An area specific mineral mixture to increase productivity of bovines i.e. milk yield and body weight in Uttarakhand and Uttar Pradesh
- Development of an indigenous methodology: IVRI cryscope as a field tool for determining optimum time for fertile insemination in animals
- An Asian origin of attenuated homologous vaccine for *Peste des petits ruminants* (PPR)
- Foot and mouth disease vaccine (FMD)



Patient application filed

- Recombinant chimeric G-protein of rabies virus produced in transgenic plants and synthetic gene for development of vaccine.
- A novel peptide as transfectin reagent for proteins and nucleic acids.
- A process of preparing a bio organo-mineral formulation for the therapy of skin ailment in animals.
- A process to prepare an indigenous drug formulation for the treatment of diarrhoea in animals.
- Development of technology for an area specific mineral mixture to increase productivity of bovines i.e. milk yield and body weight for Delhi region.
- Thresher-cum straw treatment machine.
- A novel immunobiosensor apparatus for rapid diagnosis of FMD in livestock.

antibiogram, anti-diarrhoeal property in laboratory rats and clinical trials in kids. A PCR assay from milk and tissues of goat, with primers derived from the omp31 gene sequence of the *Brucella melitensis* was developed. This PCR resulted in the amplification of a 720 bp PCR product. This PCR exhibited a specificity and sensitivity of 100 and 86% respectively.

Sheep: Application of planned flock health programme, which primarily involves vaccination against PPR, enterotoxaemia ET and sheep pox, one strategic deworming and one dipping reduced possibility of any outbreak of specific diseases.

Equines: Seromonitoring of important equine diseases is being undertaken with special emphasis on indigenous equines to study the magnitude of existing and emerging equine diseases in different states of the country. During the year, active sero-surveillance was conducted in 12 States/ UTs of India, namely Gujarat, Rajasthan, Haryana, Himachal Pradesh, Punjab, Chandigarh, Delhi, Uttar Pradesh, Madhya Pradesh and Manipur. EHV-1 antibodies were detected in 52 of the 1,138 (4.5%) samples, while *Babesia equi* sero-prevalence was detected in 168 of the 955 (17.7%) serum samples tested. None of the samples tested for equine infectious anaemia, African horse sickness, glanders, brucellosis and *Salmonella Abortus equi* infection was detected positive.

The prevalence of equine rotavirus in diarrhoeic foals in organized farms was determined using a monoclonal antibody-based sandwich ELISA developed by the centre. Stool samples were collected during three foaling seasons from diarrhoeic foals from organized farms. Out of 137 samples tested, 46 (33.58%) were positive for rotavirus by ELISA. This indicates that rotavirus-associated diarrhoea is a major problem in foals below 2 months of age.

Development of EHV-1 vaccine: Considering the significance of EHV-1 associated abortions in mares, an indigenous

EHV-1 vaccine is being developed and to test the efficacy of the vaccine in experimental ponies, a pilot study was undertaken for comparing the relative pathogenesis of EHV-1 strains isolated from India with particular reference to their ability to induce abortion in pregnant ponies of non-descript breed.

Ponies inoculated with Raj-98 EHV-1 strain showed severe nasal discharge up to 5 days. Profuse vaginal discharge was also seen on day 30 post-infection in mare that gave birth to a weak foal, which was unable to suckle milk of dam and had respiratory distress that died within 24 hr of its birth. Virus could also be isolated/demonstrated from the foetal /dead foal tissues aborted ponies infected with Raj-98 strain.

The study established that Raj-98 strain is more virulent than Hisar-90-7 strain, inducing abortion or foal mortality in 2 out of 4 pregnant ponies. Thus Raj-98 strain of EHV-1 could be used as challenge virus in EHV-1 vaccine trial being undertaken at this Centre.

Development of improved diagnostics for equine ailments: During the year, efforts were made to develop recombinant protein-based diagnostic for differentiation of EHV-1 and EHV-4 viruses which are very closely related antigenically. For this glycoprotein G gene from regions of EHV-1 were transformed into competent DH5a *E. coli* cells and expressed. The expressed 41 kDa protein specifically reacted with EHV-1 antibodies. The work on expression of EHV-4 glycoprotein G fragment is under progress. These recombinant proteins will be exploited for their use in diagnostics.

Equine piroplasmiasis caused by *Babesia equi* is a serious problem of major economic importance in equines. To develop improved diagnostics, an ELISA was standardized employing

Seroprevalence of equine diseases in various states during 2005–06

State	Number of samples tested (positive)	
	EHV-1	<i>B. equi</i>
Rajasthan	180 (5)	180 (42)
Haryana	60 (3)	62 (8)
Delhi	72 (6)	44 (20)
Manipur	40 (2)	40 (6)
Uttar Pradesh	119 (6)	67 (12)
Madhya Pradesh	206 (2)	206 (40)
Gujarat	70	70 (11)
Uttarakhand	232 (23)	232 (28)
Himachal Pradesh	54 (2)	54 (1)
Chandigarh	41 (1)	–
Punjab	64 (2)	–
Total	1,138 (52)	955 (168)



Technologies patented

- Cold process technology for the preparation of urea molasses mineral block
- Development of technology for an area specific mineral mixture to increase productivity of bovines, i.e. milk yield and body weight in Tarai and hill regions of Uttarakhand

recombinantly expressed merozoite surface protein EMA-2, for detection of *B. equi* specific antibodies. The assay was found specific and no cross-reaction was observed with *B. caballii* and *Trypanosoma evansi* antibodies. In addition, a PCR was standardized using primers to amplify the fragment of 346 bp and 800 bp specific to EMA-1 and EMA-2 genes, respectively. The work on determining the sensitivity and specificity of these assays is under progress.

Diagnosis of surra in equines is difficult when there is low level of parasitemia due to low sensitivity of routinely used parasitological tests. Therefore, a PCR was standardized for sensitive detection of *T. evansi*, using primers designed to amplify the gene of surface glycoprotein Ro Tat 1.2. A gene fragments (761 bp) of Ro Tat 1.2 gene from the Indian strain of *Trypanosoma evansi* was amplified in the PCR. The amplified DNA fragment was cloned and sequenced. The sequence analysis and comparison by BLAST search showed a very high similarity (> 90%) with the sequences of Ro Tat 1.2 gene of other known strain of the *Trypanosomes*.

Rotavirus associated diarrhoea is one of the leading causes of mortality and morbidity in foals below two months of age world over. To detect the equine rotavirus directly from the stool samples, a monoclonal antibody-based sandwich-ELISA was developed by the centre. This assay is very sensitive, specific and detects rotavirus from the stool samples within 4 hr.

RFLP based genotyping of MHC class II genes in Marwari horses: Major histocompatibility complex (MHC) genes that code primarily for cell surface glycoprotein play a key role in the regulation of immune response in the animals. The MHC provides a major genetic component of resistance/susceptibility to infectious or autoimmune diseases and regulates the basic immune response in higher animals. In horses, MHC is localized to chromosome 20q14 - q22. There are three functional and expressed MHC class II loci (DP, DQ, DR) and each locus contains class II A and B genes. The polymorphism in the MHC class II gene in 24 Marwari horses was evaluated by RFLP analysis. ELA-DRB3 locus in Marwari horses was homozygous on digestion with *HinfI*, showing two fragments of 241 and 68 bp. On digestion with *RsaI*, the ELA-DRB3 fragment was polymorphic, showing fragments of 238 and 71 and 190 and 119 bp. Similarly, *HaeIII* resolved the fragments of 221 and 88 and 170 and 139 bp. The RFLP results revealed that using above restriction enzymes, the animals could be grouped into different classes.

Isolation and characterization of seminal plasma proteins of Marwari stallions: Seminal plasma contains many proteins which may be used as a diagnostic tool/ marker to

SUCCESS STORY

Pestivirus infections of small ruminants in India

Bovine viral diarrhoea virus (BVDV) type 1, BVDV type 2 and border disease virus (BDV) belonging to the genus *Pestivirus* in the family *Flaviviridae* can infect sheep and goats and inflict economic losses in farming. The status of pestivirus infection capable of producing various disease syndromes in Indian sheep and goats was not known earlier. Moreover, border disease is considered exotic to India. Therefore, a study was undertaken to ascertain prevalence of pestiviruses in general and BDV in particular. Blood samples from 651 sheep and 562 goats in 41 flocks of seven Indian states were tested for the presence of pestivirus antibodies and pestivirus antigen by ELISA. Pestivirus antibody positive samples were tested for border disease virus specific antibodies. Prevalence rate of pestivirus antibodies was 26.1% in sheep and 29.1% in goats, and for BDV antibodies it was 7% in sheep and 2.8% in goats. Pestivirus antigen was detected in 11.8% sheep and 8.7% in goats providing serological evidence of infection first time in Indian small ruminants. From sheep 33 pestivirus isolates and from goats 23 isolates were obtained. An RT-PCR assay was standardized for specific detection of border disease virus and a nested PCR was developed for differentiation of BDV, BVDV 1 and BVDV 2 using 5' UTR primers. Another nested PCR was also developed using structural Erns region specific primers to differentiate pestivirus isolates. RT-PCR and nested PCR provided evidence of BVDV 1 and BVDV 2 infection and no BDV infection. The 5' UTR of 16 isolates was amplified by RT-PCR and sequenced. Phylogenetic analysis classified 14 isolates as BVDV 1, and 2 isolates as BVDV 2. BVDV 2 was isolated for the first time in India and identified as 2a subtype having close relationship with North American and European strains. Further genetic analysis of BVDV 2 isolate in Erns and NS5B region proved its subtype besides observation of unique amino acids. Genotyping of BVDV 1 isolates revealed existence of 1b and 1c subtypes whereas earlier we detected BVDV 1b in cattle. BVDV 1c subtype similar to Australian cattle strains was detected for the first time in India and for the first time in sheep and goats. Though clinical signs similar to border disease were noticed in small ruminants and serology indicated BDV infection, genetic characterization established existence of BVDV 1 mostly and BVDV 2 sporadically. Surveillance for BDV, however, needs to be continued.



SUCCESS STORY

FMD viral repository crosses the thousand mark

The Project Directorate on FMD maintains one of the largest viral repositories available in the country. The repository was initiated in late seventies. The representative samples of viruses isolated from different field outbreaks are preserved in liquid nitrogen as well as in deep freezers in the repository. The viruses are well characterized antigenically before including in the repository. These isolates have been the raw materials for genetic analysis of the field isolates. Being highly valuable research material, they have helped in understanding the dynamics of viral evolution within the region for assessing the relevance of in-use vaccine strains. Since the virus mutates very fast the circulating field isolates in different times and geographic locations change demanding a constant vigil on the vaccine strain used. On such occasions the viral repository only can act as the saviour in making available an array of viral types to be tested for its usefulness as a vaccine strain for the particular time. This repository also supplies the vaccine and challenge strains of the virus required by different manufacturers of the country. The National repository contained a total of 1,250 (800-O, 235-Asia 1, 200-A, 15-C) field isolates being one of the largest viral repository of the country.

select stallions of high breeding value. A study was initiated to evaluate the effect of gelatin and heparin binding fertility related proteins of stallion seminal plasma on *in vitro* fertilizing potential of spermatozoa. The heparin and gelatin binding proteins were isolated from the stallion seminal plasma. Five heparin binding proteins (17- 83 kDa) and four gelatin binding proteins (18-83 kDa) were identified. The effect of these proteins in fertilizing potential is being evaluated.

Assessment of technologies: Internal validation of kit for pregnancy diagnosis: A simple and reliable method of pregnancy diagnosis can help and improve the reproductive efficiency of

mares. This centre has developed an eCG based ELISA for pregnancy diagnosis which is quite economical, sensitive, specific, reliable, easy and animal friendly as compared to conventional rectal palpation technique. This test is effective in diagnosing the pregnancy between day 35 and 120 of gestation. However, this eCG based test is specific only for those mares which have been covered by horse stallion only and not for mares covered by donkey stallion for mule production. Internal validation of this test as well as feed back received from equine owners has indicated 100% sensitivity of this assay.

Poultry: Standardization of *in ovo* vaccination in broiler

chickens: The eggs injected with *in ovo* vaccines had lower hatchability than the control un-injected eggs. In 15th day vaccinated groups, there was higher number of embryonic death just before pipping and had lower hatchability (50.6%) than 18th day vaccinated egg (56.3%). Yolk sac vaccinated eggs (54.2%) had higher hatchability than amniotic sac route (50%). As far as dose of ND vaccination is concerned, increase in vaccine dose decreased the hatchability. At lower dose there was 66.1% hatchability as compared 41.5% in high dose group. 15th day vaccinated birds had significantly higher HI titre (log₂) value (7.17) for the first four days post-hatch than control (5.32) and 18th day vaccinated group (5.23). From 7th day onward both 15th and 18th day vaccinated birds had significantly higher HI titre value than control birds except on 28 day where 15th day vaccinated group had low HI value than control. When two vaccinated sites (amniotic sac and yolk sac) were compared there was no difference in the titre values among *in ovo* vaccinated and control birds for first four days. From 7th day onward both amniotic and yolk sac vaccinated birds had also significantly higher HI titre value than control birds even at 46 days of age. Control birds maintained HI titre of 4 or above only up to 14th day of age, then there was sharp decrease in titre values. *In ovo* vaccinated birds maintained HI titre of 4 or above even up to 46th day of age.

Development of novel herbal ectoparasitocidal product

Commonly available 30 plants were selected for development of the herbal ectoparasitocidal drug. Methanolic extracts for all plants were evaluated for their efficacy on adult ticks and lice of all livestock species. Most potential plants were selected for further studies on the basis of LC₅₀ values. Brine shrimp lethality test was also performed for simulation studies and further verification of efficacy. Different combinations of plants for synergistic action and concentrations were evaluated for final combination and concentration of the prototypes. Eight prototypes were clinically evaluated in more than 1,000 animals including cattle and buffalo calves, goats, sheep and dogs along with all necessary safety/toxicity trials. On the basis of efficacy and safety studies, one prototype was selected for drug development. Detailed phytochemistry of prototype with HPTLC and GC-MS was completed. This prototype can eliminate 80–100% parasites within two hr without staining and any toxic reaction on skin. Final clinical trials are under way and accordingly patent will be filed. Three different preparations for marketing with brand name "ALQUIT" as spray, shampoo base and water soluble have been finalized. The best product will be available in the market for management of ectoparasitic infection in livestock within six months.



Diagnosis of highly pathogenic avian influenza and development of killed vaccine

Highly pathogenic avian influenza caused by H5N1 subtype of the virus is a global problem because of its communicability from birds to humans. Till January, 2006 the disease/infection was not reported in India. However, in February, 2006 the disease outbreak occurred in Navapur area of Maharashtra and subsequently in Gujarat and Madhya Pradesh. Using OIE/WHO recommended test procedures the High Security Animal Disease Laboratory (HSADL), Bhopal, could diagnose the disease in a record time of 5 days. The diagnosis was based on virus isolation in chicken embryos, haemagglutination (HA) and haemagglutination inhibition (HI) tests, polymerase chain reaction (PCR) using OIE and WHO primers and real time PCR. On 18th February, 2006 the disease outbreak was notified by the Government of India and communicated to OIE. The Central and State Government machineries in close collaboration with HSADL could control the disease by culling 10.14 lakh birds in the affected areas of 10 KM radius and destruction of 14.75 lakh eggs and 8,600 Metric tonnes of feed and feed ingredients.

During the course of investigation the laboratory could isolate as many as 52 virus isolates, all of which belonged to H5N1 virus. By intravenous pathogenicity test the viruses were found to be highly pathogenic. Representative virus isolates were genetically characterized by DNA sequencing and phylogenetic analysis. The most important observations were that the two

outbreaks in Navapur and Jalgaon of Maharashtra were different and the infections were introduced from two different sources by migratory birds. It was also observed that Navapur virus was a reassortant, the HA gene was from mixed migratory bird (MMB) group and NA gene from Vietnam-Thailand-Malaysia (VTM) group. The virus also contained multiple polybasic amino acids at the cleavage site of the HA gene, which is an indicator for pathogenicity. Presence of amino acid lysine at position 627 of the PB2 gene indicated that the virus can infect mammals including human beings. This is the second chicken isolate in the world, next to Nigerian isolate, which possesses lysine. Genetic analysis of NA gene revealed that Indian virus isolates are sensitive to Oseltamivir (Tamiflu) which is the drug of choice for treatment of avian influenza. Attempts were also made to develop a killed vaccine which could be used for control of the disease in chickens. The killed vaccine using the Navapur isolate of the virus proved to be efficacious and protected more than 90% of the chickens against challenge with virulent field virus. On completion of laboratory trials on the safety and efficacy of the vaccine the laboratory also developed the detailed protocol for vaccine production, which could be transferred to any agency having the required biosafety Level-3 vaccine production facility. The laboratory has now produced more than 80,000 doses of the vaccine for use.



The eggs injected with low doses of vaccine had significantly higher ND titre value than control and other two vaccine doses for the first four days of post hatch period. However, after 4 days all three vaccine doses had higher ND titre value than control birds even up to 46 day of age except at the 28 day where low dose vaccinated group had low HI value than control.

Mithun: *Seroprevalence of rotavirus antibody:* The overall seroprevalence of antibodies to rotavirus in mithun was found 75% by using an ELISA test. The seroprevalence of antibodies to rotavirus

among different age groups of mithun was statistically significant. The seroprevalence increased with the increase in age of the animals. Highest seroprevalence was observed in mithuns above 3 years of age with the lowest seroprevalence recorded in mithuns aged between 2–12 months; it was 66% in mithuns of 1–3 years age. The animals with highest degree of (++++) positivity also increased with the increase in age with the highest percentage (54%) of positivity recorded in mithuns above 3 years of age. No statistically significant difference in the seroprevalence was observed between



sexes, however a tendency towards higher seroprevalence was found among females. The influence of management system on the seroprevalence of antibodies to rotavirus in mithun was statistically significant. Highest seroprevalence was observed in mithuns kept in semi-intensive system in comparison to mithuns found in free-range system of management.

Prevalence of *Cryptosporidium parvum*: The overall prevalence of *Cryptosporidium parvum* in mithun was found 56% using an ELISA test. The prevalence among different age groups of mithun was statistically significant. The prevalence decreased with the increase in age of the animals. Highest prevalence was observed in mithuns of 1–6 months of age with the lowest prevalence recorded in mithuns above 2 years of age; it was 62% in 7-month to 2-year-old mithuns. The animals with diarrhoea were more likely to be positive (96%) for *C. parvum* than non-diarrhoeic animals (48%). No statistically significant difference in the prevalence was observed between sexes, however a tendency towards higher prevalence was found among males. The influence of management system on the prevalence of *C. parvum* in mithun was statistically significant. Highest prevalence was observed in mithuns kept in semi-intensive system in comparison to mithuns in free-range system of management.

Bacterial pathogens: Faecal samples from diarrhoeic calves were collected and analyzed to find out the bacterial pathogens associated with diarrhoea in mithun by standard bacteriological methods. *Escherichia coli* isolates were isolated from faecal samples and these isolates were subjected to antimicrobial drug sensitivity

test. Isolates were susceptible only to kanamycin and streptomycin. In another study all these *E. coli* isolates (obtained from 25 diarrhoeic samples) were subjected to specific etiologic diagnosis of K99+ *E. coli* by using K99+ Pilitest. Out of 25 *E. coli* positive samples, only 5 samples were found positive for K99+ *E. coli*.

FMD is the most common viral diseases (affecting both young and adult mithuns) having economic impact on mithun husbandry, hence mithuns found in their natural habitat (from Chozuba and Porba villages, Phek district) were vaccinated with polyvalent FMD vaccine. Faecal and blood samples from these mithun were collected for investigation of various diseases in free-range mithun.

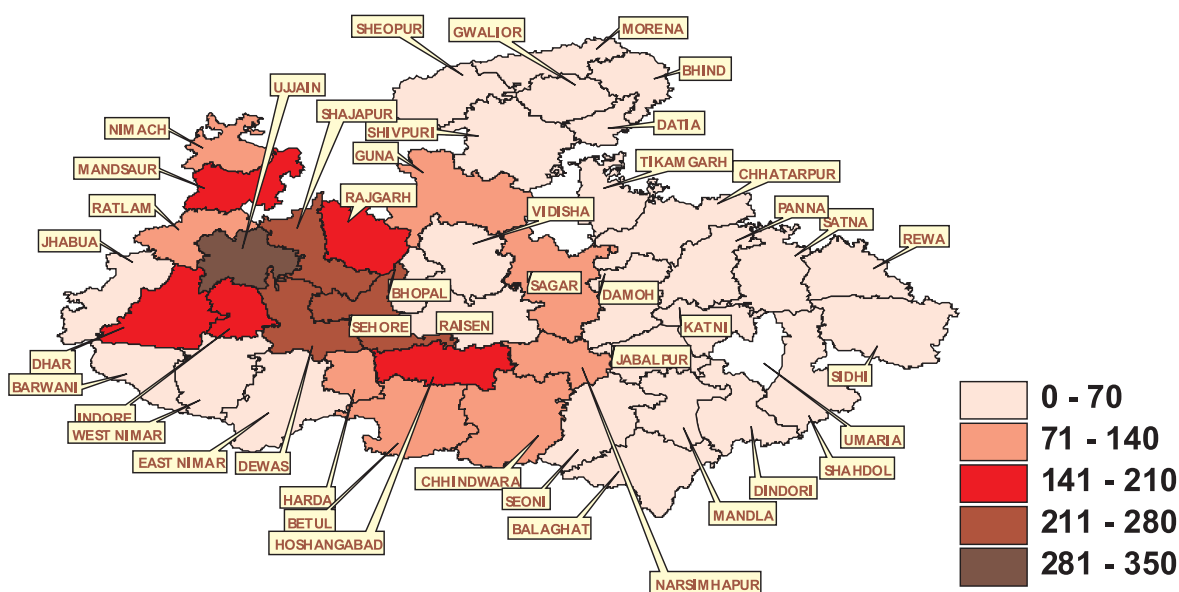
Yak: Warble infection in yak due to *Hypoderma lineatum* was recorded. Studies on exploring the mechanism of hepatotoxicity induced by senecio (pyrrolizidine) alkaloids in yak revealed that oxidative damage induced by senecio may be attributed to its toxicity.

ANIMAL NUTRITION

Animal feed resources

District-wise information on the feed and livestock resources was collected, assessed and various thematic maps depicting the salient features of distribution of feed and livestock resources were developed for Rajasthan, Madhya Pradesh, West Bengal and Bihar. The driage co-efficients of crop residues of paddy, jowar, groundnut and sugarcane were estimated for Goa, Gujarat, Kerala and Maharashtra.

Soybean cake availability (000 tonnes) in different districts of Madhya Pradesh





Amelioration of mycotoxin

Studies on preventing mycotoxin production in feeds using plant derived compounds showed that clove oil is the most effective against *Aspergillus*, *Penicillium* and *Fusarium* species of fungi, followed by turmeric powder, garlic extract, neem oil, *asafetida* powder, pepper powder and ginger extract. Anti – fungal activity of plant extracts

Plant extract	<i>Aspergillus</i>	<i>Penicillium</i>	<i>Fusarium</i>
Clove oil	++++	++++	++++
Garlic extract	++	+	+
Eucalyptus oil	+	+	++
Jerra powder	++	–	++
Karanj oil	++	+	++
Neem oil	++	++++	+
Asafetida powder	++	++++	+++
Cardamom powder	+	–	+
Turmeric powder	++	++++	+
Pepper powder	+	++++	+
Ginger extract	+	++	++
Onion extract	–	–	–
Coriander extract	+	–	–
Thulasi leaves extract	+	–	–

*Extent anti – fungal activity: high 80-100% +++++; good 60-80% ++++; medium 40-60% ++; low 20-40% +; poor 10-20% -; nil < 10 –

ICAR-ACIAR Australia Collaborative Project—Increasing productivity of cattle with rumen fungal treatments:

Isolation and purification of anaerobic fungi from rumen and faeces of cattle and buffaloes were completed. Out of the six species of piromyces, only two species were isolated of which *Piromyces communis* was predominant in all samples studied. The occurrence of anaerobic gut fungi *Cyllamyces genera* was reported for the first time in Indian cattle.

Bio-availability of micronutrients: Feeding of concentrate mixture having more wheat bran/groundnut cake as practiced under field conditions contributed to higher P intake, resulting in its higher excretion in dung and also affecting the utilization of other nutrients. Decreasing the P level in the concentrate mixture through the addition of other energy source like maize and corresponding increase in Ca level through inclusion of calcium carbonate was advantageous.

Effect of management: Higher concentrate allowances in the ration along with effective evaporative cooling system was the best

strategy to maximize production of crossbred cows under hot environmental conditions. During winter the extra climatic protection provided to crossbred cows gave no added advantage in terms of production performance with particular reference to moderate producing cows especially when ample green fodder (berseem) was available.

Bypass fat supplementation: In medium or high yielding crossbred cows bypass fat @ 300 g/day/animal significantly increased the milk yield and FCM yield up to 15.61 and 24.01%, respectively. Rumen protected DL-methionine (50 : 50 with formaldehyde (HCHO) treated maize flour) was similar to the formaldehyde protected mustard cake in terms of milk yield and its composition.

Feed supplements: Dietary supplementation of anifeed to lactating crossbred cows as per the recommended dose, increased milk yield by 10.16%.

A balanced concentrate mixture was formulated to encounter both protein and energy deficiencies in cattle of old Alluvial Zone of eastern region of the country. It contained local feed ingredients, viz. mustard/linseed cake, rice bran, rice grit, lime and salt in the ratio 38 : 30 : 30 : 1 : 1. Monensin supplementation provided nutritional and metabolic advantage to heifers around puberty. Vitamin E or vitamin E-selenium injections improved the udder health of cows.

Pesticides and nutrient utilization: Adding chloropyriphos and methyl-parathion at 100 ppm showed no effect on dry matter and organic matter solubility of paddy and ragi straw but there were differences in proximate composition. The combination of these two pesticides resulted in lower dry matter solubility in ragi straw. Supplementation of 2% activated charcoal in the diet of lactating cattle reduced the level of residual pesticides in milk.

Bio-energetic and environmental studies: *Chaffed feeding:* Feeding of chaffed ragi straw (finger millet—*Elusine corcana*) reduced energy expenditure and CO₂ emission by animals and activity of most of the cellulolytic and hemicellulolytic enzymes increase in the rumen liquor.

Solid state fermentation: *Pleurotus ostreatus* fungi proved more efficient in lignin breakdown as compared to *P. sajorcaju*. *Voriella volvoraceae*, *Phanerochaete chrysosporium*, and *T. hirsuta* did not prove to be efficient in the lignin breakdown of ragi straw. High activities of CM cellulase, xylanase, acetylesterase,

Fodder production

Pre-emergence application of atrazine @ 1 kg/ha level gave a season long effective control of weeds resulting in maximum grain yield (56.26 q/ha), stover yield (84.45 q/ha) and biomass yield (140.71 q/ha).



protease, β -glucosidase and micro crystalline cellulase were recorded upon fermentation with all these five fungi. CM cellulase isolated from *Pleurotus* gave a yield of 26% with a 2.4-fold purification. The properties of the partially purified enzyme showed it to be optimally active at pH 6.8 and the enzyme was stable over a wide pH ranging between 5 and 9.

Utilization and treatment of conventional and non-conventional feeds: Conversion of castorbean meal into wholesome protein substitute was successfully attempted after processing with sea salt, lime, and by water washing. Extracts of *Allium sativum* and *Populus deltoids* with solvents ethanol and methanol, respectively, induced significant reduction in methanogenesis without affecting *in vitro* digestibility. Bioactive plant secondary compounds (tannins and saponins) derived from tannin-rich tree forages, *Ficus infectoria*, *Ficus roxburghii* and *Quercus incana* were evaluated as natural feed additives for increasing rumen fermentation efficiency. The additive effect of CTs, tannic acid (HT) and triterpenoid saponins (S), and their combinations along with a protein rich locally available forage mulberry (*Morus alba*) were evaluated by *in vitro* gas production technique. Addition of CT led to decreased C2: C3 ratio and decreased MPS. Addition of HT+S yielded the maximum response. The EMPS increased with CT+HT; but there was mostly a decreased response with S. True degradability and partition factor showed better response with CT and S. The supplementation of tannins @ 3% in diet benefited growing animals. However, beyond 3% tannins

Updating nutrient requirements and their bioavailability

Requirements, bioavailability and inter-relationships of different dietary nutrients such as metabolizable energy, amino acids (lysine, methionine, threonine, and tryptophan), minerals (zinc, manganese, and chromium) and vitamins E for different classes and age groups of various avian species of economic importance under tropical conditions were established. The dietary protein concentration could be reduced by 1.6% in starter and finisher broiler diets through supplementation of L-threonine without affecting performance, immunoresponsiveness and feed cost of production. Similarly, the protein could be reduced from 25.46–23.21% in diets of growing Japanese quails through L-threonine supplementation to match the requirements following ideal amino acid concept. The revised and updated version of computer software "MAKEFEED POULTRY" for feed formulation was also developed.

level in diet required treatment with either PEG or calcium hydroxide. The leaves of *eupatorium* plant (*Eupatorium adenobporum*), which are rich in crude protein (nearly 25%) were found promising as an unconventional feed resource.

Buffalo

Development of economic rations is very essential for various categories of buffaloes. Costly cakes like groundnut cake (GNC) could be replaced up to 50% by expeller pressed mustard cake, and

Hay making under polyhouse

Polyhouse with natural ventilation was used for hay making to achieve faster drying rate. The experiment was conducted to observe the drying rate of *anjana* grass (*Cenchrus ciliaris*) in the polyhouse under ambient conditions. The drying rates were higher inside the polyhouse than ambient solar drying. Use of polyhouse for hay making prevented charring by direct sunlight and leaching of nutrients by unwanted rain during hay making.



Panoramic view of polyhouse



Drying inside polyhouse



up to 100% by soyabean meal or sunflower cake in the ration of growing and lactating buffaloes without any adverse effect on growth or milk production. Most economical ration with a targeted body weight gain of 500 g/head/day was all forage diet, or a diet containing ammoniated wheat straw+ available green forage and 30% barley. Under the circumstances when cereals are to be spared for human population, grainless diets can be fed to growing buffaloes with a body weight gain of 500 g/head/day. Protein utilization enhanced in buffaloes fed on zinc sulphate treated soybean cake possibly through reduced ammonia concentration and protozoa number in the rumen of buffaloes.

Goat

Sustainable goat production on semi arid pastures: Goats are mainly reared in semi arid region, which is deficient in available herbage to the grazing animals. Models, viz. natural pasture, *Cenchrus ciliaris* pasture and *Tephrosia purpurea* + *Cenchrus ciliaris* pasture were compared by introducing growing six kids (3 male and 3 female) of 4–5 months age in each model.



The initial body weight of the kids in the natural system was 8.65 ± 0.67 kg and in pure *Cenchrus ciliaris* pasture 8.65 ± 0.87 kg. Mixed pasture of *Tephrosia purpurea* and *Cenchrus ciliaris* had kids of 8.77 ± 0.85 kg weight. After 150 days of grazing, average daily gain was 35.11 ± 5.44 g in natural pasture, 39.88 ± 7.00 g in *Cenchrus ciliaris* + *Tephrosia purpurea* pasture and 39.86 ± 6.00 g in *Cenchrus* pasture.

Byproduct based complete feed: A growth trial using post weaned kids was conducted on the ration based on agricultural and agro-industrial byproducts in Barbari, Jamunapari and Marwari goats. Barbari breed responded better with this type of by-products based ration under intensive system.

Sheep

Improvement of feed resources and nutrient utilization in raising animal production: Activities of Cu and Zn-

dependent enzymes (Cu-Zn superoxide dismutase, ceruloplasmin and alkaline phosphatase) responded positively on dietary levels of Cu and Zn, and increased on increased supplementation of Cu and Zn in the diet. Plasma Cu and Zn levels also increased on increased supplementation of dietary Cu and Zn. An increase of 16–22% in Cu and 4–8% in Zn was observed on 50% and 100% more supplementation of Cu and Zn over the unsupplemented control diet. Body weight gain was higher in 100% more Cu and Zn supplemented animals than the animals of other groups. Cu/Zn-SOD enzyme activity positively correlated with dietary levels of Cu and Zn and ceruloplasmin activity with plasma Cu. Thus enzymes Cu/Zn-SOD may be used as an indicator or biochemical marker for assessing both Cu and Zn status and ceruloplasmin for Cu status of sheep. Bioavailability of Cu and Zn was better in sheep fed organic sources of Cu and Zn in the diet. Gut absorption of Cu and Zn was higher and faecal excretion of Cu and Zn was lower in organic compared to inorganic group suggesting better utilization/storage of these minerals. Relative bioavailability based on multiple linear regressions was about 141 and 122% in organic Cu and Zn supplemented group. The availability of Cu and Zn in wool and tissues especially in the liver was higher in sheep fed organic sources of Cu and Zn compared to inorganic sources.

The utilization of different types of pastures and silvi-pastures for sheep production was monitored. The herbage of grazing lands in these regions contains organic matter (OM) 78% with a crude protein (CP) of 10%. Cell wall carbohydrates (CWC) in the herbage were about 55 to 58% with 23.04% of cellulose and 3.91% lignin. The carrying capacity of grazing lands was only 0.41 adult cattle units (ACU)/ha but the stocking density was 11 ACU/ha. The diet samples of pregnant ewes contained 83.39% OM, 13.50% CP, 52.30% NDF, 28.63% ADF, 28.63% cellulose and 6.69% lignin. DM, DCP and ME intakes on metabolic body size in supplemented and non-supplemented groups were 43.65 and 38.44 g/day, 2.82 and 1.44 g/day and 0.57 and 0.50 MJ/day respectively. Under intensive system lambs for mutton may be fed on low cost animal feed grade wheat replacing up to 75% costly energy supplement like maize to economize cost of production. Maize could also be replaced even 100% with animal feed grade damaged wheat without compromising production performance.

Rabbit

Apricot seed cake, a byproduct, is generally not fed to livestock due to presence of cyanogens. Apricot seed cake after water treatment may substitute groundnut expeller up to 10% in rabbit ration as a non-conventional feedstuff.

Camel

Complete feed blocks: Feeding and nutritional trials of



SUCCESS STORY

An area specific mineral mixture to increase productivity of animals

Farmers generally are not aware of the importance of minerals in the balanced diet/nutrition of animals particularly for animals in production and the need for supplementation through designer mineral mixtures. Most of the problems associated with minerals are area specific, as distribution of essential mineral in feeds, fodder and soil are different in different regions. Area specific mineral mixtures were developed based on the soil-plant-animal status of various dietary essential minerals, and the efficacy was verified through feeding trials on growing and lactating cattle of Uttranchal and Uttar Pradesh.

The designer mineral mixture recommended for these two northern states include Ca, P, Mn, Fe, Cu, Co, Zn, I and Se at optimal concentrations to balance the deficiency of these minerals in diets of livestock. These mixtures were fortified with essential vitamins A, D, and E and a probiotic brewer's yeast. Fortification with essential vitamins and brewer's yeast enhanced the



Haifer with multiminer deficiency suffering from delayed puberty

usefulness of these products. The production and reproductive performance of cattle and buffaloes improved and also their disease resistance ability. The quality of milk also improved with a concurrent increase in lactation length up to 300 in comparison to 180 days to 240 days in animals, which were not given area specific mineral mixture. This lactation length resulted into higher economic returns in terms of approximately 90–300 kg. This gave additional income of Rs 1,530 to 5,100, while the improvement in breeding efficiency significantly decreased the dry period to 60 to 120 days from 180 to 300 days.

Significant acceleration in growth rate was also observed wherein cow and buffalo heifers attained puberty at 18 to 24 months and 24 to 30 months age, as against approximately 30 to 36 months and 36 to 42 months, respectively. The designer mineral mixtures with a positive breeding performance contributed to higher productivity and economic returns from the dairy animals.

complete feed blocks using various combinations of feed materials with minimum proportion of concentrates were conducted on growing camel calves, draught, lactating and breeding male camels. The body weight gain was higher in growing camels and lactating camels given complete feed block than those given only single fodder. The draught camels had better health, worked for longer period and generated more income than when fed only on *moth chara* or *guar phalgat*. The lactating camels produced

significantly higher milk per day when given complete feed blocks than camels fed on sole *moth* fodder, which was also economical at the same time. The stud camels generally loose about 16% body weight during breeding season (December–March). The body weight loss was less when fed complete feed blocks as compared to those given only *moth* fodder. The intake of various nutrients in the form of energy, protein, minerals was also uniform so the camels are saved from the gastric problems of acidosis/alkalosis.





Pig

Yeast culture (*Saccharomyces cerevisiae*) extract at 1% level in feed proved efficient in increasing average daily gain (ADG) in growing pigs compared to finishers. Yeast enzymes improves digestibility of feeds and thus help in attaining early growth.

Yak

Yaks under semi-range system of rearing had higher growth rate, attained mature body weight earlier (4 years vs 5-6 years), reduced age at first calving, better productive and reproductive performances compared to yaks reared in field conditions.

Mithun

Tree leaves based total mixed ration: Tree leaves, herbs and shrubs are available in plenty for feeding of mithun in north eastern states. Some of the fodder tree leaves and shrubs are excellent in terms of protein, minerals and digestibility of different nutrients for feeding of mithun.

Perennial tree leaves of *Ficus hirta* and herb like *Borrena hirticulata* could be incorporated up to 30% of total mixed ration without adverse effects on nutrient utilization and growth performance. *Borrena hirticulata* based ration showed marginal



Temichiede (*Ficus hirta*) Herb



Phegwe (*Thysalona agrostis*)



Khuki: (*Osbeckia* sp.) Shrub



Medzei (*Spondias pinnata*) tree

advantage over *Ficus hirta* based in terms of nutrients efficiency and growth. The rumen fermentation pattern showed an established trend in both the treatments but *B. hirticulata* fed animals proved to be more stable as is evident from the efficiency of nutrient utilization and growth in animals fed on this particular diet.

Feed blocks: The feed blocks were prepared at the NRC on Mithun, Nagaland, by incorporating urea treated paddy straw and concentrate mixture at 70 : 30 ratio for the first time for these animals. Feeding of these feed blocks



showed promising results for better growth rate, nutrient utilization and nitrogen retention.

Poultry

Trace mineral interaction: Retention of Mn and Zn in bone and liver increased with the level of their inclusion in broiler feed. Zn retention in bone was improved by Mn supplementation, but not the vice-versa. Mn levels depressed Cu retention in bone. Mn and Zn at higher levels in feed adversely affected Cu retention in liver. The combination of Zn and Mn at 160 and 120 ppm enhanced the immune response and the response was more conspicuous with Zn than that on Mn. Source of Zn did not affect the body weight and feed conversion efficiency. Organic Zn was useful in maintaining low leg scores and better antibody titres compared to inorganic salt. Inorganic Zn produced better tibia weight and strength compared to organic Zn. Organic form of the mineral was more efficient in bringing out the desired effect in respect of bone traits, carcass parameters or immune parameters.

Optimum energy and protein requirement: The energy and protein requirement of female parent line of Vanaraja during juvenile stage (0–6 weeks) was 2,650 kcal ME/kg diet and 20% crude protein.

Recycling of sun dried cage layer manure as feed for laying chicken:

Recycling of poultry excreta as feed may help alleviating pollution problems, decreasing feed cost and increasing supplies of available nitrogen and essential mineral sources. Dietary incorporation of SDCLM (sun dried cage layer manure) did not affect egg production, egg weight and egg shell quality indicating that it could be incorporated up to 10% in the diet of layers without affecting their performance.

Performance on low nutrient diets: Gramapriya birds need initial brooding and other management care till they attain the desired body size prior to leaving them in the free range scavenging system. Body weight gain increased with increase in energy up to



2,500 kcal ME/kg, and feed intake decreased progressively with energy concentration in diet. The humoral immunity was not affected by the energy concentration in diet. Lymphocyte proliferation increased with increase in energy level in diet. The protein level in diet did not influence body weight gain, while feed efficiency improved with increased protein in diet. Gramapriya birds needed less protein (18%) and energy (2,500 kcal ME/kg diet) during their juvenile phase of growth.

Effects of vitamin E on broiler chicks: The source of oil (sunflower, palm oil, safflower oil) or the level of vitamin E in diet did not influence chick performance. The activity of lipid peroxidase and H:L ratio, which indicate stress decreased progressively with increase in concentration of vitamin E in diet. Immune competence as assessed in terms of CBH response and lymphocyte proliferation ratio increased with increase in level of vitamin E.

Lysolecithin from rice bran: Body weight and feed conversion efficiency were higher and feed consumption was lower in the birds fed higher levels of lysolecithin, viz. 0.8 and 1.6% in diet. The slaughter variables, serum lipid profile, liver and muscle fat content and the immune response were not affected. When LL was dissolved in rice bran oil and added to broiler chicken diet at graded levels (0.025–1.6%), no effect was observed on performance and the other parameters.

Protein and critical amino acids: Diet with marginally low (–10%) level of protein and TSA (total sulphur acid) gave the highest body weight. Similar growth was seen in the group fed low (–10%) level of protein but with normal amino acids. Dietary content of protein and amino acids could be optimized for better performance of *Krishibro* chicks.

Utilization of certain alternate energy and protein: Several alternate feed ingredients such as *guar* meal, quality protein maize, earthworm (*Eisena fatida*) meal and transgenic crops like Bt cottonseed meal and Bt brinjal meal were evaluated for nutritional quality and safe/effective inclusion levels for incorporation in poultry rations. The feeding value of quality protein maize was comparable to commercial maize for broiler chicken and could be substituted up to 100% level for commercial maize in maize-soybean meal based diet. Earthworm (*Eisena fatida*) meal, processed after 6 hr of starvation contained good amount of lysine, methionine, threonine and arginine. Therefore, the meal would serve as an alternative ideal animal protein source for poultry and other non-ruminant species. Low gossypol transgenic cottonseed meal could be included @ 10% in broiler diets safely.

Augmenting digestibility/nutritive value of the feedstuffs: Dietary supplementation of 1% each of formic and propionic acid and 0.5% fumeric acid was effective for optimum growth performance, nutrient retention and to control intestinal

colonization and exclusion of harmful microbes in broiler quails, and could be used as suitable dietary alternate for antibiotic feed supplement.

In laying quails 1% formic acid and/or 1% propionic acid was effective for optimum egg production performances, immune response and to control colonization of harmful microbes in the ceaca. Use of 1% each of formic, propionic, lactic and 0.5% fumeric acid in feed resulted in promising effects on decontamination and prevention of recontamination of feed during storage up to 40 days. Feeding live culture of *Lactobacillus acidophilus* or *S. cerevisiae* @ 100 g/kg improved nutrient utilization and immune response and reduced serum cholesterol in quail broilers. In laying quails, *L. acidophilus* or *Sacromycis cerevisiae* cultures in feed improved egg mass and nutrient utilization, similar to antibiotics supplementation. Dietary addition of MOS and FOS to laying quail feed @ 1 g/kg diet enhanced the nutrient utilization and immune response of quail layers. Efforts were also made to produce designer egg through nutritional manipulation of diet.

Exploring implications of incriminating substances in diet and their amelioration: Combination of aflatoxin B1 (AF) and ochratoxin (OA), untreated cottonseed meal (UCSM) and AF and treated cottonseed meal (TCSM) and OA resulted in synergistic toxic effect in broilers. The interaction of two mycotoxins (AF and OA) on liver lipid and faecal fat content was characterized as antagonistic. The cotton seed meal because of high free gossypol (0.8%) caused toxicity in broilers, which could be averted by solvent extraction of meal and addition of iron. Combination of AF or OA with UCSM exerted synergistic toxic effect.

Hatchability and growth performance: Hatchability was apparently higher in all linoleic acid and 0.25 IU vitamin E injected group than the sham control. Though there was no difference in chick weight and egg weight, but their ratio was higher in 0.25 IU vitamin E and 25 mg linoleic acid group than un-injected control. Body weight at 28 days of age was higher in all vitamin E and 75 mg linoleic acid groups than sham and un-injected control. At 49 days of age 0.25 and 0.50 IU vitamin E and 75 mg linoleic acid groups had 63.6–109.8 g higher body weight than un-injected control. However, FCR was not affected by *in ovo* injections of vitamin E and linoleic acid.

ANIMAL PHYSIOLOGY AND REPRODUCTION

Cattle

Effect of nutritional and managerial interventions: Crossbred cattle diagnosed for anoestrus, repeat breeding, silent heat, late puberty etc. were supplemented with area specific mineral mixture under Institute Village Linkage Program (IVLP), and 55% of supplemented cows conceived in 60–90 days of supplementation.



- Time lag between heat expression and conception in cows could be reduced by mineral mixture supplementation
- Pre-partum milking training in milk parlour improved milking temperament of cows
- Isolation and partial purification of buFSH, buLH and buPRL were completed
- Efficiency of ovsynch treatment was improved for estrus synchronization/ovulation induction in anestrus buffalo heifer during summer
- Embryos of transferable stage were successfully produced using oocytes derived from *in-vitro* grown prenatal follicles—apparently first report in buffaloes
- Difference in protein profile of seminal plasma and sperm membrane may help developing molecular marker for assessing buffalo bull fertility
- Kids of 5.5 to 7.0 months of age showed fully developed thermoregulatory mechanisms
- Effect of ram was more pronounced in multiparous ewes compared to nulliparous ewes
- Peripheral blood GH levels influenced the temperament in mithuns
- Tris-egg yolk diluents could preserve mithun semen at refrigeration temperature
- Modulation of prolactin improved egg production in poultry
- Manipulation of gut melatonin improved broiler performance
- Progesterone and estrogen analogues administration improved egg production in birds
- Non-hormonal preparations enhanced egg production by 15 egg/bird

Time lag of 150–210 days duration between heat expression and conception, resulted in production loss, which could be reduced by more than 50% if mineral mixture supplementation is initiated earlier.

Semen production: The semen production performance of Frieswal bulls was estimated using the semen quality parameters—semen volume ($43.35 \pm 0.38\%$), mass motility (2.16 ± 0.02 on 0–5 scale), sperm concentration/ml ($1,175.19 \pm 11.46 \times 10^6/\text{ml}$), % motile sperm after dilution ($43.35 \pm 0.38\%$), and per cent motility of sperm after freezing ($32.76 \pm 0.47\%$). The post-thaw motility ($36.45 \pm 0.78\%$ and $32.65 \pm 0.91\%$) in summer and rainy season were significantly better than that in winter ($29.99 \pm 0.74\%$). Semen ejaculates with a low sperm concentration (up to 500 million/ml) also had significantly low mass motility ($1.21 \pm 0.04\%$) and per cent progressive motility ($24.41 \pm 1.01\%$) compared to ejaculates having more than 500 million sperm/ml.

The overall measures of length, width and depth of left and right testis indicated that scrotal circumference increased with the advancement of age, but it does not meet the minimum standard of 34 cm at the age of 24 months. Sperm abnormalities in the

Pre-partum milking training in milk parlour

In Karan Fries heifers, one week of pre-partum training in the milking parlour was adequate in improving the productive performance and milking temperament of these animals. In Sahiwal and Murrah heifers more than two weeks of pre-partum training was required to fully adapt to milking routine.

semen of different age groups were nonsignificant. Out of the total abnormalities (33.54%), the head and tail abnormalities were predominant (13.77 and 13.64%, respectively). The free heads in the semen decreased with the increase of age of the bulls. Among the various abnormalities of mid piece (6.12%) looped mid piece contributed the maximum proportion (2.56%). A large proportion of the spermatozoa showing tail abnormality had proximal droplet followed by strongly coiled (Dag defect) and tail looped on head indicating production of immature sperms and some defects in spermatogenesis.

The semen quality parameters were the best in egg yolk tris extender followed by soya milk based and milk based extenders. Microbiological aspects of semen extended in various extenders at room temperature revealed that the total plate count was the lowest in soya milk based extender followed by egg yolk tris and milk diluent.

Buffalo

Isolation and purification of buffalo hormones: Isolation and partial purification of buFSH, buLH and buPRL were completed. Antisera for progesterone and oestradiol-17 β were characterized with binding studies and are being used in radioimmunoassay of progesterone and oestradiol-17 β .

Reproductive efficiency: During cyclicity, the plasma prolactin concentrations were 40- to 70-times higher in buffalo heifers during summer than that during winter. High prolactin levels in buffalo heifers could contribute to poor fertility by lowering gonadal hormone production in summer. The ovsynch protocol for estrus induction/synchronization could be a potential tool for improvement of fertility in repeat breeding buffaloes even during extreme summer. Norprolac induced prolactin inhibition improved the efficiency of ovsynch treatment for estrus synchronization/ovulation induction in anestrus buffalo heifers during summer.

Embryo resource generation: Techniques for isolation and *in vitro* culture of preantral follicles, collection of immature oocytes from antral follicles through ultrasound guided oocyte pick up (OPU) method from live buffaloes and ovaries of slaughtered buffaloes, and maturation and fertilization, were standardized.



Embryos of transferable stage were successfully produced using oocytes derived from the *in vitro* grown preantral follicles, and this apparently is the first such report in buffaloes. Vitrification method was standardized and successfully used for buffalo embryo cryopreservation. Oocytes collected from live non-descriptive buffaloes using OPU technique were fertilized to produce transferable embryos. Brilliant cresyl blue staining technique for better selection of oocytes for *in vitro* embryo production was standardized for buffaloes.

Intra uterine protein profile: Embryo survival depends on the uterine secretions till its final attachment with uterine wall. Non-cycling animals revealed lower total superoxide dismutase (SOD) compared to cycling animals. Three molecular weight forms of SOD were detected in uterine fluid of pregnant, non-pregnant, anoestrus, infected and non-infected tract. These protein samples were subjected to separation in gradient pH gel and showed differences in protein bands. Pregnant samples contained bands at pH value 5.25, 5.6, 5.9, 6.6, 6.7, 7.0, 7.2, which were not observed in non-pregnant secretion. Similarly three bands at 5.8, 7.4 and 7.5 pH were observed in non-pregnant secretion, which were not found in pregnant animal secretion. Comparison of protein bands revealed at least 8 separate bands in allantoic fluid not similar to amniotic fluid bands. Differences in protein pattern were revealed more prominently by two dimensional electrophoresis analyses.

Male reproduction: Computer assisted semen analysis (CASA) is being used to study different aspects of semen quality. Using these facilities guidelines for different buffalo bull semen parameters are being generated. The average, motility, post-thaw motility, and viability for limited number of samples were 43, 17 and 78%. To establish most suitable glycerolization protocol sperm viability and acrosomal integrity at two different temperatures were recorded. SGOT and AKP enzymatic activities were not significantly different in two glycerolization protocols. However higher activity of these two enzymes in neat seminal plasma, suggests damage during cryopreservation process. The backward motility was not found associated with changes in the seminal plasma enzyme profile.

Semen fertility: Mitochondrial membrane potential by JC 1 staining, and plasmalemma integrity measurement by Hypoosmotic swelling Giemsa were observed as important determinants of buffalo sperm quality influencing cleavage rate and thus fertility. The differences in protein profiles between bulls were observed in seminal plasma and sperm membrane heparin binding profile (approximately 30 kDa) suggesting the importance of this as molecular marker in assessing buffalo bull fertility.

Goat

***In vitro* generation and transfer of embryos:** The average

SUCCESS STORY

Production of *In-vitro* fertilized-embryo transfer kid in goat

Goat oocytes were collected by follicle puncture method from the ovaries brought from an abattoir. Recovered oocytes were subsequently matured, fertilized and developed to 8-cell stage as per standard protocol. *In-vitro* produced eight-cell embryos were transferred into two surrogate goats of non-descript breed through surgical technique. Out of the two, one goat got pregnant and kidded a healthy female kid weighing 3.15 kg after 146 days of gestation. This is the first IVF-ET kid born at this institute and second in India.



recovery of oocytes using follicle puncture and aspiration was 2.07 and 1.26/ovary. In TC 199 supplemented with 20% EGS, 20% NCS, 20% CFE, 10% EGS, 10% EGS + FSH + LH and 10% NCS + FSH + LH + E₂ the maturation rates of goat oocytes were 77.76, 88.17, 89.32, 71–69, 75.68 and 89.63, respectively, and cleavage rates of *in-vitro* matured goat oocytes were 50.81, 41.54, 42.01, 12.92, 36.31 and 43.16%, respectively. Higher number of embryos were developed to morula stage on co-culture of fertilized oocytes with OEC than that on GCM.

Out of 5 frozen thawed embryos, 3 were normal and the two embryos of 4-cell stage developed to next stage after 24 h of incubation at 38.5°C in an atmosphere of 5% CO₂ in humidified air.

Synchronization and superovulation of anoestrus goats:

Crestar ear implant (1.5 mg norgestomet s/c for 9 days) was effectively used for oestrus synchronization in donor and recipient goats during non-breeding season. The response of PMSG + FSH-P combination was better than FSH-P alone in terms of ovulatory response and embryo recovery.

Thermo-adaptability in goat: Thermoregulatory mechanism in kids are fully developed at about 5.5 to 7.0 months of age. The comfortable zone in adult goats lies between 9.0°–38.5°C. Although the buck can regulate their deep body temperature at about the constant level but they use cutaneous evaporative



mechanism in hot-dry period or respiratory evaporative mechanism in hot-humid period to loose extra body heat. Thermal environment had distinct effect on feed and water intake and blood biochemical profile of goats.

Sheep

Fertility studies: A fertility trial was conducted in 100 cycling Bharat Merino ewes for one cycle during autumn using frozen-thawed semen through transcervical artificial insemination. Ultrasonography revealed that 19 ewes were pregnant.

Reproductive behavior: Reintroduction of rams to ewes after isolation of 90 days during non-breeding season for 30 days resulted in induction of estrus. Similarly, reintroduction of rams to ewes following 30 days isolation resulted in synchronization of estrus in the next 30 days. The response of multiparous ewes to ram effect was much more pronounced than that in nulliparous ewes. When the ewes were isolated from rams for more than one month they reacted to the introduction of a ram with a rapid increase in their plasma LH concentration and a preovulatory LH surge. A relationship was observed between nitric oxide secretion and steroid hormone secretion and LH. This states that the changes in nitric oxide concentrations are necessary for cyclic activity in sheep.

Camel

Semen cryopreservation: Cryopreservation of semen samples artificially collected from adult male camels of Jaisalmeri breed (Dromedary) revealed that pre-freeze sperm motility varied from 47 to 70% in different males. Post-thaw sperm motility declined to 23.5 from 47.5% in individual semen samples with an overall estimated loss of 62.5% of the progressively motile spermatozoa due to freeze thaw process. Based on the criteria to approve semen of 30% or greater post thaw motility, only 37% of semen samples processed in present study qualified for use for AI. Post-thaw sperm motility of same semen sample cryopreserved in duplicate vials in same batch differed significantly may be due to lack of precise control over transition phase during cooling at subzero temperature. At 37°C, the reduction in motility was about 50% than that at 0 h. At 2, 3, 4 and 24 hr after incubation, almost 93, 99 and 100% spermatozoa lost motility. At 4°C incubation, the per cent decline was 17, 30, 35.8, 44.1 and 65.5%, at 1, 2, 3, 4 and 24 hr of incubation.

Yak

Reproductive efficiency: Heatsynch could be successfully utilized for induction of estrus in anestrus yaks to cut short the long postpartum interval. Ovulation following heatsynch protocol was found well synchronized in yaks, and the application of fixed

time AI in this species could be successful. Plasma progesterone profile from individual yaks subjected to superovulatory treatment suggested that a poor superovulatory response in terms of embryo recovery in certain animals was caused by the lysis of corpora lutea before flushing which was carried out 7 days after superovulatory estrus. It was suggested that flushing 5-day post superovulatory estrus could improve the superovulatory response in this species.

Biochemical studies: Vitamin A concentration in various vital organs of yak was estimated. Vitamin A in the liver of yak was 45, 016, 910 IU/100 g (41,107 to 47,846) which is almost similar to that of ox liver but lower than that of cattle raised on pasture. In spleen, heart and lung, vitamin A was non-detectable while in kidney, vitamin A was found in traces.

Mithun

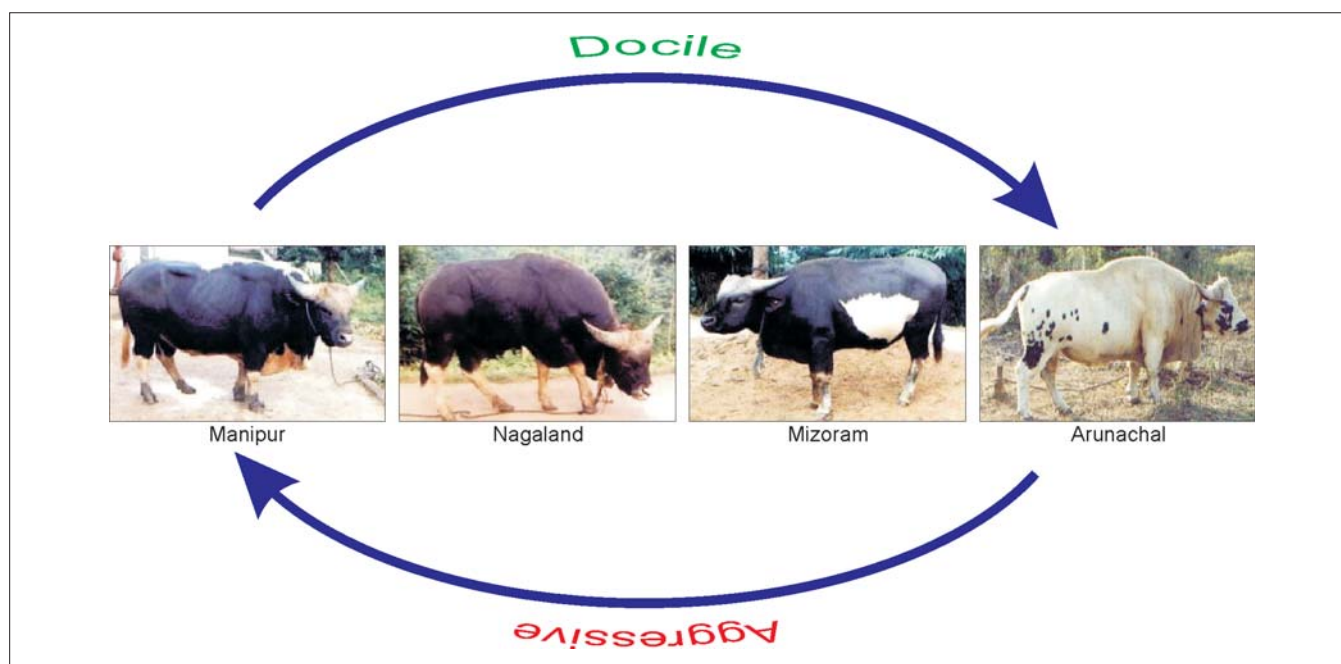
Growth hormone and temperamental behavior in mithun: The aim of this study was to verify whether or not plasma growth hormone (GH) concentrations were correlated with temperament (aggressiveness or docility) traits in mithun. Female mithuns from Arunachal, Nagaland, Mizoram and Manipur strains of Medziphema Mithun Farm of the institute, were studied. The temperament score was divided in six-scale points, scale six being very aggressive and scale one being docile. Results indicated that the strain had significant effect on blood GH levels and

SUCCESS STORY

First yak calf born through embryo transfer technology

Yak cow, superovulated with follitrop-V, was used for collection of embryos. Three embryos were successfully collected non-surgically from the donor yak cow. One of the transferable embryos (morula) was transferred to a recipient yak cow whose heat was synchronized with that of the donor. One female yak calf, named Mismo was born to recipient yak cow. This was the pioneering work on yak ETT indicating prospects of implementing ETT in *ex-situ* conservation as well as for augmenting reproductive efficiency in yak.





temperamental traits.

The temperament scores were tended to decrease with increasing age for all four strains. The highly positive correlation between blood GH concentrations and temperament for all animals regardless of age and strain differences clearly indicated the relationship between blood GH and temperamental behavior in mithuns. Results suggested that peripheral blood GH levels can influence the temperament in mithuns. This is the first report ever indicating the role of endogenous GH on temperamental behavior in livestock species in general and mithun in particular. Selection of animals of commercial importance that is better suited for human handling and management are in more demand than those are difficult to handle and manage. The established relationship between blood GH and temperament in mithuns suggest that blood GH may be used to differentiate mithuns of more docile nature within or among four different strains from the aggressive ones for commercial mithun rearing.

Preservation of semen: The colour, consistency and mass activity of fresh semen samples were creamy white, medium and 3 to 4 respectively. The average volume, pH and sperm concentration ($10^6/\text{ml}$) of mithun semen were 0.6 ± 0.01 ml, 6.9 ± 0.03 and 425 ± 48 respectively. The progressive motility and live sperm count decreased significantly after 36 hr of storage. Whereas, the total sperm abnormality increased significantly over the time of storage and the highest value was recorded at 72 h. The tris-egg yolk diluents could be used to preserve mithun semen at refrigeration temperature. An acceptable level of progressive motility, live sperm count and morphologically abnormal spermatozoa were observed

till 36 h of *in vitro* preservation at 4°C . However, further efforts are needed to design suitable diluents to extend the preservation time of mithun spermatozoa.

Cryopreservation: Ejaculates of good quality (mass activity score 3 or more) were preserved in liquid nitrogen and the progressive motility, live sperm count and acrosomal integrity of mithun sperm were recorded after cryopreservation. In cryopreserved semen approximately 40% progressively motile spermatozoa, more than 50% live spermatozoa and nearly 65% spermatozoa with intact acrosome were observed. In contrast, the morphological abnormalities of mithun sperm increased after cryopreservation and approximately 30% morphological abnormalities were recorded in cryopreserved semen. Following AI, pregnancy was established in 67% mithuns.

Poultry

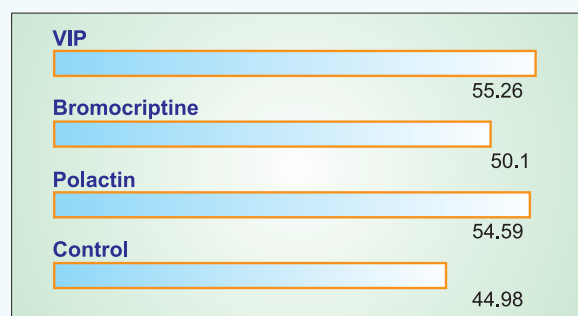
Melatonin studies: Pinealectomy (Px) and sham operation were done in day-old healthy chicks. The study was run from day-old to day 20 of age. MT was administered @ 5 ppm. Results indicated that Px does not affect gut MT level significantly but a numerical decrease was observed. Exogenous MT administration significantly increased gut MT level at day 20. Exogenous MT administration significantly increased some digestive enzyme levels while Px was accompanied by only a small numerical decrease in digestive enzyme activity. Feed conversion efficiency was significantly better in MT supplemented group compared to non-supplemented group. Pinealectomy resulted in relatively poor FCR compared to control group. MT supplementation also decreased



Prolactin modulation

Investigations at the NIANP, revealed higher than normal levels of circulating prolactin (PRL) in birds during pause days between clutches of egg laying. Hypothesizing that modulating PRL within normal physiological levels would reduce the pause days and increase egg production the following studies were conducted. The PRL levels were maintained within normal physiological range by using 3 approaches (i) administration of bromocriptine, an antiprolactin agent, through feed; (ii) active immunization against PRL; and (iii) active immunization against VIP, the PRL hormone releasing agent.

Overall increase in egg production over the control was highest at 10.28% in birds immunized against VIP as compared to birds immunized against PRL (9.60%) and birds fed with bromocriptine (5.12%). The technique was economically viable. The implications of these results would be of higher significance in country birds that show more intense broodiness/pause days; thus there is a possibility of much greater increase in egg production through modulation of PRL.



Mean percentage of egg production between control and treated Girirani birds from 19-week to 72-week of age

feed consumption/chick/day while pinealectomy increased feed consumption/chick/day. Weight gain in MT supplemented group was also better compared to corresponding control, while Px did not affect the weight gain. Px had no effect on either on jejunal MT level or various digestive enzymes activities, whereas MT administration exerted significant effect on gut MT level, some digestive enzymes and performance of broilers. These results indicated that gut MT level may be manipulated to improve broiler performance.

Behaviour of apoptotic genes during forced molting: The role of apoptotic genes, nitric oxide and cytokines in remodeling reproductive tissue during forced molting, was studied in healthy single comb White Leghorn hens. Molting was induced by feed withdrawal (FW) method in the first group; by high zinc (20,000 ppm) feeding (ZnF) in second group along with the remaining was kept as a control. The ovary and oviduct weight reduced significantly during the force molted (FW and ZnF) birds. In first

(FW) group, the reduction was drastic from the 4 DOM and further reaching about 21% of original weight in ovary and 35% of original weight in oviduct on 10 DOM. In the second group (ZnF), a significant reduction in ovary weight was noticed on 5 DOM, which reduced further reaching about 31% of the original weight on 10 DOM. The weight of oviduct also reduced significantly on 5 DOM, which reduced further on 10 DOM attaining about 41% of its original weight. In control birds, there was no significant reduction in ovary and oviduct weights.

Percentage of atresia is comparatively more in ZnF group than the other two groups. The vacuolation was very prominent in the glandular tissue of magnum in first (FW) group, whereas, Zn feeding did not cause much vacuolation on 10 DOM. Constitutive expression of caspase-1 and -2 was observed in ovary and oviduct of control birds. In ovary and oviduct of FW group there was an initial peak in caspase-1 expression that was subsequently down regulated. In ZnF group, the caspase-1 expression showed two peaks during the treatment period in both ovary and oviduct. Caspase-2 expression was upregulated significantly in the ovary and oviduct of ZnF group with two significant peaks during the treatment period. However, there was slight upregulation in the ovary of FW group. Ovarian iNOS expression exhibited different pattern in two methods of molting (feed withdrawal and zinc feeding). In fasting birds, the expression was up regulated significantly at the later stages of molting, whereas zinc feeding increased the iNOS expression from the initial days of molting. The tissue levels of NO also exhibited the similar pattern of iNOS in both methods of molting. In oviduct, the expression of iNOS was higher until end of experimental period in feed withdrawal birds. However, in zinc feed birds the iNOS expression was down regulated at the end. The same pattern was observed with tissue NO levels also in oviduct. The expression of IL 6, IL 8, MIP 1 β , and IFN γ mRNAs in ovary and IL 1 β , IL 6, IL 8, MIP 1 β , IFN γ and TGF β 2 mRNAs in oviduct were up regulated significantly during induced molting by feed withdrawal and zinc feeding, suggesting their role in tissue regression. The constitutive expression of IL 2 and MIP 1 β in both ovary and oviduct were negative up to the 40 cycles of PCR.

Induction of early maturity: Hormonal preparations—Healthy Kadaknath females of the same hatch were administered with progesterone plus estrogen analogues. The treated birds showed nearly three eggs per bird extra as compared to their counter part in control group. Peak egg production was observed in all treated birds after 24–25 weeks onwards. The average egg weight of all the groups followed the similar pattern.

Non-hormonal preparations: Healthy *desi* fowl (Kadaknath) from the same hatch were given non-hormonal preparation along with feed from 0 day onwards. First egg production was recorded in 19th week of age only in treated birds. An enhanced pattern of egg



production was found in all the experimental groups, however, maximum egg production (37.3 eggs/bird) was found in birds fed low dose of non-herbal preparation. By adopting this methodology, egg production can be enhanced around 15 eggs per bird.

LIVESTOCK PRODUCTS TECHNOLOGY

- Methods for preparation of several milk products were standardized
- Test developed for detecting detergent in milk
- Herbal ghee was prepared; it has sensory response similar to market ghee
- Mozzarella cheese was developed from Jamunapari goat milk

Milk and milk products

Developed acido-bifidus **probiotic dahi** and its health benefits for attenuation of colon cancer and dietary hypercholesterolemia and stimulation of body immune system were validated. *Lactobacillus casei* was used in combination with *L.acidophilus* and mesophilic dahi culture 167 (BD4) to prepare **low calorie probiotic lassi**.

A platform test was developed for **detection of detergent in milk**. The developed method can detect detergent up to 12.5 mg/100 ml. A multipurpose device and process was developed for **protein** concentration by dialysis and buffer exchange. **Starch estimation** by enzymatic and polarimetric methods was validated for their applicability in milk. A rapid colorimetric test was developed for detection of **vegetable oil adulteration** in ghee. A number of iron salts were evaluated for their suitability in preparation of **iron-fortified milk**. Buffalo milk exhibited about 10% more **anti-oxidant activity** as compared to bovine milk. Analysis of milk and milk powder samples collected from Southern Region indicated that **organochlorine pesticide residues** were within MRL in milk. Samples from the organized sector scored better for flavour and texture than the samples from the unorganized sector. An improved process was developed for **kheer** mix and rabri. A process for **a lassi-like beverage** was standardized using rennet whey. **Mozzarella type cheese** was developed using skim milk and vegetable oils/fat replacers. A technology was developed for **whey-based sports beverage**. Attempts were made to enhance the shelf life of the *Palada Payasam* to a commercially viable level by retort processing. The retort processed payasam was found to have a shelf life of more than 28 days at 37°C. A process was standardized for retort processed **gasa gase payasam**. The retort processed payasam had a shelf life of more than 6 weeks at 37°C. A prototype unit of continuous **paneer manufacturing** was upgraded. An automatic

Platform test for detection of detergent in milk developed

A long standing need for developing platform test for detection of adulteration of milk with so called synthetic milk has been fulfilled by focused efforts of scientists. Detergent is known to be one of the critical chemical substances used in preparation of so called Synthetic milk. A colour based test that provides the result within 5–10 min was developed for this purpose. The test can detect presence of detergent in milk up to 12.5 mg/100 ml milk.

Detection of adulteration of 'synthetic milk' in milk. Relatively more blue colour in lower layer indicate presence of 'synthetic milk' (right tube). Relatively more blue colour in upper layer indicate absence of 'synthetic milk' (left tube).



pH sensing and acid dosing control was installed for optimum curdling conditions. A **chhana ball** making machine was integrated with sugar syrup cooking equipment to produce rosogolla in synchronized manner. Conical process vat and thin film scraped surface heat exchanger were suitable for manufacture of **Basundi** for small and large scale manufacture of Basundi, respectively. Basundi could be stored for 5–7 days with acceptable quality at 35°C and for 22–25 days at 7°C on 5 psi/10 min heat treatment. Effluent treatment parameters using combined anaerobic and aerobic treatment techniques were evaluated and standardized. UASB activated sludge bed combination reactor (comb reactor) provided operational economy and efficiency for treatment of **dairy plant effluents**. Three-dimensional structure of buffalo **chymosin** determined for the first time from the crystal. A technology was developed for the preparation of customized **shrikhand** as per consumer's preference based on the starter selection and method of chakka preparation. *Bacillus coagulans* B37 was found to be a potential **probiotic culture** based on *in vitro* functional attributes and *in vivo* trials in mice and could be



Herbal ghee developed

Ghee is a fat rich dairy product, which is an integral part of our culture. It is mainly used as food and flavouring ingredient. But ghee contains cholesterol, which is one of the suspected culprits in arteriosclerosis

Dairy technologists of ICAR have now developed a process for preparing **herbal ghee** with the addition of phytosterols. The level of herb and other ingredients were optimized using central composite rotatable design (CCRD) of response surface methodology using design expert software. Based on sensory responses generated for different levels of ingredients, the final product formulation was developed. The developed ghee was found sensorily similar to the market ghee. It had overall acceptability score of 85.1 compared to the control (90.84). It complied to all the conditions laid down by PFA and AgMark (BR reading 42, moisture 0.13%, FFA 0.362%, RM value 28.2). The ghee was highly stable (8 days at 80°C) as compared to control ghee (2 days at 80°C) as it contains antioxidants like polyphenols, and terpenoids in addition to phytosterol.



used as a functional ingredient in probiotic foods. Infant stool appeared to be a potential source for isolation of probiotic microorganisms. The bifidobacterial isolates along with existing standard lactic ferments could be exploited for development of **probiotic dairy foods**. Xylanase and cellulase were purified from *B. licheniformis* and its physico-chemical properties elucidated. *Artificial Neural Network* was found a useful tool for predicting sensory based quality of long life milk and milk products and has better prediction ability than kinetic based mathematical models.

Technology for extended shelf life of mango lassi developed: Of late there has been a merging of dairy products and fruit beverage markets with introduction of 'juiceuticals' that include hybrid products like fruit based cultured milk beverages. In India *lassi* made out of *dabi* is a widely consumed fermented milk beverage. However, problems like short shelf life, post acidification, whey syneresis etc. hinder the market saleability of *lassi*. Inclusion of mango pulp in *lassi* not only helps in its value

addition but also aids in reducing the post harvest losses in mango.

Ingredients for the formulation of mango *lassi*, were optimized. The shelf life of mango *lassi* was extended using biopreservatives. The individual and interactive effects of milk fat (0.5–6%), sugar (12–17%) and mango pulp (4–14%) on sensory and physicochemical properties of Mango *lassi* were studied. The optimum formulation conditions of milk fat, sugar and mango pulp per kg curd were recommended for the blend formulation. A good quality, highly stable mango *lassi* with less than 1% whey separation was thus obtained using a blend of biostabilisers in combination with small amount of pectin. The shelf life of mango *lassi* was further extended to 50 days at refrigeration temperature using bacteriocin obtained from propionibacteria. The technology developed for manufacture of mango *lassi* with extended shelf life has considerable potential to facilitate commercialization.



Mozzarella cheese: Mozzarella cheese was made from Jamunapari goat milk using starter culture method. Pure goat milk Mozzarella cheese had a yield of $13.37 \pm 0.21\%$. Sensory score for appearance, body, texture and flavour was better in respect of vacuum packaged cheese compared to aerobic packaged cheese. The shelf life of the cheese was 14 days at refrigeration temperature and it can safely be stored in polyethylene bags under vacuum packaging. However, the product acceptability was very low on day 14th for the cheese stored under aerobic packaging system.

Meat and Meat Products Technology

Value added meat products: Chicken vada was developed by using chicken emulsion or chicken byproducts incorporation. Linseed (*til*) and soya (whole seed) could be successfully incorporated to produce nutritionally superior **emulsion based meat products**. A beneficial incorporation of capsicum, carrot

- Process developed for use of chicken neck in value added meat products
- Low acid goat meat pickle prepared
- Technology developed for preparation of different products from mithun meat
- Black pepper extract proved effective preservative for chicken gizzard snacks
- Rabbit hair (10%) blending with Bharat Merino sheep wool made woolen products more soft
- Different products were prepared from mithun leather



Utilization of fluid goat milk whey in goat meat products

Fluid goat milk whey in place of ice was used in goat meat nugget formulation. Evaluation of physico-chemical, textural and sensory quality properties of the nuggets revealed increase in emulsion stability rate, ash content and pH value. The 100% whey replacement did not produce any adverse effect in nugget's sensory properties and nuggets were highly acceptable to the panelists, suggesting that valuable animal product, often wasted can be used to create a highly acceptable and valuable food product at minimal cost.

and radish in mutton nuggets and patties was achieved.

Low acid goat meat pickle: Low acid goat meat pickle was prepared using deboned meat from Sirohi goat of around 1.5 years age. After seven days of maturation period, the product was

evaluated at an interval of 15 days up to 2 months of storage at room temperature ($32 \pm 0.5^\circ\text{C}$). The pH and titrable acidity of the low acid pickles was 4.92 ± 0.02 and 0.68 ± 0.04 whereas in



standard goat meat pickle, these values were 4.73 ± 0.02 and 0.74 ± 0.03 , respectively. Microbiological counts and sensory quality traits remained satisfactory throughout the storage period. Low acid pickle had significantly lower sourness and higher overall acceptability compared to the conventional meat pickle.

Mithun

Technology for preparation of nuggets, patties, meat blocks and dried meat powder from mithun meat were standardized in the laboratory. All meat products were equally acceptable to the mithun meat consumers. Organoleptic tests showed high rate of acceptability score of 5 to 6 in the scale of 1–7.



Chicken

Meat products: A process was developed for use of **chicken necks** in value added products. **Chicken soup** and chicken pickle were developed from deboned frames. **Chicken meat spread**, a highly acceptable variety product was successfully developed. Several suitable alternate formulations for low sodium and high **fibre meat products** were developed.

Value-added product from low-value spent hen meat: Efficient and economical disposal of spent (culled) hens is a major problem to layer farmers because of less demand of its meat characterized by toughness and excessive carcass fatness. Thus, a process for the development of premium value-added chicken meat block from low-value spent hen meat and edible by-products was optimized and its shelf-life assessed. Less preferred spent hen meat (60%) and SGH (15%) in combination with non-meat ingredients and permitted food additives (0.5% sodium tripolyphosphate and 0.02% α -tocopherol acetate) could be processed into a premium comminuted meat block. Incorporation of 0.4% lactic acid in the formulation appeared beneficial in extending the refrigerated ($5 \pm 1^\circ\text{C}$) shelf-life of the product up to 15 days without imparting perceptible sourness, comparable to that of vacuum-packed samples without acidulation, as against 10 days for control group. Both control and vacuum-packed samples had a shelf-life of 90 days under frozen (-18°C) storage.

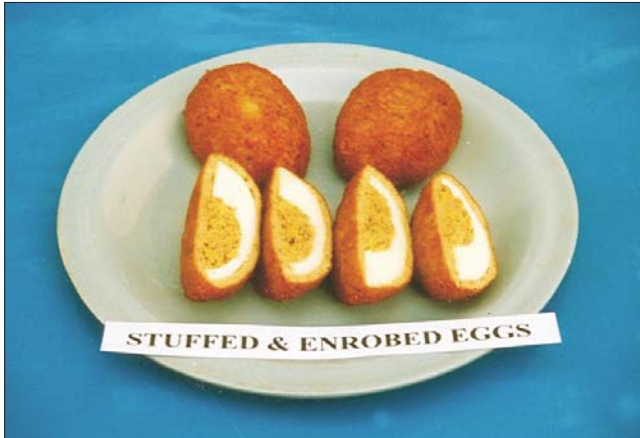
Phyto-extract as a preservative for chicken gizzard snacks: Processing of chicken gizzard snacks with 0.4% level of BPE (black pepper extract) rendered good quality product till 21 days of refrigerated ($4 \pm 1^\circ\text{C}$) and 42 days of frozen (-18°C) storage. Post-processing infrared treatment for 60 sec improved microbial quality of gizzard snacks.

Assessment of chemical and mycotoxin residues in spent hen tissues: Determination of the residual level of some heavy metals revealed that lead content in market samples of chicken liver or egg was higher (0.25 ppm) than that of spent hen lean meat (0.2 ppm). Arsenic in muscle, liver and adipose tissue ranged from 0.20 to 0.25 ppm. The residue of BHC in muscle ranged from 0.05–0.2 ppm whereas in liver and adipose fat it was in the range of 0.02–0.3 ppm and 0.02–0.05 ppm, respectively. The samples of tissues collected from commercial outlets had relatively higher level of residues than that of institute farm samples. The level of DDT was recorded to be 0.02–0.15 ppm in muscle, 0.05–0.3 ppm in liver and 0.1–0.35 ppm in adipose tissues. The residual level of malathion was 0.02–0.05 ppm in liver only and was not detected in muscle and adipose tissue. Aflatoxin B₁ was not detected in any tissue analysed. However, the residues of heavy metals and pesticides analyzed in this study in both institute farms and market samples were below MRL.



Egg products

Value-added egg product: Eggs stuffed with 1 : 1 or 1.5 : 1 yolk and meat mixture, respectively, and coated with a thin layer of chicken meat emulsion were liked most and had a refrigerated ($4 \pm 1^\circ\text{C}$) shelf-life of 18 days in vacuum and 16 days in aerobic pack with satisfactory microbiological and sensory quality.



Surveillance of bacteriological quality of chicken eggs:

Evaluation of the bacteriological quality of chicken eggs collected from selected poultry farms of Uttaranchal and Haryana and in marketing (wholesale/retail) channels revealed that farm fresh eggs had lower aerobic ($\log 3.1\text{--}3.7/\text{cm}^2$) and coliform counts than those collected from wholesale/retail outlets. The incidence of *Salmonella* in chicken eggs was 1.9% while that of *E.coli* 9.7%, and their occurrence in feed sample was 2% and 18.5% respectively. *Salmonella* detection using cell lysate PCR appeared as a quick and reliable method.

Wool, fibre and hide

The evaluation of farm bred Chokla sheep wool samples revealed that wool has become very fine (26.5 micron) as compared to the Chokla sheep wool from the field area (30 micron). Avikalin

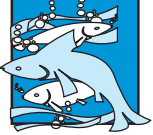
Mithun leather products

Mithun hides were processed for the first time and different types of leather products were produced. These were of very high quality. Leather processed with intact hair was a stuff of excellence having good usability as outer cover of sofa as well as carpet. The mithun leather could be used for bag leather, shoe upper, garment leather etc. with superior finish.



sheep wool is also more or less similar to it. Both the wools have staple length of around 40 mm, which is less from processing point of view.

Angora hair: Rabbit hair (10%) was blended with Bharat Merino sheep wool to make the woollen products more soft. About 5 Nm yarn was spun on woollen systems for its conversion in to shawls. The final product after wet processing was more soft and white than woollen product. Woolen yarn (4 Nm) obtained from Bharat Merino sheep wool was dyed into yellow, black, red and green colours is being used for the preparation of standard quality blankets. Finished blankets have shown excellent appeal, softness and warmth.

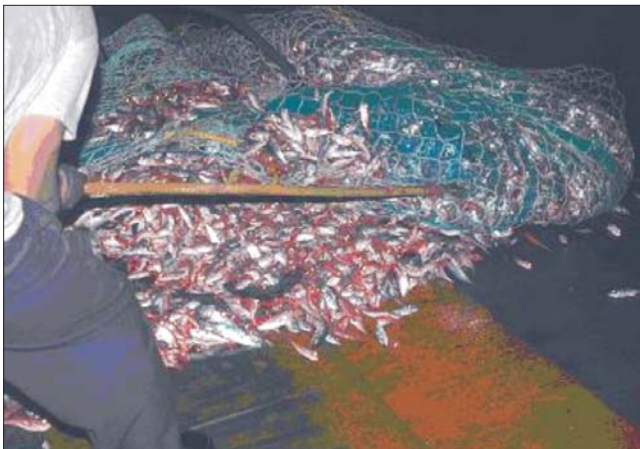


Fish Production and Processing

CAPTURE FISHERIES

Marine sector

Deep-sea fisheries resources: The deep-sea fishing survey by FORV *Sagar Sampada* conducted during 2005–06 revealed that the shelf-break area between 500–1,000 m depth off southwest and southeast coast of Indian EEZ is rich in a diverse group of organisms. Nearly 77 species of non-conventional deep-sea demersal finfishes, shellfishes and other organisms were recorded. Dense and profuse growth of the deep-sea glass sponge *Hyalonema* sp. was located in extensive mud plateau at 900 m depth off Mangalore. The species has high commercial value as the bio-



Deep-sea resources being released from the bottom trawl on board FORV *Sagar Sampada*

silica extracted has a wide range of applications in medical field. Eight species of deep-sea shrimps indicated commercial concentrations. These resources remain under exploited as at present the private trawlers exploit only a small portion. The important species are *Aristeus alcocki*, *AcanthopHIRA armata*, *Oplophorus* sp., *Heterocarpus woodmasoni*, *H. gibbosa*, *Plesionika spinipes*, *Hymnopenaeus equalis* and *Solenocera bextii*, which showed a catch rate varying from 10–25 kg/h.

Pelagic fish production: Pelagic finfish production during 1985–2005 fluctuated from 0.78 million tonnes (mt) in 1985 to 1.4 mt in 2002 forming 54% of the total marine fish production. Mechanized sector contributed about 45% to the total pelagics

- Deep sea fisheries resources in southwest and southeast coasts of Indian EEZ assessed
- Possible negative influence of the global climate change on the marine fisheries indicated
- Studies conducted on the impact of water flow on the ecology and fisheries of rivers : management strategies formulated on its basis
- Sediment load affected the breeding and recruitment process of commercially important fishes in the river Ganga
- A scoring chart using index of biotic integrity (IBI) developed and tried for assessing the state of the riverine ecosystems
- Multiple breeding *Labeo fimbriatus* achieved paving the way for restocking this important medium carp in peninsular rivers
- Successful breeding of *Ompok pabda* achieved
- Protocol developed for captive breeding of *Chitala chitala*
- Floating feed prepared for rainbow trout
- Pelleted feed was more economical in crab culture
- Fibreglass reinforced plastic (FRP) protected the wood of boat from marine borer
- *Eichhornia crassipes* found to be the most promising source for bioactive substances
- Tuna red meat proved useful in preparation of edible fish powder
- DNA bar-coding of 32 Indian marine fish species were completed
- DNA sequence of marine mammals deposited in gene bank

followed by motorized (38%) and non-motorized (17%). In 2005, 62% of the production of pelagics was obtained from the west coast and 38% from the east coast. In total landings, major pelagic finfish groups were those of oil sardine (14.4%), carangids (6.2%), ribbonfish (5%), mackerel (5.5%), Bombay duck (5.3%), lesser sardines (3%), anchovies (4.7%), seerfish (1.8%), Hilsa (1.7%) and tunas (1.7%) of the total production. The Indian mackerel showed signs of recovery from the progressive decline in catches experienced since 2001 as the catches in 2005 were 1.25 lakh tonnes.

Oceanic climate change: A national network project “Impact, adaptation and vulnerability of Indian fisheries to climate change” was carried out during the year 2006 and the salient findings are:

Southern Oscillation Index had a negative influence on Sea Surface Temperature along the northeast, southeast and northwest



Biodiversity shift in Hooghly estuary

The salinity regime of the estuary has changed and major portion in its middle stretch has almost changed into a freshwater zone, due to increased freshwater discharge from the Farakka barrage. The biodiversity changes reflected that a sizeable length of Hooghly Estuary has lost its estuarine characteristics. The Barrackpore stretch of the estuary is dominated by freshwater mullet *Sicamugil cascasia*. The brackishwater fish species, *Liza parsia*, *Scatophagus argus*, *Mystus gulio*, *Osteogeneiosus militaris*, *Hemiramphus gaimardi*, are no longer available in large stretches of the estuary. The plankton composition of this estuary, has changed. The once dominant marine diatoms like *Chaetoceros*, *Bacteriastrum* have been replaced by the freshwater plankton species *Scenedesmus*, *Pediastrum* and *Microcystis*.

coasts of India. Trend of the sea surface temperature during the period 1960–2002 along the maritime states showed a significant increase. In the northeast coast sea surface temperature showed a negative correlation with total landings, demersal, cephalopod and crustacean landings resulting in low catches in the succeeding year with increase in current year SST. Along the southwest coast, the sea surface temperature revealed positive correlation with pelagic and total landings resulting in high catches in the succeeding year with increase in the current year SST. The oil sardine distribution has extended towards the northern latitudes and the catch has increased with increase in SST.

Database on coral bleaching events was generated based on published literature and classification made based on bleaching effect as low, medium and high. In India coral-bleaching events reported in 1998 and 2002 coincided with the coral bleaching monitoring products such as Hotspots and Degree Heating Weeks. The severity was high in 1998 and medium in 2002. Mangalore coast revealed the shift of peak abundance of copepods and fish eggs and larvae towards the earlier months of the year indicating phenological changes.

Inland sector

Ecology and water flow impact on riverine fishery management:

The impact of water flow changes on riverine ecology is an important issue and the relevant studies are being made at the river Ravi at Punjab. In the upper zone fish species are represented by carps, *Tor putitora*, *Schizothorax richardsonii*, *Labeo dero*, *L. dyocheilus* and *Cyprinus carpio*. To sustain fish stocks in this stretch natural recruitment areas of *T. putitora* and *S. richardsonii* are to be protected. High rate of water abstraction in the river stretched between Modhopur barrage and Kathlour results in significant reduction in water flow, which adversely impacts

commercial fishery. It is estimated that this zone would require a regular water flow of at least 300 cusecs during lean season to enable bottom feeding fish population to develop and sustain. Stocking of minor carp seed can also restore the fishery in this zone. The lower stretch from Kathlour, Gurdaspur to its exit point at Amritsar, receives sufficient water influx from perennial tributaries. This augmented water flow, helps this stretch to sustain reasonable fish production of 1.16 tonnes/month on an average. On the basis of data generated, different management practices are suggested, for each zone in the river Ravi vis-à-vis fishery restoration.

Changes in the Fisheries of Ganga and Yamuna: The most important hydrological change observed in river Ganga is the sharp increase in sediment load during current decade by almost 20-times at Allahabad and 30 times at Varanasi. This change has resulted in considerable reduction in discharge rates, seriously impacting the breeding and recruitment process of commercially important fishes and significant shift in species composition in favour of miscellaneous and exotic species. Fish landings at Sadiapur and Daraganj centers were estimated at 56.89 tonnes and 29.51 tonnes respectively. The fish catch data from Ganga river system at Allahabad indicated dominance of miscellaneous fish group (54.3%) followed by common carp (24.4%). The landings of major carps and catfishes declined sharply and presently these are contributing only 9.5% in the total landings.

Community fish smoking kilns

Eight community fish smoking kilns (CoFiSmki) were successfully erected for the benefit of fishermen community which included one in Junput, Kontai, East Midnapur, West Bengal, two in NEH region, viz. Amranga (Kamrup district) and Morigaon (Nawgaon district) in Assam and five in the remote fishing villages adjoining Hirakud reservoir, viz. Kurumkel, (Bargarh district), Pujaripali (Jampali), Thebra and Rampaluga all three in Jharsuguda district and Sapne in Sambalpur district of Orissa.



Smoked tuna is seen through pouches



Mapping of water bodies of Orissa and Rajasthan

Water bodies above 10 ha were mapped for 15 districts of Orissa state and all the districts of Rajasthan. In Rajasthan, 807 water bodies above 10 ha have been identified having a total water spread area of 91,705.26 ha, during the post monsoon period.

The correlations between different water quality parameters and digital values of different bands of remote sensing image and various indices like normalized difference vegetation index (NDVI), normalized difference water index (NDWI) were analyzed. Water quality parameters like temperature, specific conductivity, total alkalinity, sulphate, silicate, calcium, magnesium and hardness showed significant correlation.

Index of biotic integrity developed for riverine ecosystem:

The anthropogenic impact on the fishery of degraded river Churni was assessed by the index of biotic integrity (IBI). A scoring chart using IBI metrics was developed for the riverine ecosystem. The number of native species and families, species in the column, benthic species, intolerant species and percentage of herbivores declined. But the percentage of tolerant species, omnivores and carnivores increased indicating impairment of the ecosystem. The IBI was significantly lower at stressed sites, based on the IBI score of 3. About 60% of sampling sites supported fishery in acceptable condition in the Churni river.

Design and development of eco-friendly tunnel fish dryer

A solar tunnel dryer having an efficient heat absorbing and utilization system was designed and developed. Special quality toughened glasses are used in the system to enhance the absorbivity of solar radiation and to reduce the emissivity. The solar heating system is well insulated to prevent loss of thermal energy. Continuous flow of hot air is maintained by a forced circulation system with the help of photo voltaic cells to enable faster drying rate. Perforated plastic trays are introduced in the drying tunnel to get uniform drying. Training and demonstration programmes were conducted among fisherwomen and other users.



Tunnel fish dryer

Evaluation of visible implant elastomer tags (VIE tags) in juvenile freshwater prawn *Macrobrachium rosenbergii*

The suitability of a visible implant fluorescent elastomer tag (VIE) as a method to identify juveniles of *Macrobrachium rosenbergii* (mean weight 1.25 ± 0.21 g) was evaluated. Fluorescent colours, such as red, orange, yellow and green tags, were tested for tag retention and readability during the grow-out of 100 days in outdoors fibreglass tanks. Tag retention was 96–100% in survived prawns. Tag visibility was fair after 100 days of grow-out culture and tags could be easily seen with the naked eye. Red tags were most visible followed by orange and green. No significant differences in growth or survival were observed between the tagged and untagged prawns. These results indicated that *M. rosenbergii* can be effectively tagged with VIE tags, and it can be used as batch tag to identify families in a selective breeding programme.

Application of microbes for trichloroethylene (TCE) degradation:

TCE is a common industrial contaminant in water. Methods were standardized for detection of microbes having capacity to degrade TCE. A total of 9 TCE degrading bacteria could be isolated and tested using plate and flask culture method. Pure cultures of TCE degrading isolates were preserved in glycerol at -20°C for further tests and identification.

Effect of deltamethrin on common carp: In common carp negative growth of -4.3% was recorded with diet containing sub-lethal exposure of deltamethrin for 45 days. Histopathological studies of gill, liver and intestine of fish exposed to deltamethrin with control diet containing ascorbic acid showed that the ascorbic acid acts as an antidote for pesticide.

Microbial diversity: Under the project on Application of Micro-organisms in Agriculture and Allied Sectors, water and sediment samples collected from the sea off Mumbai were subjected to microbiological analysis and 11 species/groups were tentatively identified. These are: *Chromobacterium violaceum*, *Enterobacter cloacae*, *Pantoea* sp., *Photobacterium damsela*, *Pseudomonas stutzeri*, *Rhizobium radiobacter*, *Shewanella putrefaciens*, *Sphingomonas paucimobilis*, *Vibrio alginolyticus*, *V. fluvialis*, and *Yersinia enterocolitica*.

CULTURE FISHERIES

Freshwater aquaculture

Multiple breeding of *Labeo fimbriatus*: The medium carp, *Labeo fimbriatus* was successfully bred in the pond ecosystem twice in a season. After first breeding in March, spent brooders were maintained separately in a pond and fed with special maturation feed. They were once again bred for a second time in August and 1.52 lakh spawn were obtained from 2 sets. Multiple breeding of



this threatened species will be a major boost in attempts to restock this medium carp in peninsular rivers.

Development of sexual maturity in *Puntius pulchellus* under captivity: The peninsular carp, *Puntius pulchellus*, which had been successfully incorporated in culture conditions, achieved sexual maturity under captivity. More than 80% of the 3-year-old males were mature, which started oozing milt upon gentle pressure. In addition, the males which had hitherto not shown any secondary sexual characters, exhibited clear papillary growth on dorsal surface of snouts, giving them a rough texture.



Snout of male showing rough rosy papillomatous growth Smooth snout of female

Evaluation of *Puntius gonionotus* for polyculture system: The growth of silver barb was better than the three Indian major carps, thereby showing possibility of its incorporation in grow-out carp culture system. The mean growth and survival rates



A haul of *P. gonionotus*

of silver barb, *Puntius gonionotus*, in 10 ponds of 0.08 ha each for 10 months, were 380–427 g and 81.9–95.8%, respectively.

Breeding and mass seed production of *Ompok pabda*: Successful breeding of the *Ompok pabda*, popularly known as *pabda* was achieved by using ovaprim as inducing agent @ 0.5 ml to 1.5 ml/kg weight of fish. A total of 2 lakh spawn of *pabda* were produced, and are being reared in yard and earthen ponds. The fry attained an average size of 8.5 cm/2.72 g in a period of 60 days rearing period.

Captive breeding of freshwater fish *Chitala chitala*: A significant breakthrough was achieved in up-scaling the protocol

SUCCESS STORIES

Collapsible fish Trap for Inland Fishing

The CIFT has designed and fabricated a collapsible fish trap and crab trap for helping the poor fishers operating fish traps. The new crab trap is fabricated using two rectangular SS frames having 0.9 m × 0.4 m size. The upper frame is made using SS rod of 6 mm dia whereas the lower one is made using 10 mm dia rod to make the trap sink. Black nylon (PA) multifilament netting (210D × 8 × 3) with 60 mm mesh size is used to cover the frames. Entrance funnels are fabricated using PA multifilament netting (210D × 6 × 3) with 40 mm mesh size. Eight PVC floats of 50 × 20 cm are attached to the four corners of the top frame to lift the upper body of the trap. The floats and weight are balanced which enable the trap to achieve a box shape under water. A bait bag is suspended inside the trap between the entrance funnels. An openable window is provided at one side of the trap to remove the catch. Crab traps were operated in Cochin backwater with fish and chicken waste as bait. The catch was much better in the trap operated with chicken waste (Plate). With an average soaking time of 2 h the trap with chicken bait caught 1kg of *Scylla serrata*. Mud crab weighing about 700 g fetches about Rs 250/kg.

for captive breeding of *Chitala chitala*, with two different hormones, based on repeated successful trials. A larval rearing experiment for *C. chitala* for 30 days indicated that the larvae



The fertilized eggs of *Chitala chitala*

actively fed on live organisms (tubifex and chironomus larvae, plankton), artificial diets (*Spirulina*, *Daphnia* and dry tubifex) and other non-conventional feed (fish egg and boiled egg yolk). Highest mean survival rate was recorded in larvae fed with live tubifex (94%) and chironomous larvae (92%), than (88%) with *Spirulina* and *Daphnia* and the lowest (66%) with boiled egg yolk. Owing to its hardy nature, *C. chitala* seed can easily be transported and fish seed can survive up to 5–7 days, without any artificial feeding. This technique can successfully be applied for ranching in the habitat for stock enhancement, and seed production for aquaculture.



Quality seed production of freshwater prawn freshwater prawn

Under the National Seed Project 8.3 lakh of quality seed of giant freshwater prawn *Machrobrachium rosenbergii* were produced. Nearly 6 lakh were supplied to prawn farmers from different parts of the state and to those from Chhattisgarh and Haryana generating revenue of Rs 2.9 lakh.

Artificial propagation of catfish, *Pangasius pangasius* for diversification of aquaculture: Attempts were made for induced breeding, seed rearing, and suitable feed development of the catfish, *Pangasius pangasius*. During July–August, free oozing male and gravid female were selected for induced breeding. The



A haul of *P. pangasius* fingerlings

fertilization and hatching rates were 61% and 25%, respectively, during the spawning trial. The hatched larvae were initially fed on mixed zooplankton and slowly weaned with formulated feed. The larvae grew to 15–21 mm during 15–20 days of hatchery rearing. These fry grew to 1.5–2 g in length in 30 days of growing period

Upscaling of seabass seed production

Breeding trials were conducted to produce quality seed of seabass *Lates calcarifer*. Eight million eggs were produced with an average fertilization rate of 60%. The average hatching rate was 78% and the total yield of hatchlings was 3.74 million. The hatchlings were reared @ 20–40 no./litre. After 21 days of rearing 5.72 lakh fry in the size range of 1–1.5 cm were produced. Nursery rearing of seabass fry was carried out in tanks @ 500–2,500 no./m² for 25–40 days in tanks. The average survival rate was 58%. The nursery rearing was also carried out in hapas wherein the fry was stocked @ 5,000 no./m². After 45 days of rearing a survival rate of 65% was achieved and the fry had reached average size of 7.5 cm. During nursery rearing, grading was done once in three days to avoid cannibalism.

DNA bar-coding of Indian Marine Fishes—a new initiative in the Asian region

Over 1,300 samples covering 270 marine fish species from Mumbai, Kochi, Vishakhapatnam, Andaman and Nicobar Islands and Mandapam regions, were cultured and DNA isolation and PCR amplification were carried out for more than 250 samples. The DNA barcodes (DNA sequence profile of 655 bp fragment of cytochrome c oxidase I) of 32 marine fish species were completed, for the first time in India.

under artificial feeding resulting in 50–60% survival during fingerling raising programme.

Evaluation of kalbasu for polyculture system: Study on performance of kalbasu (*Labeo calbasu*) stocked along with the three Indian major carps showed 73.23% and 53.3% higher yield in treatment provided with fertilisers + feed + periphytic substrate and feed + fertilizers, respectively, over treatment with provision of fertilizer alone. Only rohu and kalbasu showed significantly higher growth and biomass production with provision of periphytic substrates.

Upland aquaculture

Feed for coldwater fishes: The nutritional requirements of golden mahseer (*Tor putitora*) were 40% protein, 15% lipid and 25% carbohydrates, as these gave better growth performance and feed efficiency. Floating feed prepared for rainbow trout, was accepted by them and their growth performance was significantly better.

Brackishwater aquaculture

Development of formulated feed for grow-out culture of mud crabs: Field trial of the crab feed was conducted in six ponds of 0.08 ha each. In 113 days, the production and survival obtained from the ponds fed with pellet feed were 372 kg/ha and 34% indicating that the pelleted feed can be used for crab culture profitably compared to the conventional trash fish feed.



Scylla serrata crabs cultures using pellet feed



Mariculture

Hatchery production of marine ornamental fishes: The seed production technology of marine ornamental fishes such as orange clown (*Amphiprion percula*), false clown (*A. ocellaris*),



Hatchery produced *Amphiprion ocellaris* – False clown fish

blue damsel (*Pomacentrus cearuleus*), spot damsel (*Dascyllus trimaculatus*) and Humbug damsel (*Dascyllus aruanus*) was standardized.

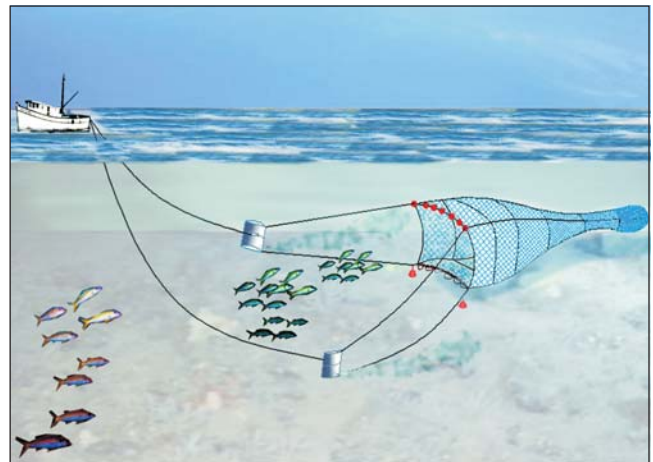
Mabe pearls from Blacklip pearl oyster: Mabe pearl production technology was extended to the blacklip pearl oyster (*Pinctada margaritifera*) at Port Blair. The technology was further improved by standardizing the narcotization and adhesion methodologies. New designs of images were made locally and a design for converting mabe-on-shell to a decorative table souvenir was finalised in consultation with local shellcraftsmen.



Mabe pearl from *Pinctada margaritifera*

FISH HARVEST AND PROCESSING TECHNOLOGY

Cod end selectivity of trawls for fish resources off south-west coast: In the trawl cod end selectivity experiments off Kochi, using 18 m semipelagic trawl fitted with 100 mm diamond mesh cod end and 30 mm cover, about 94% of the catch components, predominantly juveniles and sub-adults, were found excluded from 100 mm diamond mesh codend, while large size individuals of *Pampus argenteus* (FL 105-180 mm), *Portunus pelagicus* (CL 110 mm), *Charybdis feriatus* (CL 140 mm), *Megalaspis cordyla* (TL 215-220 mm), *Parastromateus niger* (TL 175-190 mm), *Rastrelliger kanagurta* (TL 110-242 mm), *Uroteuthis*



(*photololigo duvauceli* (ML 110 mm) and *Congresox* sp. (TL 1,300 mm) were retained. The L_{25} , L_{50} , L_{75} , selection range and selection factor for *Trichurus lepturus* in respect of 40 mm square mesh cod end were determined as 307.5 mm, 362 mm, 416.5 mm, 109 mm, and 9.05, respectively, based on selectivity experiments off Visakhapatnam.

Fibreglass reinforced plastic (FRP) as a physical barrier for chemically treated wood for boat construction: Studies carried out at Cochin estuary, showed that the rate of leaching of copper from unsheathed and FRP sheathed wood panels were 0.687 and 0.0026 mg/cm²/day respectively. For chromium it was 1.3 and nil, and for arsenic it was 1.02 and 0.15 mg/cm²/day respectively. FRP sheathing accorded a 100% protection from the attack of marine borers. X-ray radiography showed that after one year of exposure in the test site, the untreated panels showed failure with borer tunnels covering more than 50% of the area of the exposed specimen whereas in FRP no sign of attack was observed. Sheathing the CCA treated wood with FRP proved effective in reducing leaching.

Bioactive substances from aquatic sources: *Octopus vulgaris*, *O. variabilis* and aquatic weeds, viz. (*Vallisneria spiralis*, *Euchemia cottoni* and *Eichbornia crassipes*) were screened for the presence of bioactive substances. *E. crassipes* was the most promising source for substances with antipyretic, anti-inflammatory, antiulcer, wound healing and hypoglycemic effects.

Fish drying

Two fishermen associated with dry fish marketing and export to Sri Lanka were trained in scientific methods of drying fish in the sun at the CIFE, Mumbai. After the training, they are developing high quality dry fish at Madh Island of Mumbai and Veraval in Gujarat. These trained fishermen have already exported 50 tonnes of dry fish of higher quality at a premium price to Sri Lanka.



Further detailed investigations were made with extracts from different parts of *E. crassipes*. Triterpenoids, saponins and flavanoids were present in these extracts. The analgesic effect of the extract was compared with paracetamol. Analgesic activity of the extract from root was higher than that of paracetamol. Extract from leaves did not show any significant analgesic activity. The root extract was more effective than leaf extract.

High value products from fish and fish processing waste:

Tuna red meat, which is discarded as a processing waste, was used for the preparation of edible fish powder. The dried powder had a chocolate brown colour with 86.15% protein. It can be stored at



Fish powder incorporated cookies

ambient temperature for a month without any change of quality. Cookies were prepared using standard recipes by incorporating edible fish powder at different levels. Edible fish powder prepared from *Nemipterus* (whole fish) was compared with red meat of tuna. Cookies prepared using tuna powder was rated to be good at 5% level. Purified Carrageenan was prepared from cultured sea weed, *Kappaphycus alvarizi* with a yield of 33%. Gel strength, sulphate content and clarity were determined. Fish calcium was extracted and purified from sardine and rohu scales after removing protein with a yield of 9.5%.

Preparation of marinade: Safe and quality improved marinades were prepared from tuna, mackerel and shark. At ambient condition of 28 to 30°C, the storage life was 12 weeks, and at 10°C, it was 18 weeks. After this period, the product was found unsuitable due to turbidity of the liquor, colour change of meat and very soft texture and flavour changes. Biochemical, bacteriological and sensory evaluations revealed they were acceptable for 12 to 18 weeks at 10°C.

Ready-to-cook freshwater fish steaks: A ready-to-cook product with a shelf life of 16 days under refrigeration temperature

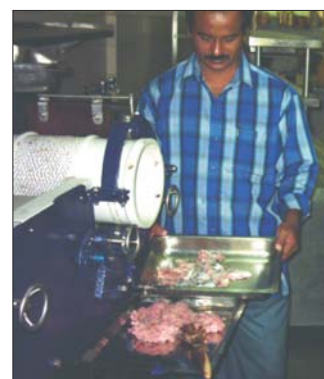
Commercialization of portable FRP carp hatchery

The technology of portable FRP carp hatchery of 1 million capacity designed and developed for small fish farmers by CIFA, Bhubaneswar has been commercialized.

of 1°–2°C with excellent sensory properties was prepared from *Labeo rohita*. The product in the form of 40–50 g steaks is presented in an optimized packaging, which also serves to display the product. The product has been treated using a special process by which the fish steaks can be directly taken for frying or curry preparation.

Storage studies of fish sauce: Storage studies of the three samples of fish sauce prepared from anchovy (*Stolepherous* spp.) were carried out for one year. The colour comparator readings indicated that there was not much variation in the colour of the fish sauce samples. The characteristic taste and flavour of the sauce remained unchanged. The TVN (total volume nitrogen) values after 12 months of storage were 98.7, 184, 166.6 mg/100 ml. Peroxide content was below the detectable limit and the histamine content was negligible, being 2.88, 2.68 and 3.27 mg/100 ml respectively. The nitrogen content appeared to be stabilized at 14 g/litre in all samples. No fungal growth or other signs of spoilage was observed. The fish sauce can be kept well for more than 12 months storage, and it may be attributed to the high content of salt (28%).

Fish meat-bone separator: A fish meat-bone separator was designed and the prototype was fabricated. The meat yield of the machine was about 60%. The capacity of the fish meat-bone separator is 100 kg raw material/hour and approximate cost of the machine is Rs 2 lakh.



FISH GENETIC RESOURCES

DNA marker technology: Development of microsat DNA markers is in progress for generating a low resolution genetic linkage map in rohu. So far, more than three dozens of microsatellite markers have been isolated and characterized from rohu genome.

Cloning and characterization of vitelogenin cDNA in catla: cDNA fragments were amplified by PCR and 5'RACE from induced catla liver RNA using vitelogenin specific primers of carp.



National Marine Fisheries Census, 2005

Recognizing the need for a strong real time and reliable database on various aspects of marine fisheries and the expertise and experience of the CMFRI, Kochi, in conducting such massive census surveys, the DAHD&F, Ministry of Agriculture, Government of India, entrusted the task of conducting the All India Marine Fisheries Census in the mainland to CMFRI. The entire census operation was carried out from 15 April to 15 May 2005 for the maritime States except Tamil Nadu and Pondicherry where the census was carried out during November–December 2005. The major findings were that there are 3,202 marine fishing villages with a total population of 3.52 million living in 756,212 households. Nearly 56.5% of fisherfolk are educated with varying levels of education. About 46.8% (1,645,919) of fisherfolk are occupied with active fishing and fishery related activities. About 25.7% (889,528) of the fisherfolk are actively engaged in fishing of which 80.7% (717,999) have fishing as a fulltime occupation. About 21.5% of fisherfolk are engaged in fishing related activities. Of this, those working as labourers form 29.2% and those associated with marketing are 27.4%. Among males, the major

fishery related occupations are: labour (39.2%), mending of nets (28.6%) and marketing (14%). Among women, the major fishing associated activities are, marketing (41.8%), labour (18.4%) and curing/processing (18%). In 10% of the fisherfolk families of Maharashtra, only women are involved in fishing or fishing allied activities and in all India level it is about 5%. There are 238,772 craft in the fishery of which 58,911 are mechanized, 75,591 are motorized and rest are non-motorised/non-mechanised. Out of 29,241 trawlers in the fishery, Gujarat (8,002) accounts for the maximum followed by Tamil Nadu (5,300), Maharashtra (4,219), Kerala (3,982) and other states. The maritime states on the east coast account for about 73% of the non-motorised/non-mechanised craft—Andhra Pradesh (24,386) and Tamil Nadu (24,231) being the lead States. Out of 185,438 craft owned by fisherfolk, 35,806 are mechanised, 52,971 motorised and 96,661 are non-motorised/ non-mechanized. Nearly 47% of the fisher families involved in fishing neither own any craft nor gear. In the maritime states, Kerala has 66% of such families, followed by West Bengal (49%), Tamil Nadu (46%) and others.

The amplified cDNAs were cloned in pGEMT vector and sequenced. The sequences when BLASTed in gene bank database, showed significant similarities with the vitellogenin I sequences of *Pimephales promelas*, *Cyprinus carpio* and *Danio rario* both at the nucleotide as well as amino acid level.

Gene expression studies in fish exposed to pollution:

Endocrine disruption is a common sequel to exposure to pollutants that lead to changes in population structure. Vitellogenin gene expression at transcriptional level was studied using reverse transcriptase PCR (RT-PCR) method in male *Labeo rohita* subjected to 17- β estradiol exposure and this could serve as a biomarker to detect pollution-induced endocrine disruption in fish.

DNA sequences of marine mammals deposited in gene bank: Till date, 20 PCR products (cytochrome b and control region of mt DNA) from 10 individuals of seven species were cycle sequenced using ABI AmpliTaq FS dye terminator cycle sequencing

chemistry, aligned using ClustalW Multiple alignment (*Bioedit*) and deposited in the GenBank (NCBI). Sequencing of mitochondrial DNA of two species of baleen whales and dugong is also completed.

PCR-based gender identification of marine mammals:

A PCR-based sex determination technique was developed based on the amplification of genomic DNA extracted from their skin tissues. This is done by amplifying a 444 bp Y-chromosome specific region (*SRY* or Sex-determining Y chromosome gene) in the genome using specific PCR primers. A 220 bp ZFX/ZFY (zinc finger protein genes located on X and Y chromosomes, respectively) band is also amplified using another pair of primers in this multiplex PCR as positive controls for absolute confirmation of sex. Molecular sexing was standardized in bottlenose dolphin, spinner dolphin, Indo pacific humpbacked dolphin, Risso's dolphin, finless porpoise, dugong, blue whale and Bryde's whale.



Agricultural Engineering and Technology

FARM IMPLEMENTS AND MACHINERY

Tractor-operated Machinery

Tractor-operated lug wheel puddler: Tractor-operated lug wheel puddler has been developed for high speed shallow puddling of rice fields with higher amount of soil dispersion required for mechanized transplanting of rice. The unit price of the PTO driven rotary puddler is Rs 36,000 and cost of operation Rs 270/ha.

The results of field performance of the lug wheel puddler compared to other puddling equipment tested in single pass showed that with the tractor-operated lug wheel puddler the depth of puddling was maintained shallow (130 mm) with higher amount of soil dispersion (48.6%). The effective field capacity was found



Tractor-operated lug wheel puddler for high speed shallow puddling of rice fields

higher by 21.2–81.8% with higher cost-effectiveness varying from 12.7 to 46% over the other puddlers tested. The unit covers 2.5–3 ha/day and makes the field ready for transplanting in single pass as compared to 3–4 passes of the peg type puddler commonly used by farmers with average coverage of 1 ha/day.

Tractor-mounted inclined plate planter: Six-row tractor-mounted inclined plate planter was modified and adapted for intercrop planting on raised and broad beds.

In laboratory tests, maximum variation in quantity of seeds dropped from different metering units was –4.21 to 4.07% for soybean and –4.86 to 3.84% for pigeonpea seeds. There was no visible mechanical damage to the seeds. Average percentage of cell filling was 99.3 for soybean and 98.9 for pigeonpea. The variation

- Tractor-operated lug wheel puddler developed for high speed shallow puddling of rice fields
- Twin auger digger sugarcane planter to dig two pits simultaneously developed by PAU
- Tractor-operated garlic planter developed and observed seed rate during testing varied from 500 to 700 kg/ha
- A three-row tractor-mounted rotary weeder developed and operated in rows spaced at 1,000 mm in sugarcane ratoon
- Flail type chopper-cum-spreader developed to harvest the straw left after combining and for chopping into pieces for spreading in the field
- High capacity groundnut thresher selected for feasibility testing gave cleaning and threshing efficiency ranged from 96.1 to 99.4% and 97.8 to 99.4%, respectively
- For sowing small seeds like sesame, cumber and sorghum, power-tiller-operated air-assisted seed drill developed

in the quantity of seeds dropped from different seed metering units was within the limit of 5%.

During field trials, three rows of soybean and two rows of pigeonpea at 300 mm row-to-row spacing were sown on broad beds with 1.55 m top width and 1.85 m bed-to-bed spacing. Average depth of sowing was 83 mm. The field capacity of planter was 0.418 ha/h with an effective width of coverage of 1.85 m. Field efficiency was 64.2%.

Sowing of soybean + pigeonpea intercrop on beds with intercrop planter-cum-bed shaper





Furrower: The TNAU, Coimbatore centre has developed a tractor-mounted rotary furrower/trencher. It employs a rotating cutter disc with radial soil cutting blades. The total number of blades were 8 with 45° angular spacing in between. The total effective cutting width offered by the set of blades arranged on both sides of the disc, was 300 mm. The staggered arrangement of blades was provided for uniform cutting action on the soil and to avoid excessive impact loads on the shaft carrying the disc. The replaceable blades were mounted on appropriately positioned frog plates.

A conventional 8.95 kW rotovator gear box was selected for driving the cutting disc. The gear ratio offered by the selected gear box was 1.7 : 1. The driven shaft's end carried a chain and sprocket giving a speed ratio of 2.4 : 1, thus providing 200 rpm rotational speed of the cutter disc at a PTO speed of 540 rpm. An idler wheel was provided to tighten the chain drive accordingly.

Twin auger digger sugarcane planter: PAU, Ludhiana centre in collaboration with M/s Dashmesh Mechanical Works, Amargarh has developed twin auger digger sugarcane planter to dig two pits simultaneously.

The machine consists of a heavy duty frame made of channel sections. Two rotary units are fixed in opposite directions around a heavy duty pipe of 98 mm diameter. A set of three triangular shaped blades made of EN-45 steel are fitted at the end of each helical auger for digging. The distance between the two augers is 1,220 mm. Power from tractor PTO is transmitted to the twin augers through a reduction gear box and belt-pulleys. Cost of the machine is Rs 50,000.

The performance results of the machine gave field capacity from 0.02 to 0.025 ha/h. The effective diameter and depth of pit varied from 700 to 720 mm and from 350 to 400 mm, respectively, in sandy loam soil (moisture content 12.2% d.b). The fuel

consumption and cost of digging were from 6 to 6.5 litres/h and Rs 2.60/pit, respectively. The machine can dig a set of two pits in 40–50 sec depending upon the depth of operation including time loss from one set of pit to the next. Under average conditions it is capable of digging 140–180 pits/h.

Garlic planter: Tractor-operated garlic planter has been developed by MPUAT, Udaipur centre. It is provided with star wheel type seed and fertilizer metering mechanism. The two-row paired hopper and adjustable seed rate are the main features of 12-row unit which has minimum row spacing of 150 mm. The observed



Tractor-mounted garlic planter. The observed seed rate during testing varied from 500 to 700 kg/ha depending on size of garlic cloves

seed rate during testing varied from 500 to 700 kg/ha mainly dependent on size of garlic cloves. The spacing of garlic cloves ranged from 50 to 100 mm. The field capacity, field efficiency and cost of planting were 0.35 ha/h, 70% and Rs 1,300/ha, respectively.

Three-row rotary weeder: A three-row tractor-mounted rotary weeder has been developed at TNAU, Coimbatore centre which

Stationary view of TNAU tractor-operated rotary weeder with rear covers on cutting blade

Twin-auger-digger sugarcane planter in operation





consists of four “L” shaped blades per flange. The length of blade is 129 mm with a blade pitch of 46 mm and bite length of 20 mm. The orientation angle of blade is 50° with the horizontal. The design speed of the rotary unit is 200 rpm.

The test trial of machine was carried out in a total of 16 ha at TNAU, Coimbatore and PAU, Ludhiana centres of AICRP on FIM. For efficient machine operation in sugarcane the row spacing of 3,000 mm is required. At PAU centre of AICRP on FIM, the machine was operated in rows spaced at 1,000 mm in sugarcane ratoon.

Air sleeve boom sprayer: An air sleeve boom sprayer was developed by MPUAT, Udaipur centre. Air sleeve consisted of 4,000 mm length and 260 mm inner diameter with total 44 orifices of 35 mm diameter spaced at 107 mm. As per the laboratory evaluation air velocity of 28 and 32 m/s provided better spray pattern in terms



The air sleeve boom sprayer brings about a major improvement in spraying process by boosting the effectiveness of chemicals and speeding of spraying process thus achieving greater coverage

of droplet size and density, over air velocity of 20 and 24 m/sec. Nozzle angle of 35° and 10° air sleeve angle gave better spray coverage. Droplet size and density varied from 169 to 270 µm and from 11 to 26, respectively.

Flail type chopper-cum-spreader: PAU, Ludhiana centre, in co-operation with a manufacturer has developed a tractor-operated straw chopping machine. It harvests the straw left after combining



Rice-straw chopper-cum-spreader



Modified cutter-bar type rice-straw chopper-cum-spreader

- Flail type mower-cum-chopper developed and commercialized for fodder crop harvesting
- Power tiller-operated groundnut digger developed and tested under prototype feasibility testing in Orissa
- Tractor-mounted rotavator accepted by farmers in many states as a time-saving equipment
- Lowland paddy seeder tested on a large scale in Tamil Nadu, West Bengal and Andhra Pradesh
- Self-propelled high clearance sprayer developed and commercialized
- Self-propelled vertical conveyer reaper accepted for harvesting rice and wheat in Rajasthan, West Bengal and Uttar Pradesh due to high capacity over manual harvesting with sickles
- Portable electronic weighing system for 1.5 tonnes weighing capacity developed for weighing draught animals

and chops it into pieces for spreading in the field in a single operation.

The modified cutter bar type machine has reel speed of 70 rpm and reel diameter of 457 mm. A reel is attached in the front to feed the straw to the cutter. The cut stubbles are conveyed to the chopping cylinder with the help of feeding cylinder attached between the cutter bar and chopping mechanism.

Comparative evaluation of the two rice straw choppers having different types of cutting mechanisms, i.e. flail type and cutter bar type was carried out for paddy straw management. Both the machines were operated in two different straw load conditions of 5.85 and 9.23 tonnes/ha using 37.3 kW tractors. Field capacity of flail type machine varied from 0.35 to 0.38 ha/h at speed of operation of 2.72 km/h. The cutter bar type rice straw chopper-cum-spreader gave field capacity from 0.35 to 0.37 ha/h at speed of operation from 2.65 to 2.69 km/h. After chopping, the straw was incorporated by two passes of disc harrow. Then the field was irrigated and subsequent sowing of wheat was done with no-till drill. The machine is commercially available.

Six-row inclined plate planter: Field trials of CIAE tractor-mounted inclined plate planter were conducted at 5 centres namely JNKVV Jabalpur, AAI Allahabad, MPKV Rahuri, OUAT Bhubaneswar and RAU Pusa centres in total 35 ha.

The seed rate observed for maize in Bihar was 20 kg/ha. The row-to-row spacing was 600 mm. The depth of sowing varied from 30 to 50 mm. At the forward speed of 3.4 km/h, the field capacity and field efficiency were 0.8 ha/h and 75%, respectively. The cost of operation was Rs 274/ha, whereas the cost of manual planting was Rs 480/ha. At OUAT, Bhubaneswar center trials were carried out in 15 ha for groundnut, mustard, maize and greengram in Gajapati, Rayaada Keonjhar, Jajpur and Puri districts. The machine gave field capacity of 0.20 to 0.43 ha/h for different crops in sandy



Inclined plate planter in operation

loam soil. The field efficiency of machine was 62 to 68% for the above said. The working width varied 1,200 to 2,400 mm for different crops. The cost of operation varied from Rs 526 to 1,130/ha. The farmers required spacing from 350 to 400 mm for mechanized sowing operation.

Tractor-drawn ridger seeder/raised bed planter: Tractor-drawn bed planter was demonstrated for sowing cotton crop in 2.4 ha area. The yield was 20% higher over control. There was 35-40% saving in irrigation water. The FLD was carried out at farmer's fields for sowing raya crop covering an area of 26.2 ha. The equipment demonstrated for sowing wheat crop at farmer's fields covered 5.4 ha. The average seed emergence was 189 plants/m² and an average yield was 44.45 q/ha. For sowing of clusterbean, pearl millet and mungbean machine covered total area of 12.2 ha. At farmers' fields there were savings of 25-30% irrigation water, 25% in seeds and 22-25% in fertilizer. The equipment is under large scale popularization. The machine was demonstrated at four centres (TNAU Coimbatore, PAU Ludhiana, JNKVV Jabalpur and GBPUAT Pantnagar) in total 80 ha.

TNAU, Coimbatore centre of AICRP on FIM conducted frontline

Tractor-drawn raised bed planter in working mode



demonstration trials of raised bed planter in total 9.4 ha. The field capacity and field efficiency of machine were 0.278 ha/h and 71%, respectively. The cost of operation was Rs 1,447/ha.

Flail type forage harvester-cum-chopper: PAU, Ludhiana centre has developed and commercialized a flail type mower-cum-chopper for fodder crop harvesting. In a single operation, the machine is capable of harvesting, chopping and loading of fodder crops such as maize, pearl millet, oats in a trailer, attached behind the machine.

Field trials of the machine were conducted at Research Farm, Punjab Agricultural University, Ludhiana for harvesting two major fodder crops. The harvesting of each crop was done after 70 days from the date of sowing. The machine was operated on different forward and flail speeds. The effect of these parameters was observed on the field performance of the machine in terms of average length of chopped fodder, fuel consumption, height of cut, throughput capacity, labour requirement and operational problems encountered.



Forage harvester-cum-chopper. Field trials were conducted for pearl millet and maize

The per cent-weight of chopped fodder up to 80 mm length increased with the increase in the flail speed at all levels of forward speed of the machine for both the fodder crops, i.e. pearl millet.

The throughput capacity of the machine increased with increase in forward speed from 2.16 to 4.40 km/h. The average value of throughput capacity increased from 7.55 to 14.97 tonnes/h for pearl millet fodder crop and 8.09 to 15.97 tonnes/ha for maize fodder crop at flail speed of 36.76 m/s.

Fuel consumption increased with the increase in the flail speed at all levels of forward speed of the machine, for both the fodder crops, i.e. pearl millet and maize. Increase in the flail speed resulted in the reduction of the length of chopped fodder per unit time, thus it involved more energy and increase in the fuel consumption. The overall cost of operation was Rs 1,725/ha at flail speed of 52.75 m/s and forward speed of 2.16 km/h.

Three manufacturers have started its commercial production and a few machines have been sold to farmers.



Rotavator: It is accepted by the farmers of Punjab, Maharashtra, Madhya Pradesh, Uttaranchal, Uttar Pradesh, Andhra Pradesh and Kerala, as a time-saving equipment under lowland and upland conditions. It saved 30–35% of time and 20–25% in the cost of operation as compared to tillage by cultivator. It gave higher quality of work (25–30%) than tillage by cultivator. Soil pulverization with rotavator was found to be better than traditional implements. It could be used effectively for intercultural operation in horticultural crops and for puddling in paddy cultivation. It destroyed weeds, stubbles of paddy, sugarcane, maize and cotton completely. A total of 1,124 ha was covered under frontline demonstrations by 13 centres of AICRP on FIM.

Zero-till-seed drill: It is highly accepted by farmers of Punjab, Uttar Pradesh, Uttaranchal and Bihar after harvest of rice for wheat and vegetable pea crops prevailing in these areas. At 8 centres,



Zero-till seed-cum-fertilizer drill in operation. The machine was demonstrated at Pantnagar (176 ha) and Jabalpur (650 ha) at farmers' field

demonstrations of machine covered 6,691 ha of wheat crop. Sowing is done timely as machine capacity is 4–5 ha/day. Human drudgery is reduced as less number of operations are required. The machine saved Rs 1,000–1,500/ha. The use of machine resulted in 5–6% increase in yield due to early emergence (one week). The machine use was 60–65% cost effective. It saved 60–70% diesel and time of operation. The machine could be used for Bengalgram and pea at NDUAT, Faizabad by replacing furrow openers with those of shovel type.

Eight centres of AICRP on FIM, viz. CIAE, TNAU, PAU, OUAT, CCSHAU, RAU, JNKVV, and GBPUAT conducted field trials in 6,691 ha. The machine was demonstrated at GBPUAT, Pantnagar and Jabalpur in 176 and 650 ha at farmer's fields.

At RAU, Pusa centre of AICRP on FIM the zero-till-drill machine was tested at farmer's field. The field capacity of the machine was found to be 0.65 ha/h and the field efficiency was recorded to be 84%. The seed rate and fertilizer rate were 1,256 kg/ha and 150 kg/

ha, respectively. The average row-to-row distance was measured to be 180 mm. The average number of plants per square meter was 110. The average number of tillers was observed to be 4. It has been found that population of *Phalaris minor* was reduced by 90% and *Chinopodium album* by 75% in the fields sown with zero-till-drill in comparison to conventional sowing. The machine was also demonstrated in Samastipur, Muzaffarpur, Madhubani, East Champaran, West Champaran, Saharsa, Madhepura, Begusarai, Patna, Bhagalpur and Nalanda districts of Bihar. The machine was also used for direct sowing of paddy, mustard, mung, lentil and gram crops. Sowing is done timely as machine capacity is 0.4–0.5 ha/h. Human drudgery is reduced as less number of operations are required. The machine saved Rs 1,000–1,500/ha. The use of machine resulted in 5–6% increase in yield due to faster emergence (one week). The equipment has been commercialized.

Pneumatic planter: The planter saved 16–40% in cost of operation compared to conventional practice by bullock-drawn seed drill. CIAE, Bhopal, TNAU Coimbatore and RAU Pusa conducted demonstrations in a total area of 61 ha.

Semi-automatic potato planter: The machine was demonstrated at NDUAT, Faizabad and CCSHAU, Hisar in 416 ha. Farmers adopted the semi-automatic potato planters due to saving in labour (80%) and cost of seeds (15–20%).

Sugarcane cutter planter: The planter was found to be a time saving equipment over traditional methods. It also saved labour due to combining of many unit operations in a single pass. Sixty-two frontline demonstrations of tractor-mounted sugarcane sett cutter planter were conducted at 5 centres for a total of 226 ha for various sugarcane varieties. The labour requirement and time of operation were reduced by 78% and 50%, respectively. The use of machine gave uniform depth and placement of setts. Planting of sugarcane could be done timely as machine covers about 1.2 ha/day, which also resulted in higher yield.

Strip-till-drill: In Punjab it has been accepted by a few farmers in combine harvested fields. Five centres demonstrated strip-till-drill in 433 ha area. Sowing is done timely as machine capacity is 3–4 ha/day. There was saving in time of 60–62% and in cost of operation by 50–55%. The increase in yield from 2 to 5% was observed at farmers field. The machine reduced human drudgery as less number of operations are required. The machine succeeded in fuel saving of 50–60%. The machine prepared good strip of soil and churned the weeds and stubbles.

Power tiller-operated Machinery

Power tiller-mounted air-assisted seed drill: For sowing small seed like sesame, cumbu and sorghum, TNAU, Coimbatore centre has developed power tiller-operated air-assisted seed drill. The spacing between the rows can be adjusted from 300 mm (for 4



Power tiller-mounted air-assisted seed drill for sowing small seeds like sesame, cumbu and sorghum

rows) to 600 mm (for 2 rows). The machine costing Rs 7,500 covers 2 ha/day. The power to seed metering shaft can be cut off by lifting the tool bar.

The machine was tested at Regional Research Stations, Paiyur, Aruppukkottai and Kovilpatti. Trials were also conducted at farmers field in Veerakeralam. The field capacity of the unit and the fuel consumption were 0.15 to 0.2 ha/h and 0.8 to 1 litre/h, respectively. The cost of sowing of air-assisted seed drill was Rs 250/ha.

Power tiller-operated groundnut digger: A power tiller-operated groundnut digger has been developed by OUAT centre of AICRP on FIM and tested under prototype feasibility testing in different locations in Orissa. The equipment was tested in farmers' fields in village Debil and Bahupadar under sandy loam and clay loam soil at a moisture content of 9.5% and 5.5% (wb), respectively. Effective field capacity and field efficiency varied from 0.05 to 0.07 ha/h and from 72 to 78% respectively.

The harvesting efficiency and cost of operation varied from 97 to 98% and from Rs 1,448 to 2,027/ha, respectively. Effective working width varied from 566 to 575 mm and labour requirement varied from 14.3 to 20 man h/ha. Fuel consumption during test trials was observed from 1.6 to 1.65 litres/h. The power tiller-operated groundnut digger loosened the soil so that groundnut plants with pod could be easily picked up. The machine proved useful under low soil moisture content. The pods remaining in the soil were less than 3%, which could be recovered once the soil was loosened.

Power weeder: The power weeder covered one ha in a day using one operator and two labourers for weeding in between the rows. This equipment was demonstrated in 180 ha area by 5 centres. The farmers observed that use of machine reduced cost of

cultivation, labour and time of operation. The machine performed well when ridges and furrows are less pronounced. The cost of operation was 1/3–1/2 compared to manual weeding. The power weeder worked well in cotton, jasmine, sugarcane, grapes and tapioca crops.

Stationary Machinery

Rice thresher for small farmers: A 0.5 hp single phase electric motor powered thresher for rice has been developed. It is suitable for small farmers, especially farmers of hilly regions. This thresher operates in hold-on mode. It was evaluated for threshing Kranti variety of rice. With a threshing efficiency of 96–98%, the thresher gave an output of 100–150 kg/h. Labour requirement was observed to be 14–20 person-hours/tonne. Initial cost of thresher is estimated to be Rs 8,000 (including Rs 3,000 for motor) and the cost of operation Rs 250–300/tonnes (including labour charges). Weighing only 45 kg (with motor), it can be easily carried by two persons in the hilly terrain.

High capacity groundnut thresher: High capacity spike tooth type axial flow groundnut thresher (PAU design) was selected for feasibility testing. The thresher consisted of threshing cylinder, concave, cleaning system, a blower and a feeding platform. The



Stationary view of groundnut thresher

modifications included change of concave from perforated GI sheet to MS bar type to reduce thrower loss, increase in the opening size/area of cleaning sieve for free flow of pods and provision to check sieve overflow and bifurcation of air flow to both sieves for better cleaning. Cleaning and threshing efficiency ranged from 96.1 to 99.4% and 97.8 to 99.4%. Broken grain loss was almost negligible but breakage of pods was observed at 300 rpm (less than 1%).



Whole crop maize thresher (5.5 kW capacity) in operation

Whole crop maize thresher: The thresher (5.5 kW capacity), was designed with spike tooth cylinder with bolts or flats (6–7/row) fitted in 6 rows on cylinder. Concave was provided with 8 mm square bars at a spacing of 18 mm. Two speed arrangements were provided (720 rpm and 540 rpm) for the threshing cylinder. Two blowers provided better cleaning of grain due to higher straw content. The sieves of 12.5 mm and 4 mm were provided for the removal of trash. Field tests of the thresher gave an output of 3.5–4 q/h and straw size was less than 50 mm.

Straw combine: Demonstrations of straw combine were carried out at CIAE Bhopal, CCSHAU Hisar and GBPUAT Pantnagar in 95, 254 and 105 ha, respectively. Total area covered by the machine

Straw combine in operation at farmer's field



was 454 ha in Madhya Pradesh, Haryana and Uttaranchal.

The test trials of straw combine, at CCSHAU, Hisar centre, gave average field capacity 0.4 ha/h at speed of operation of 2.5 km/h. Average fuel consumption and cost of operation were 4.0 litres/h and Rs 800/ha. Straw recovery was 70.7% with good quality. The straw split was 92.36% and length of *bbusa* was 23 mm. There was an additional grain recovery of 141 kg/ha. The cost of grain recovered is almost equal to the amount paid for hiring the machine. The time required in completing the operation of harvesting and threshing with traditional practice (manual harvesting + threshing with mechanical thresher by manual labour) was about 20 h. Whereas with combine + straw reaper is 3.5 h. During the last two years 3,500 units have been procured by farmers in Haryana.

Sunflower thresher: TNAU Coimbatore centre conducted field trials of sunflower thresher for 112 h at farmers' field. It was introduced by the UAS, Raichur centre in Karnataka. The PFT trials have shown very high acceptance by farmers as there is negligible damage to the seed and very high threshing efficiency (99%). At UAS, Raichur centre, the thresher was demonstrated for 11.5 h. The axial flow sunflower thresher gave 3–4 times higher threshing capacity than conventional thresher. The use of thresher completed the job in shorter time reducing human drudgery. The threshing efficiency was higher (99.5%) and broken grain percentage was very less (<1%). The farmers got sufficient time for subsequent operations for next crop due to timely completion of threshing. It saved 75% labour, time of operation and 30–40% cost of operation as compared to the traditional method.

High capacity multicrop thresher: It was demonstrated at CIAE Bhopal, UAS Raichur, AAI Allahabad and CCSHAU Hisar for a total of 325 h for wheat, sunflower, Bengalgram, sorghum, pigeonpea and soybean. CIAE Bhopal centre demonstrated high capacity multicrop thresher for 160 h. The high capacity thresher was demonstrated among farmers of Allahabad (Uttar Pradesh) and Dharwad (Karnataka) for threshing safflower and redgram. At Dharwad, the thresher gave three times more output than local thresher and it saved 50% labour and time of operation. It reduced human drudgery through saving of time for the same quantum of crop compared to local thresher. The thresher gave clean grain (99%) with negligible grain losses (< 2%).

Paddy thresher (hold on): It is very popular in West Bengal and Tamil Nadu. It was taken up under FLD in Kerala by KAU, Tavanur centre and accepted by the farmers as it saves straw from any breakage. This thresher was found 1.5–2 times more cost effective. About 90% of clean grain could be obtained which further required separate cleaning by employing one man-h/q. For small holdings, it was accepted due to less drudgery and more output



than hand beating. The thresher was highly appreciated due to negligible broken material for fine and medium varieties of paddy in BAU, Ranchi, and it was demonstrated for a total of 180 h.

Manually-operated Machinery

Lowland paddy seeder: It was tested on a large scale in Tamil Nadu, West Bengal and Andhra Pradesh. It was accepted by the farmers as a new technology. Grain yields were higher than transplanted rice and broadcasting method. Line sowing helps in easy interculture and weeding operation. It can be fabricated locally. It was demonstrated by four centres on a total of 121 ha.

Cono weeder: It was used in combination with paddy row seeder in Tamil Nadu and West Bengal. The cono weeder was demonstrated for paddy covering 353.5 ha at seven centres. The implement reduced drudgery due to less time taken (50–55%) compared to hand weeding. The use of the equipment was cost effective by 40–45%. Due to shortage of labour for timeliness of operation, farmers liked the equipment for enhancing productivity. The equipment proved acceptable to women labourers for faster and higher coverage.

Self-propelled Machinery

Self-propelled biasi cultivator: The commercially available light weight power rotary tiller was modified to develop self-propelled biasi cultivator to overcome the problems associated with



Field testing of self-propelled biasi cultivator

the traditional animal-operated biasi tools and to maintain timeliness of biasi operations. The machine is operated by 3.36 kW (4.5 hp) 1,500 rpm light weight diesel engine. Cost of the machine is Rs 50,000. The field performance of self-propelled biasi cultivator in 35 days old dry seeded rice with 150 mm depth of standing water showed that the biasi operation was cost-effective by 15.9 and 47.7% and work rate of self-propelled biasi cultivator was higher by 52.1 and 70.4% over the animal-drawn two bottom biasi

- For planting okra and pea seeds animal-drawn raised bed planter developed
- Commercially available bullock-drawn sprayer modified in respect of orientation of beam and hitch system, operator seat and clutching system for the pump based on the feedback from the field test in soybean
- Wheeled tool carrier developed with attachment of tools for tillage, seeding and interculture
- Technology for hardening of hoof shoes developed
- Economics of animal-based farming system with improved package of implement and practices studied for different cropping system

plough and improved wedge plough, respectively.

Mini combine: The self-propelled mini combine (Model no 4 L 80, Sifang, India) was tested for wheat at CIAE, Bhopal and IIT Kharagpur. The rated power of combine and rated width are 5.15 kW and 800 mm, respectively. It is provided with rubber wheels (size 584 mm × 254 mm) inflated at pressure of 2.11 kpa. For harvesting in paddy fields, these wheels need to be replaced with iron wheels having diameter of 780 mm. The rated engine speed and specific power consumption are 2,600 rpm and 278.8 g/kWh, respectively. The operation can be performed at a speed of 1.6 and 4 km/h in first and second gears.



The field performance of mini combine was assessed for wheat crop at moisture content of 15.4% (db)

The field performance of the mini combine was assessed for the wheat crop at moisture content of 15.4% (db). The combine gave an average field capacity of 0.142 ha/hr and field efficiency of 74%. Fuel consumption and broken grain loss were 1.65 litre/h and 2.1%, respectively.

Rice transplanter (8-row): It was used by the farmers on their own due to scarcity of manual labourers in the areas. Mat type of seedlings helped in growing more number of tillers per



SUCCESS STORY

Custom hiring of improved equipment in Haryana

The farmers and unemployed youth were motivated to use equipments on custom hiring basis as an enterprise. There was wide spread response in its adoption, particularly in areas where paddy-wheat crop rotation is followed. The farmers and unemployed rural youths have already purchased 1,992 rotavators. The enterprising farmers and unemployed rural youth engaged in custom hiring business of rotavators are charging on an average Rs 1,000–1,500/ha for puddling in paddy and Rs 1,500–1,800/ha for sowing of wheat after harvest of paddy. The average area covered by one entrepreneur is about 125–130 ha/year (80 ha in puddling and 50 ha for wheat sowing). The net profit by an individual is about Rs 101,625/year. The pay-back period of rotavator is just one season. The total estimated area covered in Haryana with the use of rotavators in 2004–05 and 2005–06 for puddling was 30,000 and 40,000 ha, respectively. The total estimated area covered to prepare field as reduced tillage technology after harvest of paddy for sowing of wheat in 2004–05 and 2005–06 was 50,000 and 60,000 ha, respectively.

The farmers and young unemployed rural youths have already purchased 8,480 zero till seed-cum-fertilizer drills. Zero-till seed-cum-fertilizer drill covered 4–5 ha/day.

The entrepreneurs/farmers are charging on custom hiring an average Rs 900/ha. Total earning is estimated to be Rs 10,000–12,000/year and the pay-back period of machine is two years. There is about 70–80% saving in fuel. The capacity of machine is 0.4 ha/h. The price of machine is Rs 16,000. The average area covered by an entrepreneur was 50 ha/year. The total area covered by zero-till drill in Haryana was about 5 lakh ha. It saved Rs 2,500–3,000/ha in the cost of wheat production. There are about 25 manufacturers engaged in the production of zero-till seed-cum-fertilizer drill. Zero-till seed-cum-fertilizer drills are being used on large scale in paddy-wheat rotation, particularly to conserve residue of previous crop and to save energy, time and money.

It is estimated that about 50% area under wheat crop is harvested by combine harvester in Haryana with the introduction of straw combine. Farmers were motivated to buy straw combine for self use and on custom hiring for increasing their income. Nine farmers purchased this machine. The area covered by these

farmers was 199 ha (own) and about 570 ha on custom hiring and on an average area covered by a farmer is about 85 ha. The average rate of custom hiring varied from Rs 1,250/ha to Rs 1,325/ha. Average grain recovery was 100–120 kg/ha and *bhusa* recovery was 25q/ha. The cost of machine is Rs 90,000 to 1,20,000 depending upon quality and capacity of machine.

The machine gave a net return of Rs 2,400/ha to the machine owning farmers and about Rs 2,100/ha to one who gets the works done on custom hiring basis. The average field capacity of machine was 0.4 ha/hr while operating at speed of 2.5 km/h. The average fuel consumption was 4 litres/h and two persons are required for its operation. The cost of operation was Rs 800/ha. A farmer can save on an average Rs 66,250–72,625 while the annual expenditure is about Rs 40,000/year. The pay back period of machine is two years only.

The total estimated area covered by straw combine is about 6 lakh ha. The estimated numbers of straw combines in Haryana are about 5,050.

The farmers and rural youth were motivated to buy high capacity multicrop thresher and adopt custom hiring business. About 30 farmers having land from 1 ha to 10 ha were pursued to buy their own thresher and do custom hiring business. All these farmers purchased their own thresher and have adopted it as an enterprise for custom hiring. In *rabi* 2004, area threshed on custom hiring was 137 ha and 327 ha under *raya* and wheat crop, respectively whereas in *rabi* 2005, the area threshed under different crops was 152, 152 and 40 ha (own area) and 431, 780 and 600 ha (custom) under *raya*, wheat and gram crops, respectively. However, the area (1000 ha) threshed by high capacity multicrop threshers in Haryana was about 1,400, 90, 400, 500 and 11 out of total area 2,300, 142, 585, 536 and 13.6 in wheat, chickpea, pearl millet, *raya* and moong crop, respectively.

The farmers and young unemployed rural youths had already purchased about 15,500 high capacity multicrop thresher till 2005–06. The net saving per year is estimated to be Rs 86,000 and the pay-back period is one year. The capacity of machine varies from crop to crop, makes and models. The price varies from is Rs 70,000 to Rs 80,000.

hill. Eight centres conducted demonstrations of self-propelled rice transplanter for different paddy varieties covering a total of 436 ha. The farmers felt that the machine really eliminated human drudgery due to riding facility and very less (1/10) area requirement for raising mat type nursery. The machine saved 80% labour and increased yield by 10–12%. It gave cost effectiveness up to 47% compared to hand transplanting. The machine covered 1–1.2 ha/day and only 4–5 persons were engaged. Training to farmers for mat type nursery raising and machine operation at

each centre resulted in success during large scale demonstration under all types of soils.

High clearance sprayer: It was developed by the PAU, Ludhiana centre and commercialized. UAS Raichur centre introduced it in Karnataka among cotton growers and has been found to perform better as compared to local sprayers. The frontline demonstration of sprayer was conducted in 10 ha area by two centres, organizing demonstrations on cotton without any mechanical damage to the crop even when the crop height was up



SUCCESS STORY

Farm mechanization for tribal region in southern Rajasthan

The equipments demonstrated in Udaipur, Chittorgarh and Banswara districts were tractor-mounted rotavator (42 ha), CIAE multipurpose tool frame (22 ha), power weeder (14 ha), PAU tractor-mounted multicrop planter (40 ha), self-propelled vertical conveyor reaper (65 ha), manual garlic planter (5 ha), CIAE power-operated groundnut thresher (102 h), CIAE high capacity thresher (89 h), multicrop thresher 5 hp Amar make (166 h).

to 1.5 m. During demonstration a good swath (13.5 m) and efficient spraying were observed. It saved 15–20% labour and time and 30% in the cost of operation. It was found that yield increase of 10% was achieved in the demonstration fields.

Vertical conveyor reaper: It is accepted for harvesting of rice and wheat in Rajasthan, West Bengal and Uttar Pradesh by farmers due to high capacity over manual harvesting with sickles. It is commercially available at many places. The self-propelled reaper was demonstrated for rice and wheat for different varieties and soil conditions covering 1,132 ha at 15 centres. It saved 50% labour and cost of operation and 75% operating time. The reaper covered 1.5 ha/day by employing two operators alternately to avoid ill effect due to vibration of handles of the machine.

Animal-drawn Machinery

Animal-drawn raised bed planter: For planting of okra and pea seeds animal-drawn raised bed planter has been developed by mounting 2-row inclined plate planter unit on a bed former. The cost of the unit is about Rs 3,000. The results of field trials have shown an average of 10% increase in yield of okra and peas with savings in irrigation water by 15%. The machine may be more useful in lighter soils for vegetable cultivation.

Bullock-drawn sprayer: The commercially available bullock-drawn sprayer was modified in respect of orientation of beam and hitch system, operator seat and clutching system for the pump based on the feedback from the field test on soybean. The unit having 0.1 m ground clearance was operated at speed ratio (wheel : pump) of 1 : 4 through pulley-belt drive. Six hollow cone nozzles on 5.4 m boom while working at 2.4 km/h speed (112.5 kg draft) gave a discharge of 410 ml/min-nozzle at an average pressure of 344 kPa. The tank capacity is 200 litres for pesticide solution which could be operated for 40 min only at a stretch. The actual work rate was 0.4 ha/h. The unit costs Rs 25,000. The sprayer would be useful for spraying pesticides in soybean, cotton, pigeonpea and other crops.

Tool carrier: Wheeled tool carriers have been developed with attachment of tools for tillage, seeding and interculture. The unit consists of main frame, tool bar and wheel (pneumatic/iron wheels) with provisions for attachment of tools and lifting of tools on turns. The wheeled tools carrier showed advantage in terms of higher command area (1.5–2.5 times) than the conventional implements. The unit with attachments may cost Rs 20,000.

Portable electronic device for weighing draught animals

Portable electronic weighing system for 1.5 tonnes weighing capacity (least count –200 g) has been developed for weighing of draught animals. The system can be operated with 12 V battery and inverter when grid electricity is not available. Average weighing time per animal is 30 s as compared to 129 s for the mechanical-cum-manual system. The labour requirement for weighing of animal is 1.1 person-h/100 animals compared to 7.2 person-h/100 animals with mechanical weighing system. The system can be assembled in 40 min. at the site and found useful for weighing of draught animals in villages.

Improved yokes and harness

Modified yokes have been developed at different centres of the AICRP on UAE to suit the local draught animals as per their size and neck configurations and using local materials.

The modified yokes for bullocks showed an average of 10% increase in pulling capacity resulting into 10–15% increased command area per season. The improved yoke caused no injury to the neck of animals even during prolonged use due to increased contact area of yoke on the neck muscles facilitating reduced pressure on neck and preventing frequent sliding of yoke causing frictional injury on the neck.

Equipment for donkeys in farm operations

Raichur centre of UAE has developed package of equipment for donkey (body weight 160 kg for large white Kathiawad breed) matching their draft capacity (25% of body weight). The package includes iron plough, blade harrow, two-row seed drill, blade hoe, two-wheel steel cart and agro processing gadgets (chaff cutter, caster decorticator and winnower) for operation in rotary mode.

Rotary transmission system for rotary mode application of draught animals

Rotary mode operations of draught animals, especially in off season, would increase the annual utilization by 300–400% compared to the present utilization of about 400–500 h/year. Efforts have been made to develop suitable transmission system for high speed applications. The system consists of a set of bevel gears that converts horizontal rotary motion of draught animal to



SUCCESS STORY

Farm Mechanization Research in NEH Region

NEH, Barapani centre of AICRP on FIM evaluated 4-row manual paddy seeder (15 kg weight). It was pulled by single person which provided field capacity from 0.04 to 0.06 ha/h. The seed rate used between 60 and 80 kg/h in seeder (overall dimensions 1,700 × 940 × 600 mm). The net saving with the use of seeder was Rs 2,000/ha. The labour requirement was 30–40 man-h/ha.

NEH, Barapani centre of AICRP on FIM has developed manual seed drill (13.80 kg weight). The overall dimensions of seed drill are 87 cm × 44 cm × 110 cm. The drive ratio from ground wheel (diameter 40 cm) to metering shaft is 1 : 1. The V-shaped furrow openers; seed hopper (capacity 2 kg) and cup feed type seed metering are salient features of machine. The balanced machine operated by two persons proved boom for farmers for sowing maize and pigeonpea.

NEH, Barapani centre of AICRP on FIM adopted light weight power tiller powered by 3.7 kW diesel engine (Amar make). In valley farmers appreciated its use on narrow terraced lands. The shifting of unit from one terrace to other was easy due to small turning radius and light weight. During field test, the field capacity varied from 0.06 to 0.08 ha/h in tilling. The fuel consumption was from 1 to 1.25 litres/h.

Self-propelled vertical conveyor reaper has been demonstrated on farmers' fields on large scale for rice crop in valley land of the region. Total 5.0 ha was covered during harvesting season of 2004 and 6.0 ha in 2005. The average field capacity of the machine was observed around 0.05 ha/h.

A motorized paddy thresher has been developed and

promoted in the region, which helps in completion of operation in time. In this operation, threshing of paddy crop can be done by holding paddy bundles against moving cylinder and blower helps to throw the broken chaff at some distance away from grain. Thus grain obtained have less chaff and broken straw than pedal type thresher. Overall dimensions of thresher are 850 mm × 750 mm × 750 mm (lxbxh) and total weight excluding prime mover is 50 kg. Two persons are employed to perform threshing operation. One person holds paddy bundle against moving cylinder and second person is required for supplying paddy bundles. Threshing cylinder and prime mover can easily be detached (if necessary) from the frame to enable easy transportation of thresher in hilly area.

Grain output capacity was about 4–5 times more in power thresher as compared to pedal type depending upon crop condition and variety. Labour requirement in per quintal of threshed grain was only one man-h in power thresher and 5 man-h in pedal thresher. Thus there is about 80% saving in labour requirement and cost of threshing grain can be saved up to 74% by using power thresher as compared to pedal type paddy thresher.

For the purpose of winnowing, the farmers of north-east region are mainly dependent on natural wind. The average output of the manual winnower was observed from 2.5 to 3.5 q/h. Due to timeliness of operation, it is gaining much popularity among the farmers of this region. Equipment has been demonstrated for 200 h during last two years.

vertical rotary motion with stepping up speed in the ratio of 1 : 5. The output from the bevel gear has been further stepped up by two sets of spur gears making the combined speed ratio of 1 : 120. A shaft enclosed in a hollow pipe transmits power to the gadgets outside the circular track. The MPUAT, Udaipur centre has provided fly wheel for maintaining uniform rotary speed to the gadgets. A ratchet has also been provided to cut off power when the draught animal stops walking or walks slow. Chaff cutter, paddy thresher, winnower, caster decorticator and few other gadgets are being evaluated at different centres.

Saturation of improved animal-drawn implements in villages and FLDs

Improved equipment packages specific to the prevailing cropping systems in the identified regions were introduced to the farmers in participatory mode. The working of equipment were demonstrated to the farmers through FLDs and feedback was collected for design improvements.

The feedback has revealed that with improved package of

tillage, seeding and inter-culture equipment, 15–25% additional area could be commanded by a pair of draft animals. Using improved package of equipment and practices the farmers have reported 3–5% increase in yield of rice with 18.75% higher cost effectiveness compared to their traditional practices (grain yield 2.9 tonnes/ha and benefit cost ratio 1.44). Similar trend was also reported for other crops. The cost of package of improved tillage/puddling, seeding and interculture equipment for different cropping systems is about Rs 10,000.

Commercialization and mass production of hardened hoof shoe

Technology for hardening of hoof shoes was developed. Pantnagar centre has manufactured 3,000 hardened hoof shoes and supplied to users. Die for mass production of hoof shoe based on the average dimensions of hoof was also developed. Results of FLD showed that the life of the hardened hoof shoes increased by 147% compared to the traditional hoof shoes (life = 145 h) and resulted into savings on the cost of shoeing.



Economics of animal-based farming system

Economics of animal-based farming system with improved package of implement and practices has been studied for different cropping systems. At CIAE Bhopal for bullock-operated rice (direct seeded)—wheat (zero tillage) system the annual productivity was 7.4 tonnes/ha (rice=3.6 tonnes/ha and wheat = 3.8 tonnes/ha) giving overall benefit cost ratio of 2.04 : 1.00. Besides, the specific operational energy and specific cost of production were 1.26 MJ/kg and Rs 2.55/kg of grain produced, respectively.

Horticultural tools

Field trials of horticultural equipment were organised at ten centres namely CIAE Bhopal, TNAU Coimbatore, BAU Ranchi, PAU Ludhiana, KAU Tavanur, MPKV Rahuri, IIT Kharagpur, UAS Raichur, CCSHAU, Hisar and HPKV, Palampur. A total 188 demonstrations of manual and power-operated equipment, namely pruner, chainsaw, grubber, wheel hoe, hedge cutter grafting and budding knives, bill hook, crowbar, fruit harvester, knapsack/rocker arm sprayer, engine powered post hole digger were organised at farmers fields.

TNAU, Coimbatore centre organised a total of 40 demonstrations of horticultural equipment in 16 districts in which 1,427 farmers got familiar with use of these tools and benefited.

PAU, Ludhiana centre organised FLD trials of manual and power-operated horticultural equipment in 16 ha. IIT, Kharagpur centre demonstrated budding knife, lopper, secateur, hedge shearer and wheel hoe for horticultural crops. The capacities of budding knife, secateur and hedge shear were 50–60 grafting/day, 6–7 plants/h and 24 min/hedge, respectively.

KAU, Tavanur centre organised a total of 64 frontline demonstrations of horticultural equipments, namely post hole digger, budding and grafting tools, tree pruners, fruit pluckers, rotavator and mini tillers.

AAI, Allahabad centre demonstrated power chainsaw for cutting tree branches of 310–430 mm diameter at 17 places. The equipment required operational skill to avoid accident. The centre also demonstrated engine powered post hole digger for digging of 445 pits.

BAU, Ranchi centre conducted demonstration of horticultural equipments, namely garden rack, weeding fork, weeding trowel, garden hoe, dutch hoe, pruning secateur, digging fork and hand cultivator. Weeding fork and garden rack gave 3–4 times output capacity as compared to local method. The output capacity of weeding trowel was 6–7 times more than local *khurpi*.

HPKV, Palampur centre demonstrated manually-operated fruit harvester at farmers' field for different fruit crops. The capacity of equipment was 125 fruit/h. The centre also carried out trials of rotavator, ridger, lister, post hole digger etc. under horticultural crops cultivation.

RAU, Pusa centre carried out test trials of manually-operated horticultural equipments namely grass shear, weeding trowel, dutch hoe, hand cultivator, falcon *khurpa* and hand weeder. Farmers appreciated the usefulness of equipments due to high output and lesser fatigue as compared to local hand tools.

CCSHAU, Hisar centre conducted FLD trials on *aonla* picking tool. The manual *aonla* picking tools with 10 nos. of serrations was demonstrated at farmers field which saved costing picking with good quality produce. The centre also demonstrated post hole digger by digging 12,550 pits for planting jatropha, *aonla* and *jamun*, in Shahbad (district Kurukshetra), Agroha, Daulatpur, Baheri, and Dobi (district Hisar).

Ergonomic studies

Ergonomical layout of tractor operator's workplace: The dimensions and location of the important and frequently operated controls of tractor like steering wheel, hand accelerator lever, brake pedals, clutch pedal, gear-shift lever, accelerator pedal etc. have been worked out on the basis of compiled anthropometric data of over 5,000 male Indian agricultural workers and existing work



Ergonomical layout of tractor operator's workplace

place layout of some tractors. Recommendations have been made for optimum length/breadth of accelerator/brake/clutch pedals, steering wheel diameter and its rim thickness.

Tractor seat based on anthropometric data: The seat dimensions of five designs of seats provided on tractors of leading tractor manufacturers in the country were measured using 3-D digitiser in the laboratory. The results indicated that there was wide variation in seat dimensions on different models of tractor seats provided by different manufacturers. However, the different models of the tractors are being used by the same anthropometric population of Indian tractor drivers.

The dimensions for the appropriate design of seat of a tractor were optimized based on compiled anthropometric data of 5,434



male agricultural workers and ergonomic evaluation of five commercial tractor seats. The recommendations of the study are being passed on to leading tractor manufacturers for modification of seats on existing tractors through consultancy projects.

Belt and chain conveyer feeding system for high capacity thresher: A belt and chain conveyer feeding system was developed by PAU centre of AICRP on ESA in collaboration with an industry. The thresher with this type of feeding mechanism was tested for threshing of wheat crop from 16 ha, i.e. about 70 tonnes of crop. The thresher was operated by a 55 hp tractor. The throughput capacity of the thresher was 3.3 tonnes/h and the output capacity (grain) was 1.5 tonnes/h. Not only the labour requirement was reduced, the drudgery involved in feeding of crop to the thresher was also reduced as the crop was to be lifted to waist height only as against 180 to 240 cm (above shoulder height) in case of traditional high capacity threshers.

Safety gadgets for sugarcane crusher: A power-operated sugarcane crusher is one of the accident-prone equipment. TNAU centre, Coimbatore has developed safety gadgets to make the operation safer for workers. The gadgets include feed plate/feed chute, guard for power transmission system, tool for applying grease to transmission system and a hand hook for begasse removal. These devices were demonstrated to the farmers.

AGRICULTURAL ENERGY AND POWER

Renewable Energy Technologies

Solar tunnel dryers: CIAE Bhopal and SPRERI V V Nagar centres have developed low tunnel solar dryers of different geometries. The dryers consist of two sections—one works as solar air heating section and other as drying section. Solar photovoltaic unit-operated mini DC fans have been used for circulation of air and removal of humidity from the drying unit. The solar dryers have been evaluated for drying various fruits, vegetables and fish. The inlet air temperature increased by 20°–30°C in the dryer. Clean, unprocessed Bombay duck fish having moisture content of up to 85%, got dried in 10–11 clear sunshine hours in the dryer. Drying time for unripe mango pieces, gooseberries and chilli, in general, reduced by 50% in the dryer as compared to open sun drying. Besides, quality in respect of microbial count, ascorbic acid and acidity of the product obtained from the dryer was significantly superior to the open sun-dried product.

High rate anaerobic treatment system for dairy effluent: Based on the technology developed at SPRERI centre of the AICRP on RES, a pilot plant for anaerobic treatment of dairy effluent has been designed, installed and commissioned at Vidya Dairy of Anand Agricultural University, Anand. The plant consists of a collection chamber, an anaerobic filter and gas storage unit, biogas-based

SUCCESS STORY

Anti-cancer properties of soybean and soy-isoflavones

An *in vivo* study was conducted to explore the anti-cancer activity of soybean and its isoflavones on B16-F10 melanoma tumour in mice with special reference to tumour growth inhibitory, therapeutic and preventive effects. Among various treatments, the maximum regression in terms of the volume doubling time (VDT) and growth delay (GD) was observed in case of the therapeutic treatment with daily intake of FFSF or isoflavones @ 1 g or 0.88 mg, respectively/kg body weight of mice, given orally. For both the parameters the effects were highly significant ($P < 0.0001$) as compared to control. The response of silent period and VDT of preventive effect was also highly significant ($P < 0.0001$) while the GD was significant ($P = 0.030$) as compared to the control.

The mean survival time (MST) of 39.25 days and 41.5 days for FFSF and isoflavones treatment respectively, against 30.76 days for control, in growth inhibitory effect were also highly significant. In case of therapeutic treatment, the MST were 28.6, 40.0 and 44.9 days for control, FFSF and isoflavones, respectively. The preventive treatment of soyflour and isoflavones were observed to be most effective in increasing MST (41.5 and 46.6 days as against 29.2 for control group). The results indicate that the treatment of FFSF and isoflavones, in both the treatments exhibited highly significant increase in the MST ($P < 0.0001$).

Oral administration of FFSF and isoflavones observed to produce 33.33 and 41.37% increase in life-span in the growth inhibitory experiments. The respective percentage increases in life span were 28.79 and 42.42% for therapeutic and 38.33 and 55.33% for preventive treatments for FFSF and isoflavones. It has thus been concluded from the study that daily intake of recommended levels of appropriately processed soybean (60–65 g) or isoflavones (1 mg/kg body weight) has highly significant effect in retarding or preventing cancer and also increasing mean survival time and life-span of cancer patients. No curative effects have however, been observed.

power generating system and necessary pumps, piping and accessories to treat 12,000 l/d of effluent having organic load of 15,000 mg COD/l. The treatment plant including power generating set costs about Rs 6.5 lakh. The plant is producing 95 m³/d of biogas having 80% methane content and the residual COD of the effluent is reduced to only 1% of the COD of the influent in the reactor.

Family size floating dome type biogas plant for solid-state digestion of cattle dung: The MPUAT Udaipur centre of AICRP on RES modified 2 m³ capacity floating dome KVIC biogas plant for solid-state digestion of cattle dung. The inlet of the plant has been replaced with RCC/OVC pipe of 30 cm internal diameter,



SUCCESS STORY

Entrepreneur established soy-based food products enterprise with technical help of CIAE Bhopal

SPU Centre of CIAE, Bhopal has developed process technologies for 24 soy products and 18 equipment and regularly organizes entrepreneurship development training programmes for transfer of process technologies to upcoming entrepreneur. About 866 participants from different states attended the same and 160 entrepreneurs established their own cottage scale soy processing enterprises at different regions of the country. Mr Eknath Dhamdhare is one of them who is successfully running his soy-based food products enterprise under the banner of Sangram Soy Food Products at Mundhawa, Pune, Maharashtra.

laid at a minimum angle of 75° with horizontal and the upper end of the pipe kept approximately 1 m above the ground level for easy feeding of dung under gravity. An agitator has been provided inside the gasholder for breaking the scum. Provision has also been made for locking the gasholder. Initially the plant is charged with well-prepared 1 : 1 mixture of cattle dung and water and 10% digested slurry collected from a plant under operation. When the plant gets stabilized the substrate is changed to fresh cattle dung.

Biogas plant 2, 3 and 4 m³ capacity have been installed at more than 50 selected users' sites during the last 2 years in Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Assam, Gujarat, Karnataka and Tamil Nadu. Compared to the common designs, these plants cost up to 10% more, but require 75–100% less water for operation, produce up to 30% more gas, require ¼th space for slurry drying, and feeding/handling of digested slurry is far more easier.

Technology for enrichment of biogas digested slurry:

UAS Dharwad centre carried out operational research demonstrations of the technology at 5 selected farmers' fields. All the farmers owned 2 m³ or bigger biogas plants and used lignite based PSB D1 culture @ 100 g for every 100 litres of digested slurry along with rock phosphate for enrichment. The incubation period was 30 days. The enriched biogas slurry was used by the farmers for growing onion, groundnut and potato crops in *kharif* 2005 season. It was found that the crop yield in plots treated with P-enriched biogas slurry was almost at par with the plots given recommended dose of mineral fertilizers.

Anaerobic digestion of crop residues: The SPRERI centre of AICRP on RES studied anaerobic digestion behaviour of rice straw and sugarcane trash at 25% and 35% total solid concentrations and 35°C reactor temperature. The C : N ratio was

adjusted by adding oilcake and FeCl₃ was used as process enhancer. It was found that the substrate at 25% TS and supplemented with FeCl₃ and organic nitrogen resulted into substantially higher gas yield (210 litres/kg TS for sugarcane trash and 280 litres/kg T for paddy straw) in 35 days of incubation period. Subsequent bench scale trials were encouraging. The gas production was in the range of 370–430 litres/kg TS.

Biogas burner for community applications: CSKHPKV Palampur centre of AICRP on RES has developed blower type biogas burner for community applications. It consists of an electric motor, gas nozzle, gas mixing column and conical flat type burner. The cost of these burners has been found to be Rs 2,000–2,500. The burner efficiency of 70% has been recorded as compared to 42% for the conventional ring type burner of 1.1 m³/h gas burning capacity. The blower type burner is under regular use in veterinary hostel of the University at Palampur.

Technology for biodiesel (ethyl ester) production:

GBPUA&T Pantnagar centre of AICRP on RES carried out studies on esterification of raw Jatropha oil with ethanol using KOH as catalyst. Various levels of aqueous ethanol, catalyst concentrations and reaction temperatures were investigated using 6 : 1 molar ratio for oil and alcohol, reaction time of 90 min and settling time 24 h. The results of the study indicated that the Jatropha oil at 6 : 1 molar ratio may be treated with 170° proof ethanol at 70–75°C reaction temperature for 90 min in presence of 3% KOH and the allowed to settle for 24 h to get maximum ester recovery with lowest possible kinematic viscosity. The result of 12 h continuous rating test of 3.73 kW engine at a constant speed (1,500 rpm) using methyl and ethyl esters and diesel fuel indicated that the fuel consumption and emissions of HC and CO were lower for ethyl ester of Jatropha oil as compared to methyl ester.

Industrial scale solar drying of fruits and vegetables:

SPRERI Vallabh Vidyanagar centre installed a forced flow solar drying system on a farm near Ahmedabad for drying 125 kg of tomatoes per batch. The PAU design, packed bed type, solar air heater used in this system is 30–40% more efficient than conventional solar air heaters. The drying system was provided with LPG back-up for supplementing the heat for operation during cloudy weather/non-sunshine hours. The total investment in the system has been about Rs 4.1 lakh and the cost of dried tomatoes has been estimated to be Rs 50/kg. Comparative evaluation of the system was carried out for drying chilli using LPG alone and solar drying without LPG. The moisture content of chilli was reduced from 94 to 16% in 9 h of operation at 80°C using LPG fuel. When the system was operated only on solar energy, the moisture content of chilli was reduced from 94 to 14% in 12 sunshine hours.

Jute caddies briquettes as an alternative fuel: Attempts were made to produce briquettes from the caddies in a ram type



mechanical press coupled with a hammer mill grinder having capacity of 125 kg/h. The calorific value of jute caddies briquettes having 1,068 kg/m³ density was estimated to be 3,923 kcal/kg. The briquettes could also be gasified to generate producer gas successfully in a gasifier plant of 10 kW capacity. Briquettes of jute caddies as well as jute stick can be suitably exploited to generate thermal energy as the process heat in industry. Moreover, the low ash content of caddies makes it an appropriate feed material in gasifier reactors. Thus, gasification of briquettes may provide a new avenue for cogeneration of heat and power to meet industrial need by waste recycling and management.

POST HARVEST TECHNOLOGY

Optimization of process parameters for hulling of pigeonpea

Hulling efficiency and hulling losses were optimized for pigeonpea. Effects of hulling time, moisture content and cottonseed and mustard oil as pre-milling agents were studied and optimized using response surface methodology. The maximum hulling efficiency of 89.59% was obtainable at 9.84% moisture content (wb), 11.96 second time of hulling and 0.28% cottonseed oil treatment. The hulling efficiency was 83.19% at 10.11% moisture content (wb) and 12.3 second time of hulling with 0.30% mustard oil treatment after optimization. Linear model developed for hulling loss showed significant effect of time of hulling, whereas effect of oil treatment and moisture content were non significant.

Cleaner-cum-grader for light seeds

A cleaner-cum-grader for light seeds like berseem, cumin and coriander has been developed at CIAE, Bhopal. The unit separates the seed based on their pneumatic/aerodynamic characteristics by air classification method. The capacity of the equipment for

Cleaner-cum-grader for light seeds



- Effect of hulling time, moisture content and cottonseed and mustard oil as pre-milling agents studied and optimized
- Cleaner-cum-grader for light seeds like berseem, cumin and coriander developed
- Broken sunflower kernels used to prepare three confectionery products
- A process technology for scientific production of anardana developed
- A mobile cool chamber designed with a conventional cycle rickshaw for short distance transportation of fish

separation of berseem is 300 kg/h, whereas it is 130 kg/h for cumin and 180 kg/h for coriander seeds. The power requirement is in the range of 250–300 W.

Curry leaf stripper

A curry leaf stripper has been developed at the CIAE- Regional Centre, Coimbatore. The capacity of the machine is 40-50 kg/h



Curry leaf stripper in operation

with stripping efficiency of 90–95%. The cost of the unit is approximately Rs 15,000 and saving in labour over the conventional method is about 80%.

Determination of the maturity of intact mango on tree

A model to predict maturity index based on correlation of colour with TSS has been defined to measure the maturity of mango objectively. The model can be used on farm with the colorimeter by orchard owners. Alternatively, colour and maturity index charts have also been developed to use it with any colorimeter. If colorimeter is not available, one can get digital photograph of the mango and can know the maturity or sweetness in terms of TSS using a commercial software using this technique. This technique



can be employed to sort the mango based on either maturity index or TSS (sweetness) at export port, big *mandies* and in processing plant. It will also help in fixation of price of individual mango based on total soluble solids.

Process technology for making *aonla* beverage

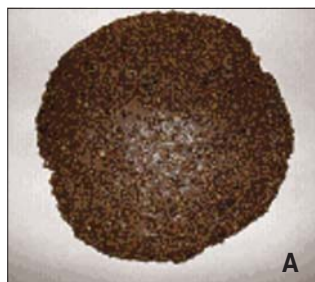
A process technology was developed to prepare *aonla* beverage in the form of juice with attractive colour, appealing flavour and smell. The composition of *aonla* juice (20%), sugar syrup (70% –25° B), other fruit juices (guava, pineapple etc.) (10%) were found best in terms of acceptability.



Black salt, white salt, black pepper, *amchur* powder and dhania were the other ingredients used for making the beverage. The final mixture is bottled and sterilized in hot water before storage.

Development of sunflower kernel-based confectionery products

Broken sunflower kernels were used for preparation of three confectionery products. The broken kernels were cleaned manually to remove any adhered hull or damaged kernels. Cleaned broken kernels were graded to have uniform size with appropriate set of sieves to improve the appearance of sunflower kernel-based confectionery products. Sunflower kernel caramel snack, a sugar based sweet containing sunflower kernels, was prepared using different sugar and kernel levels. Sunflower-sesame kernel confection *chikki* is an improved traditional product and prepared taking jaggery, sunflower kernel and sesame kernel in different proportions. Likewise, sunflower kernel ready-to-eat sweetmeat was



A. Sunflower kernel caramel snack food; B. Sunflower-sesame kernel confection *chikki*; C. Sunflower kernel ready-to-eat sweetmeat

prepared incorporating sugar, jaggery, sunflower kernels, liquid glucose and honey.

Rotary maize cob sheller

The sheller is simple and safe with an output capacity of 65 kg/h and costs only Rs 1,500. It has been found suitable for all varieties of maize with zero damage during shelling, and thus better suited for seed purposes.

Process technologies for value-added products from pomegranate

A process technology for scientific production of anardana has been developed at CIPHET. The product contains desirable acid sugar ratio and retains maximum quality parameters (sugars, TSS, vitamin C and minerals) up to six months of storage. Process for pomegranate jelly has been developed. The jelly is good in



The value-added products from anardana contain desirable acid sugar ratio and retain maximum quality parameters

appearance, colour, nutritionally rich in vitamin A and minerals, has good keeping quality with natural flavour. It can be stored for 4 months under ambient conditions and 6 months in cold storage. Mouth refreshing, nutritive and digestive tablets from anardana have been prepared. The product has acceptable taste and flavour, is rich in nutrition, minerals and digestive in nature. It can be stored up to six months when packed.

Technology for soy-millet biscuits

Efforts have been made to develop soy-based *kodo* and *kutki* millet biscuits. Various levels of flours 70, 80, 90 and 100% of both *kodo* and *kutki* (black and white varieties) were tried for substitution of refined wheat flour in the standard formula of soy-fortified biscuits.

Based on the physical and textural properties and sensory evaluation, substitution of refined wheat flour with *kodo* flour up to 70% level and addition of 10% skimmed milk powder produced



Soya-kodo biscuits

acceptable soy-*kodo* biscuits. In case of *kutki* refined wheat flour substituted at 80% level with 10% skimmed milk powder produced biscuit of acceptable quality. The process and composition have been standardized and is ready for adoption at commercial level.

Guava leather/bar

A process technology for production of guava leather/bar has been developed. The product was prepared by mixing various blends of different fruit pulps. Guava, mango, papaya, sugar, citric acid and permissible preservatives are the main ingredients. Drying



was carried out in a cross flow cabinet dryer. The dried sheet was then cut into definite shaped fruit bars. This guava leather/bar can be stored for 2–3 months under normal condition and more than nine months under cool dry condition.

Fish container mounted on cycle rickshaw

A mobile cool chamber has been designed with a conventional cycle rickshaw for short distance transportation of fish. An insulated chamber made of GI (inner) sheet having length 1,250 mm,



Mobile cool chamber with a conventional cycle rickshaw for short distance transportation of fish

breadth 760 mm, and 750 mm height with a single door opening at back was mounted on the cycle rickshaw. The chamber was provided with 40 mm thick insulation of thermocol all around. A 300 mm × 300 mm opening was kept at the top of chamber for retail marketing the fish. A backside door is provided for loading the ice-fish filled crates inside the chamber. The total capacity of this chamber is 150 kg of fish with 80% filling of each plastic crates and 1 : 1 ratio of ice and fish. This could store the freshwater fish for 5–6 days.

Performance of poly house solar dryer for chillies

Bapatla (ANGRAU) centre has tested a poly house solar dryer of size 7.5 m × 4 m × 3 m to dry about 10 quintals of ripe chillies. The dryer consists of an arch type poly house to hold chillies in two tiers. The drying time is 5–8 days to reduce moisture from 75% to 10% (wb) in comparison with 15–20 days required to dry chillies in traditional open yard sun drying. The added advantages are high retention of colour and quality. Such dryers are being promoted by the Government of Andhra Pradesh.

Processing and preservation of drumsticks

Drumstick (*Moringa oleifera*) pieces processed and preserved at Coimbatore (TNAU) centre by curing process (10% saline alone and in combination with 1% acetic acid) and by canning process (in 1, 2, 3% saline and tomato pulp from local and hybrid variety tomatoes) were found to be good without any fungal attack after one year of storage.

Cryofreezer

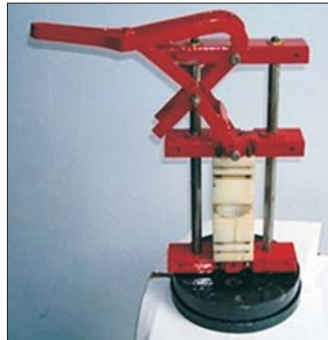
A freezer of 10 kg capacity has been designed, fabricated and tested at IIT, Kharagpur in an ICAR Project. It uses liquid nitrogen (LN₂) as coolant. Use of two chambers, one for precooling the food materials by exit nitrogen gas and other chamber for freezing by LN₂ improved



the thermal efficiency of the system by more than 25%. This has also reduced the LN₂ consumption considerably. Reversal of the LN₂ flow after achieving the required freezing has permitted to overcome the problems of food handling (loading and unloading) from pre-cooler to freezer and vice versa. Shrimps, tomatoes and potatoes of different sizes were used to evaluate the freezing characteristics.

Hand-operated *aonla* pricking machine

HAU Hisar centre of AICRP on PHT has developed a hand-operated *aonla* pricking machine. The capacity of the machine has been estimated to be about 15 to 20 kg/h and the approximate cost of the machine is Rs 2,000.



Seed pelletizer

A power-operated seed pelleting machine was designed and developed at Anand Agricultural University, Anand (Gujarat) for safe and efficient pelletization of seeds, particularly the small and irregular seeds. All the desired constituents such as fertilizer, micronutrient, growth hormones, seed protection agents, etc. can be incorporated into the pelletized seeds. The capacity of the machine is 1.5–2 kg/h depending on the seed characteristics. Pelletizing efficiency was greater than 90% in all cases with 85–95% of these pellets containing only single seed. The size of the seed pellets could be increased to about 4–5 times the original size of the seed, with sphericity ranging from 0.82 to 0.91. Field experiments for different types of stored pellets showed high germination percentage and plant height. The cost of the machine is about Rs 31,000. The estimated cost of seed pelletization is about Rs 28/kg of seed.



Production of a protease and a biosurfactant by a *Bacillus* sp. and their potential applications as bread improvers

Use of protease as an additive or improver of quality and to retard the rate of crumb forming will limit the use of chemical additives as antistaling agents for baked products. In this study,

microbial strains of *Bacillus* sp. were isolated and screened for concomitant production of protease and biosurfactant under an ICAR funded project at University of Delhi, New Delhi. One of the strains selected for higher production was identified, using 16 Sr DNA sequencing, to be *Bacillus licheniformis* RG1. Among the various carbon and nitrogen sources studied as the substrate medium, soyflour and corn starch were found to be the best for protease production.

The protease produced was successfully applied in a bakery (M/s Tushar Food Industries, Delhi) for preparing bread loaves with better softness and longer shelf-life (up to 5 days) compared to control loaves.

HCl-gas based cotton seed delinting plant

A cottonseed delinting plant of one tonne per hour capacity has been designed, developed and tested successfully by Maharashtra State Seeds Corporation Limited (MSSCL), Akola under an ICAR funded project and found commercially viable. The process developed makes use of hydrochloric gas for cotton seed delinting to replace employing wet sulphuric acid, which involves environmentally unsafe effluent. Demonstrations and trainings of pollution-free cottonseed delinting were organized at cotton delinting plant, Shivani (Akola) in collaboration with Directorate of Cotton Development (Government of India), Mumbai. Maharashtra Pollution Control Board has certified that this technology is pollution free.

FIBRE TECHNOLOGY

Design and development of an improved cotton saw gin

Despite their higher productivity, saw gins available in India provide inferior quality lint with loss in length, particularly while processing long and extra long staple cottons. The high speed of saw results in fibre breakage and lower ginning percentage. A lot of fuzz also remains with the seed thereby affecting the quality of

Improved cotton saw gin

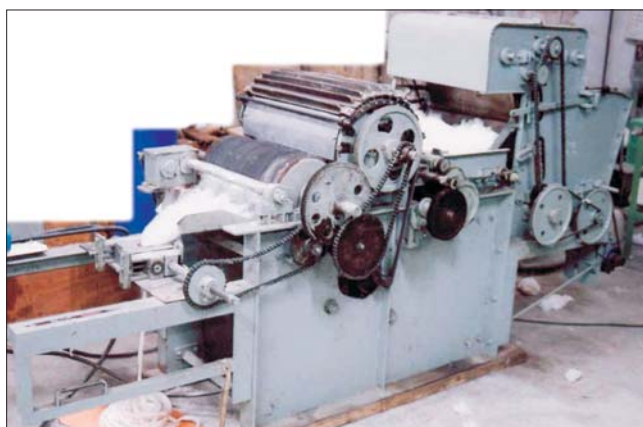




output. The currently available saw gins do not have provision to optimise the output based on the staple grade. To overcome the above deficiencies, a prototype of an improved 45 saw ginning machine has been designed and fabricated. This model has, apart from a provision for regulating feeding rate, necessary controls for saw speeds to be optimized depending on the staple grade.

Low cost cotton sliver making machine (CIRCOT Mini Card)

A low cost sliver making machine, named as CIRCOT Mini Card, has been developed for sliver production from cotton with 1.8 kg/h production. The machine consists of two detachable units (a) pre-opener and (b) carding including sliver making unit. It is suitable for application at village level and can be used in conjunction with traditional roving and yarn making machines



CIRCOT Mini Card, the low cost sliver making machine

for production of good quality yarn. Recent field trials have indicated that the quality of yarn from the sliver produced on this carding machine by conventional method followed in the village was quite satisfactory.

Extraction of banana pseudostem fibre

Use of only outermost 5–6 layers of banana pseudostem for fibre extraction has been in practice. Studies have indicated that up to 10 layers could be effectively used for the fibre extraction. This has resulted in substantial increase in fibre yield. The fibre thus collected is lustrous, clean and free from other extraneous matter. The fibre yield was higher in machine extraction than hand extraction, but the quality was better in hand extracted fibres than machine extracted fibres. The chlorinated lime as a bleaching agent at 0.75% produced better quality lustrous fibre irrespective of the banana varieties. Thus machine extraction coupled with bleaching of fibres chlorinated at 0.75% produced maximum yield and better quality fibres.

A machine known as Banana Pseudostem Fibre Cleaner has been developed that removes non-fibrous material and gives silvery white and lustrous appearance to the fibres.

Pilot plant for particle boards from cotton plant stalks

A one tonne per day (1 TPD) automatic particle board plant using indigenous machinery has been installed at the Ginning Training Centre of CIRCOT, Nagpur, to demonstrate the feasibility of cotton stalks as raw material for particle board manufacture.



Pilot plant to manufacture particle boards from cotton plant stalks

This plant has been put into operation and 1.2 m × 0.9 m three-layered particle boards are being manufactured. By making available cotton stalks for particle board industry, a farmer can earn Rs 500/tonne.

Value-added textile from sunhemp fibres

Raw sunhemp fibres could be processed using jute spinning system. When subjected to chemical treatments (such as scouring, bleaching and softening as used for jute), the fibres retained enough strength for its subsequent use in spinning and weaving. There was a substantial improvement in whiteness and brightness of the bleached fibres which would facilitate dyeing in several colours to produce bright shades. Union fabric has been produced weaving sunhemp yarn in the weft and cotton in the warp direction by optimizing the weaving parameters (especially the picks per inch at 20). The thick fabric has been effectively used for making baggage, upholstery items, etc. and possibly for jeans and jackets.

Flush door shutter using jute stick particles and jute felt

Low-cost flush door having dimensional stability in extremities of climatic conditions has been developed for both household as



SUCCESS STORY

Empowerment of Women

- Bhopal sub-centre of National Research Centre for Women in Agriculture (NRCWA) conducted a survey to assess the involvement of women in agriculture and found that women devote 43.7% of their time in agriculture.
- Ergonomical evaluation of manually-operated two-row drum seeder, TNAU four-row drum seeder and CRRRI four row rice transplanter was carried out with women workers. It was found that the physiological load in terms of heart rate and pulse rate was higher than the acceptable limits of 110 and 40 beats/min, respectively. The working heart rate and pulse rate for operation of CIAE sickle, KKV Dapoli sickle, improved sickle and local sickles were within the acceptable limit.
- Training of woman workers on woman-friendly tools and implements were conducted at Village Chawani Pathar, Adampur and Nepania Jhat, attended by 52 and 103 women workers, respectively. The training was imparted on fertilizer broadcaster, 2-wheel seed drill, one-wheel seed drill, twin-wheel weeder, groundnut decorticator, hanging type grain cleaner, naveen dibbler, seed treating drum and furrow and bund makers.
- During September 2005 – October 2006, the SPU centre of CIAE organized seven training programme for 115 rural women from nearby Bhopal district of Madhya Pradesh on various aspects of soybean processing and production soy milk, soy paneer, bakery items and soy snacks for use of soy foods in daily diet for nutrition and health benefits. Awareness camps and demonstrations were also held at different places like Seoni, Guna, Shajapur and Baramati.

well as industrial applications. This substitute of conventional veneer board is made using composites prepared from 10 mm thick non-woven jute felt. Jute felt is impregnated with water soluble phenol-formaldehyde resin which imparts the water repellent property. The physical and mechanical properties of the boards; swelling character, impact strength, internal bond strength and modulus of rupture; were found comparable to those of wooden veneer board. Nearly 80% wood used in conventional flush door shutter can be replaced by the use of jute veneer boards.

Warm fabric (shawl) using bulked yarn made from jute polyester blends

Jute and hollow polyester fibres can successfully be blended in the ratio of 70 : 30 in the conventional jute spinning system to produce bulked yarn suitable for making warm fabric. Shawl fabric can be woven using the blended yarn as weft and commercial cotton yarn of about 6 tex as warp in handloom weaving machine with jacquard attachment. Plain and twill designs were developed.

Body and border of the shawl were decorated by specialized jacquard weaves. The shawls, though heavier than the commercially available woolen shawls by about 12%, give 62% more warmth as evident from the thermal insulation values.

Fancy jute fabric using jute-based cover yarn

The major problem associated with jute yarn is its hairiness and fibre shedding. The protruded hairs, besides affecting adversely the weaving system, impart a cloudy appearance to the fabric. Furthermore, the extensibility of jute yarn is poor restricting its diversification. The problem has been overcome by developing cover yarn in the existing jute spinning system using jute polyester blended core and synthetic fibres such as polyester, lycra and metallic filament as covering material. About 90–95% hairiness is reduced, work of rupture is increased by about 40% and there is an overall improvement in flexural rigidity and packing co-efficient. Percentage of jute in this fabric can be maintained in the range of 75–98%. Several utility products such as school bag, office bag, soft luggage have been developed out of the fabric made from cover yarn. Knitted products such as bottle-carry bag, ladies bag/purse with better aesthetic appeal and physico-mechanical properties are the other potential uses.

Trainings

Short Course on Drainage Technologies

A training programme on Drainage Technologies for enhancing agricultural productivity in vertisols was organized during August 2–11, 2006 for 27 participants at CIAE, Bhopal.

Advanced Instrumentation

A six-day training programme on Advanced Instrumentation for R&D in Agricultural Engineering was organised at CIAE, Bhopal for faculty members of the SAU's during August 21–26, 2006.

Agro-based Products

CIAE organized entrepreneurship development training programme on agro-based products for 29 participants of District Poverty Initiative Programme (DPIP) during June 12–17, 2006 and July 10–17, 2006.

Manufacturing Technology

A 11-day training programme on Manufacturing Technology for Fabrication of Agricultural Implements for Teachers/Instructors of Farm Machinery Vocational Education was organized in collaboration with PSSCIVE, Bhopal at CIAE, Bhopal during September 18–28, 2006. Eighteen instructors from different vocational training institutes from Punjab, Haryana and Madhya Pradesh participated in the programme.



LAC TECHNOLOGY

Lac marketing in India

The study revealed that the Palas tree is the most important lac cultivating host tree in all the selected states when compared to Ber and Kusum. Net returns from lac cultivation was much higher in Maharashtra (Rs 214,848) in comparison to Chhattisgarh (Rs 12,117). The low extent of host tree exploitation was the prime factor for low lac production. Constraints adversely affecting lac production at the farmers' level were lack of funds (own) and non-availability of cheap credit for purchase of inputs including brood lac. Cultivators received better price in those markets where purchaser sold scrap lac directly to processing units.

Small scale lac processing unit

Indian Lac Research Institute, Ranchi has developed a set of four machines required for setting up small scale lac processing unit, viz. scraper-cum-crusher, washer, winnower and grader. These machines can be driven manually or by electric motors. If such unit is established by setting up manually-driven machines then total cost of machinery will be approximately Rs 40,000. The area where electricity supply is available, then such units can have power driven machinery which will cost approximately Rs 60,000. The capacity of such small lac processing units will be 100 kg/day. If a processing unit remains functional for six months in a year, about 750 man-day/year employment can be generated. Net profit of about Rs 30,000/month can be earned. Total cost for establishment of such unit including civil works will be about Rs 500,000.

Pilot-plant of lac dye

A pilot-plant has been designed and developed at the Institute for production of technical grade lac dye from wash water of sticklac. The plant can produce up to 2 kg (max.) of technical grade lac dye from washing of 400 kg of sticklac. The different

A new host of kusmi strain of Indian lac insect

Prosopis juliflora, a native of South and Central America, has recently been identified as a quick growing potential host of kusmi strain of lac insect. It was introduced in India to combat desertification but has spread in different states and often considered as a weed. The potentiality trials conducted on this host in Gujarat have shown an overall yield ratio of 1 : 21 (brood lac input : output) of aghani (*kusmi*) crop during winter season. Due to its abundance (in millions) with less economic significance, its identity as a good lac host is expected to help not only for boosting kusmi quality lac production in the country, but also for socio-economic development of the rural mass in these disadvantaged areas. It is a quick growing species having a good coppicing response and can reach lac inoculable stage after 2-3 years of planting. A large scale trial of aghani crop is in progress on 300 plants, in three locations of Bhavnagar and Kuchh districts of Gujarat.



wetted parts of the plant like tanks, pipes, valves, pumps and filtration unit are made of synthetic material (HDPE, HDPP, PVC) and stainless steel to avoid the contaminations in the final product (pure/food grade lac dye).

The technical grade lac dye is further purified for making it pure/food grade. The lac processing industries are presently disposing of the wash water as effluent, can recover this byproduct, as pure lac dye, which can, further enhance economy of the lac processing units. The pure/food grade lac dye has present market price of Rs 5,000–6,000/kg (approx.).



Agricultural Human Resource Development

Education Division of the Indian Council of Agricultural Research has the mandate to plan, coordinate and guide the higher agricultural education in the country. The programmes of the Education Division include: development grant to universities, accreditation of different programmes in the universities, conduct of All-India Competitive Examinations for admissions in Under Graduate and Post Graduate Programmes in SAUs, ICAR DUs, CAU, and CUs with agricultural faculty, award of scholarships and fellowships and internship assistance for veterinary students. The programmes also include ICAR National Professor Scheme, National Fellow Scheme, Emeritus Scientists Scheme, Admission of Foreign Students, Centres of Advanced Studies, Niche Area of Excellence, Scheme for Experiential learning Model Farms and Pilot Plants, Best Teacher Awards and University Level Textbook Writing Scheme. The achievements under these programmes during 2006–2007 are as follows.

CAPACITY DEVELOPMENT

Deemed Universities

Central Institute of Fisheries Education, Mumbai:

Altogether 71 students were admitted in different M.F.Sc and Doctoral programmes during the year 2006–07.

The Niche Area of Excellence project on ‘Utilization of inland saline and sodic soil for aquaculture’ was started with Rs 82 lakhs. Under this, renovation of 10 (0.1 ha) ponds at CIFE’s Rohtak Centre for the flow-through system; the design for the wet lab and procurement of equipments and programmes on stocking the ponds with *Chanos chanos* and *Mugil cephalus* seed have been finalized.

Two training programmes on “Recent Advances in Biochemical and Molecular Techniques and their Applications in Aquaculture and “Genetic Improvement of Fish—A Biotechnological Approach” were conducted under Centre of Advanced Studies.

Dr A. K. Pal, Principal Scientist, received the “Bharat Ratna Dr Subramaniam Award for Outstanding Teachers” for the year 2006. The institute organized the fourth Deans’ Committee Meeting to revise the undergraduate teaching programmes in fisheries colleges. Also, the institute arranged a series of meetings with the experts in various specializations to upgrade the M.F.Sc. and Ph.D. syllabi.

National Dairy Research Institute, Karnal: Academic

Session 2006–07 started from 1st August 2006, and the students admitted to the various courses were: 27 in B.Tech. (Dairy Technology) 81 in Master’s in Dairying and 60 in Ph.D.

Foreign students from Bhutan, Nepal, Ethiopia and Iran were also admitted in various courses. Mr. Arul Murugan M., Ph.D. scholar in Animal Biochemistry was selected for the award of “Commonwealth Split-site Doctoral Scholarship-2006” at the Royal College, University of London for a period of one year.

A set of 6 genes (Caspase, RASPA, GATABP, FSHR, LHR and NALP) were identified and their expression during oocyte maturation process in buffalo is being worked out under the Niche Area of Excellence Project on ‘Buffalo Production and Reproduction Genomics’. The genes have been successfully amplified in buffalo oocyte. Work has been initiated to reveal polymorphism in the casein milk protein at DNA and protein sequence level in buffalo.

State Agricultural Universities

Acharya N.G. Ranga Agricultural University, Hyderabad:

During the academic year 2006–2007, a total of 672 students in various undergraduate, 162 in postgraduate and six in to the doctoral programmes were admitted.

New postgraduate programmes of M. Tech. were started in three disciplines of Agricultural Engineering, viz. Soil and Water Engineering, Agricultural Process and Food Engineering and Farm Machinery and Power and Ph.D. in Agronomy at Agricultural College, Bapatla; one-year Diploma in Food Analysis and Quality Control at College of Home Science, Hyderabad were started from the academic year 2006–07.

The unstinted efforts of the scientists of ANGRAU resulted in development and release of a set of 26 new improved varieties/hybrids of crops, thus bringing the total number of varieties/hybrids released by ANGRAU, so far, to 328.

To increase research for development of efficient water

- Vice-Chancellor of ANGRAU Dr S. Raghu Vardhan Reddy, inaugurated the Educational Technology Cell at Rajendra Nagar, on 30th June 2006. It is the first of its kind in the country to establish an exclusive Educational Technology Cell.



- The ANGRAU entered into MOUs with many international organizations and universities like Wageningen Agricultural University and Research Centre (WUR), International Land Reclamation Institute (ILRI) in Netherlands, United States Development Agency (USDA), Tuskegee University, Alabama and Cornell University in USA, Food and Agriculture Organization (FAO), Rome, for exchange of Academic Staff, exchange of students, collaboration for research and other academic activities.

management technologies, the University has established a Water Technology Centre at Rajendra Nagar campus and entered in to Memorandum of Understanding with the University of Florida, USA and the University of Wageningen, the Netherlands in this regard. The University also entered into Memorandum of Understanding with World Wide Fund for Nature (WWF), Hyderabad, to undertake System of Rice Intensification (SRI) Project.

Two projects, viz. (i) Mega Seed Project with an outlay of Rs 6.5 crore to improve Seed Replacement Rate of field and horticultural crops and (ii) Distinctness, Uniform and Stable project with an outlay of Rs 93.25 lakh, with the objective of preparation of plant variety protection under DUS testing were sanctioned.

The main training programmes organized by the College of Home Science, were 21-days Training Programme on 'Food Enterprises—Opportunities and Challenges'. Winter School on Computer Aided Residential and Commercial Interior Designing from 17 January 2006 to 6 February 2006; and six-day certificate course on 'Basics of Field Functioning'.

Assam Agricultural University, Jorhat: The Assam Agricultural University comprises four faculties, viz. Agriculture, Veterinary, Home Science and Fishery. Altogether 425 students were admitted in different faculties of the University during 2006 under UG, Masters' and Ph.D programme.

Although no new courses were added in any programme in different faculties of the University during the year, but recasting of the UG courses in Agriculture, Fisheries Science and Home Science faculty were already made as per recommendations of the 4th Deans' committee.

The scheme of experiential learning—setting up of facilities for hands on training on: (i) Production of ornamental, medicinal and aromatic plants and nurseries management (ii) Post Harvest Technology and processing for value addition to the university have been started.

The Rural Agricultural Work Experience (RAW), an internship programme is running regularly since 1993 and during the year, 61 students benefited from the programme. Besides. Rural Home Work Experience (RHWE) and the Rural Fishery Work Experience

(RFWE), similar other two internship programmes of the faculty of Home Science and Faculty of Fishery Science respectively were also carried out.

The faculty of Home Science carried out the programme during February to April 2006 in Mudoijan village of Jorhat District. Rural women and local youths were the target group beneficiaries who greatly benefited from the training imparted by the students primarily in various aspects of germane designing/dress designing unit, clothing practices and care of fabrics and food and nutrition.

Horticultural exhibition and competition was organized at Jorhat on February 15, 2006 by the Department of Horticulture, to demonstrate good quality horticultural crops. Similar horticulture exhibition cum competitions were also organized on February 2nd, 2006 by the University at different locations in the state.

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur: The University admitted 143 students in undergraduate (UG), 187 in postgraduate (PG) courses during the year. All the UG students also successfully completed their RAW.

The undergraduate classrooms have been modernized with OHP, multimedia LCD projectors with the support provided by the ICAR.

Construction of new Girls Hostel was started out of ICAR grant. Under KVK-Nadia, construction of administrative building, trainees hostel and various farm structures have been completed.

Education Technology Cell and Students' Counseling and Placement Cell have successfully been established.

The Examination Cell has been provided with all the facilities required by the cell. The NISAGNET cell has also been set up.

The University was awarded with Niche Area of Excellence in 'Arsenic Management Options including Organic Agricultural Systems in West Bengal'. The World Health Organization, on the other hand, has assigned the task of monitoring the pesticides residues in sugar samples to the Pesticides Residue Laboratory of the Viswavidyalaya. The Viswavidyalaya has also established the 'Regional Analytical Quality Control Laboratory of Medicinal and Aromatic Plants'.

Extension and Training activities in the Farmers' Training Centre are going on regular basis.

The plant physiology aspects being examined mainly include the (i) basis of arsenic uptake, (ii) remobilization pattern of arsenic within the plant biomass, and (iii) pattern of diurnal fluctuation of arsenic uptake.

The studies relating to soil microbiology explored the potential

- International seminar on weed control and several national seminars and workshops on Export of Horticultural Crops, IPM, Water Management, Cultivation of Medicinal and Aromatics Plants were organized at BCKV.



soil micro-organisms, which are responsible to transmute the toxic form of arsenic to less toxic forms (of arsenic) and those, which are responsible for methylation of arsenic to less harmful as species.

The objective of the genetic studies is to find out varietal differences in arsenic uptake pattern by different genotypes of paddy and to identify molecular markers to tag gene(s) responsible for arsenic uptake. From such evaluation significant difference in regard to arsenic uptake by different genotypes has been noted.

Chaudhary Charan Singh Haryana Agricultural University, Hisar: The University brought about significant developments in its approach to teaching by modifying its course curriculum, establishing a sound infrastructure and upgrading the skills of its faculty. The university admitted 354 students for undergraduate courses, and 350 students for postgraduate courses.

A Memorandum of Understanding (MOU) was signed in April 2006 between the University of Maryland, USA and this University to promote and accelerate the programme of research, training and extension. Dr Terry Young, a renowned scientist from Michigan State University, USA visited the university for framing the policy and regulations for Intellectual Property Rights (IPR) Management at the university.

A grant of Rs 125 lakhs was received from the ICAR for setting up of four Model Plants equipped with modern facilities and equipments for practical study of students. The facility will also help in generating employment on a large scale.

During the session under report, HAU got Rs 14.5 crores prestigious project on guar gum from the Ministry of Rural Development and the Ministry of Commerce, Government of India. This project is on Quality Seed Production of guar for distribution to farmers.

The generous grant from ICAR has helped the University to consolidate its position.

Chandra Shekhar Azad University of Agriculture and Technology, Kanpur: The University admissions to all the courses were completed in July 2006. Admissions to new PG programmes in Microbiology and Biotechnology were also done. Practical manuals for 12 courses of the B.Sc. Ag. Hons. and 27 courses of Home Science have been prepared. Fifth batch training programme of agri-clinic and agri-business scheme started in the Directorate of Extension for unemployed agricultural graduates for establishing their own business.

Two new Colleges were sanctioned by the Government of Uttar Pradesh at Kanpur Campus, viz. College of Horticulture and College of Forestry with a financial allocation of Rs 328.54 and 217.66 lakhs, respectively. Two more Colleges at Etawah Campus, viz. College of Dairy Technology and College of Fisheries Science with a financial allocation of Rs 1,307.36 and 409.96 lakhs, respectively were also started. An Advance Centre on “Agri-industrial Enterprise

and Agricultural Management” was sanctioned by the Government. The University has introduced automation in its library by providing facilities as online use public access catalogue, Bar Coded Member ID Card and internet facilities.

The 45th All India Wheat and Barley Workshop Meet–2006 (ICAR) was held from 18–21 August 2006. A three days training programme for IAS probationers was organized on “Agrarian Structure and Rural Development”.

Tenth Convention of Indian Society of Agricultural Biochemists and International Conference on post harvest technology and value addition in cereals, pulses and oilseeds was held on 27–30 November, 2006.

Dr Y S Parmar University of Horticulture and Forestry, Solan: Human Resource Development both in Horticulture and Forestry sector is the major objective of the University. Two new departments, one that of Forest Plant Protection and the other of Business Management were created in September 2006. The admissions made under different programmes in College of Horticulture and College of Forestry are 98 in B.Sc., 76 in M.Sc. and 34 for MBA programme.

The Niche Area of Excellence project on Research Strategies For Sustainable Apple Production was sanctioned. The University has started Experiential Learning Programme for which the funds to the tune of Rs 60 lakhs were made available by the education division of ICAR.

In the development of infrastructure facilities, the major ones have been starting of work on Girls Hostel for which Rs 75 lakhs are being spent and the building will be completed in January 2007. An International Hostel is also coming up at a cost of Rs 84 lakhs. Work on construction of College of Forestry is also being awarded at an estimated cost of Rs 1.6 crores. Jawahar Lal Nehru Communication Centre was inaugurated on October 6, 2006 by the Chief Minister of Himachal Pradesh.

Hon'ble Chief Minister of Himachal Pradesh dedicating the Jawahar Lal Nehru Communication Centre to the farmers





Under postgraduate research on apple, new clonal rootstocks for cultivars Oregon Spur and Red Chief were identified. “Myrocal” a clonal rootstock for plum and apricot was identified. In tomato, new indeterminate hybrids were developed having firmness and long shelf life. Low-pressure treatment of ginger rhizomes resulted in complete control of rhizome rot. Thirty-one novel kinds of Chrysanthemum could be established. Agroforestry models for plantation of trees and medicinal plants were developed. Successful domestication and development of agro techniques for cultivation of a number of aromatic and medicinal plants were standardized.

Junagarh Agricultural University, Junagarh: The Junagadh Agricultural University has adopted the revised post graduate syllabus as per the recommendations of Third Dean’s Committee on Agriculture as well as Fisheries from the year 2006. Post Graduate Degree Programme in Fisheries has also been started from 2006.

Construction of two new Girls hostel was started, one at College of Fisheries, Veraval and other at College of Agricultural Engineering, Junagadh from ICAR support.

Under the scheme for Experiential Learning - setting up of facilities for hands on training from ICAR, three programmes, viz. (i) Mushroom, bio-agents and vermicompost production and processing, (ii) Seafood processing centre for value added products and byproducts, and (iii) Production and management of alternative/renewable source of energy were started with the total cost of Rs 110 lakhs.

Rural Agricultural Work Experience (RAWE) Programme for the students of seventh semester of Agriculture faculty was organized and the students were exposed to various learning situations during different phases of the programme.

400 Scientists/Officers of the University actively participated in the Krishi Mahotshav-2006 programme, which was organized by Government of Gujarat and guided the farmers for adoption of new agricultural technologies.

Kerala Agricultural University, Thrissur: Students admitted in various programmes of the university were 402 in undergraduate courses, 123 for postgraduate and 23 for Ph.D degree.

The university started two new programmes, a MBA programme on Agri-business Management at college of Co-operation, Banking and Management, and a Post Graduate programme on Veterinary Biochemistry at the College of Veterinary and Animal Sciences, during the year.

Dr C Lekha Rani, Assistant Professor was honored with the ICAR Jawaharlal Nehru Award for the year 2004 for outstanding PG agricultural research for her Ph.D. Dr C Subramanian Best teacher ICAR Award for Outstanding Teachers 2004–05 was given to Dr M R Sasindranath, Associate Professor, College of Veterinary and Animal Sciences, Mannuthy.

Maharana Pratap University of Agriculture and Technology, Udaipur: During the academic year, 426 undergraduate, 88 postgraduate and 42 Ph.D. admissions were made through Joint Entrance Test (JET). Pre-Engineering Test (PET).

- Campus Interviews and placement of graduates and Post Graduate students in reputed firms, institutions and NGOs were organized by the Maharana Pratap University of Agriculture and Technology. There was 100% placement of the passed outs in Dairy Technology and Food Technology and 90% in Engineering and Technology. There was spectacular increase in the placement of students of Agriculture and Home Science.

A new educational UG programme in Electronics and Communication Engineering was initiated. The AICTE has approved the UG teaching programmes in Dairy and Food Science Technology. Professional packages leading to job-oriented education in Home Science as recommended by the Fourth Dean’s Committee of the ICAR have been initiated from the academic session commencing from 2006–07.

A model of hi-tech horticulture unit was established at the university with a financial support of Rs 282 lakhs from the ICAR. The forced ventilated green house with cooling system is the first in Rajasthan and three naturally ventilated green houses have been installed. Small replicable models of the hi-tech horticulture units were also established in two KVKs.

Model Plastic Lined Water Pond

MPUAT has been in the forefront for demonstration of important technologies whose impact can be felt at the state and national level. One of its major success has been in the area of water harvesting. Rajsamand KVK is the finest example where plastic lined farm pond has been developed on scientific lines. Based on the success, such plastic lined ponds are being constructed at 100 KVKs in the country. This year the entire farm would be under drip irrigation and plantation. The water harvesting at Rajsamand KVK represents a success story, which has no parallel.

A herbal park has been established to conserve valuable biodiversity. Experiential learning unit, specially in fruits and vegetables processing and speciality food for imparting six months hands on training to final year B. Tech students in the College of Dairy and Food Science Technology was established using ICAR grant of Rs 120 lakhs.

The university strengthened its seed production and processing capabilities through financial support of Rs 4.86 crores from ICAR.



AGRICULTURAL HUMAN RESOURCE DEVELOPMENT

Dr Ritu Singhvi, Associate Professor, College of Home Science was awarded Bharat Ratna Dr C Subramanian best teacher award by the ICAR. Dr F L Sharma, Assistant Professor, Rajasthan College of Agriculture, Dr A K Sharma, Associate Professor, College of Technology and Agricultural Engineering and Dr Vandana Kaushik, Associate Professor, College of Home Science were bestowed with best teacher award at the university level.

Marathwada Agricultural University, Parbhani: The University admitted 1614 under-graduate and 212 post-graduate students in 2006–07. A total of 1,572 Bachelors, 68 Masters and 61 Doctoral candidates obtained their degrees in the 15th Convocation held on 10th February 2006.

- The Agricultural Technology Information Centre at the Marathwada Agricultural University, a single window delivery dissemination and support system for various innovative techniques provides technical advice; diagnostic services and input supply, viz. Seeds of different crops, Planting materials, Agricultural implements, Agricultural Literature, etc. to the farmers. It operates through Telephone Help-Line, Kisan Call Centre and Internet connectivity.

Under RAWE programme the students were placed in different villages under the jurisdiction of the university.

Training programmes, viz. Fruit processing; Post harvest management of fresh fruits and vegetables and their export; Application of extrusion cooking for designer foods and educational methodology and instructional technology by NAARM, Hyderabad were organized.

Professor (Mrs) D Murlu, Associate Dean and Principal, College of Home Science, MAU, Parbhani got Excellence Education Award 2006.

The University released sweet tamarind variety Ajantha, suitable for table purpose and value addition. The spineless variety of safflower PBNS 40 was released at national level. Two production technologies in sorghum, four in cotton, one in pearl millet and guava were recommended by this university. During the current year university targeted 9,818 quintals seed production during *kharif* and 5,363 quintals in *rabi* season of different crops.

The Rural Bio-resource Complex was established at Karmad village of Aurangabad district to mitigate the social problems of rural masses. Department of Biotechnology, Ministry of Agriculture, Government of India, New Delhi provided financial support of Rs 489.96 lakhs to run this project for five years.

Navsari Agricultural University, Navsari: The new courses on Environmental Science, Biotechnology and Protected Cultivation were initiated in the undergraduate curriculum. The



Biotechnology laboratory at Navsari

Postgraduate curriculum was revised and implemented as per the recommendations of Deans Committee.

The Central Library was strengthened by acquiring Libsys Software package for handling the in-house activities of the Library. The Library has also developed LAN using TCP/IP technology and



Processing of tomato at the Post-harvest technology lab

connected with University Internet through fibre optic line.

As a part of the Centre of Excellence on Post-harvest Technology, Mango fruit processing plant with a capacity of 5 tonnes and a Tomato Processing Unit were established. A commercial production unit for bio-agents was established in the Department of Entomology. Advanced Centre for Research in Biotechnology with State of the Art facilities has been commissioned in the ASPEE College of Horticulture and Forestry.

Short-term training programmes of 3 months were conducted on tissue culture techniques and hi-tech Horticulture. Gardeners training certificate programme was conducted in the ASPEE College of Horticulture and Forestry.

Punjab Agricultural University, Ludhiana: Students were



admitted in various undergraduate and masters' programmes on the basis of merit in entrance tests of eligible candidates while in doctorate programmes on the basis of merit in qualifying degrees.

Diploma in Fisheries was the new course started. The annual convocation of the University was held on October 31, 2006 to confer degrees to 333 PG students including 70 Ph.D, 263 M.Sc/M.Tech and MBA students.

A new girls hostel, a new international hostel, renovation and modernization of classrooms, laboratories, conference hall and library were taken up for upgrading infrastructure facilities. An electronic book bank was also established in the College of Agriculture to provide electronic connectivity to acquire technical information through e-journals and e-books.

The Indian Council of Agricultural Research sanctioned a Niche Area of Excellence on Soil and Water Management. Four farmers' training camps were organized for sustaining soil and crop productivity. A five days training programme on "Efficient Management of Soil and Water for Sustainable Agriculture", and a one-day workshop on "Water and Nutrient Management in Rice" were organized. Amelioration of manganese deficiency in wheat: Demonstrations were carried out at cultivators' fields in districts Ludhiana, Faridkot, Jalandhar and Kapurthala.

The Experiential Learning programme was introduced in the Colleges of Agriculture and Home Science. A sum of Rs 1 crore has been received from ICAR to start this programme.

Tamil Nadu Agricultural University, Coimbatore: A total of 728 students were admitted for 10 undergraduate degree

- The TNAU launched 17 days Agro-industrial Tie Up programme in which students underwent *in-plant* training in marketing for which a workshop was organized. Various issues involved in implementation of the AITP were discussed in the workshop.

programmes of TNAU. The new course B. Tech (Bio-informatics) has been introduced in TNAU during 2006–2007. Under the School of Post Graduate Studies, 29 masters and 23 doctoral programmes started by admitting 321 and 95 students respectively. Also, TNAU has launched two post-graduate diploma courses, one in Organic Farming and the other in Capital and Commodity Markets, this academic year.

The Rural Agricultural Work Experience (RAWE) programme for the final year undergraduate students was conducted for 60 days.

Educational technology trainings were given to teaching staff

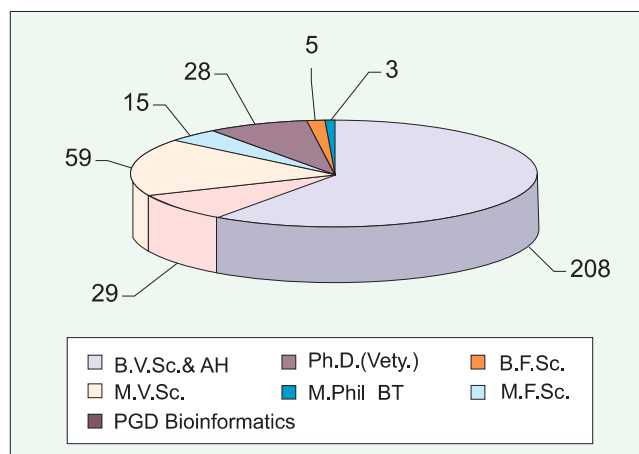
- The launching of open and Distance learning programmes of the TNAU, Coimbatore for 2006 was held at the Directorate of Extension Education.

for creating awareness on modern methods of teaching in association with NAARM, Hyderabad and Bharathidasan University, Trichy, Tamil Nadu.

Tamil Nadu Veterinary and Animal Sciences University, Chennai: The overall intake of students during the year 2005–2006 was 455. The programme wise intake was 226 in B.V.Sc. and

- Bilateral collaborative programme has been established between TANUVAS and Michigan State University, USA through a Teaming Agreement for a period of five years in the areas of staff and student exchange, teaching and research activities.

AH, 35 in B.F.Sc., 95 in M.V.Sc., 44 in Ph.D., Veterinary, 21 seats in M.F.Sc., and 8 in Ph.D. (Fisheries). The intake for PG diploma in Bio-informatics was 20 and M. Phil in Biotechnology is 6.



A new undergraduate degree programme, viz. Bachelor of Technology (B. Tech.) (Food processing) with admission strength of 20 students was introduced. Also, one year Post Graduate diploma in Companion Animal Practice with the strength of six students and one year Postgraduate diploma in Veterinary

- Some of the technologies developed by the Scientists in Veterinary and Fisheries are: Custom hatching unit at cheaper cost, hybrid Namakkal Quail I possessing higher growth rate, value added milk products, PPR diagnostic kit, PPR vaccine for sheep and goat, new vaccines for New castle disease and Fowl cholera in poultry, vero cell rabies vaccine for animals and TANUVAS-RUSITEC (Rumen simulation machine) in Veterinary Science and in Fisheries Science Raceway technique in shrimp aquaculture, poly herbal product for the production of disease resistant tiger shrimp, production of live fish food white worm, fish processing technology and lobster fattening technology.



The Chancellor of the University, Hon'ble Shri Surjit Singh Barnala conferring the degrees at the convocation of the university.

Laboratory Diagnosis with the strength of six students were introduced for B.V.Sc. graduate students.

Dr Dhinakar Raj G., Associate Professor, Department of Animal Biotechnology, MVC, Chennai received Dr Maruthamuthu Mariyayee Best Teacher Award of TANUVAS for his innovative methods in teaching. Mrs Sohini Dey, Ph.D. student in Animal Biotechnology received Jawaharlal Nehru Award for her Ph.D. thesis titled "Development of Recombinant Leptospiral Antigen for the Diagnosis of Leptospirosis".

The Indian Council of Agricultural Research sanctioned a Niche Area of Excellence project on molecular diagnostics for emerging avian viral diseases and their immunopathogenesis for Rs 200 lakhs, which is functioning at the Department of Animal Biotechnology.

MANPOWER DEVELOPMENT

All-India Competitive Examinations for Admissions to Agriculture and allied Science Subjects

For admissions to 15% seats in Under Graduate Programmes in Agriculture and allied science subjects, the 11th All India Competitive Examination was conducted on May 07, 2006. This was conducted for 11 subjects of undergraduate programmes including award of National Talent Scholarships (NTS) for 45 Universities (40 SAUs, CAU, BHU, Viswa Bharati and Nagaland University) and all seats at NDRI Karnal. In this examination, 16,500 candidates appeared and 1,271 were finally admitted through counseling held during July 2006. All the candidates who joined any university falling outside their state of domicile were awarded National Talent Scholarship (NTS) of Rs 1,000 per month.

For admissions to 25 percent seats in Postgraduate programmes at 40 State Agricultural Universities, five Central Universities (CAU, BHU, Viswa Bharti, AMU and Nagaland University), and 100% seats

at IARI, NDRI, CIFE, and IVRI including the award of Junior Research Fellowships, competitive examinations were held on June 21, 2006. A total of 466 Junior Research Fellowships (JRF) were awarded to meritorious students. Based on the number of graduates getting JRF awards, the following Universities were rated the best five. (i) University of Agricultural Sciences, Dharwad (37 JRF), (ii) University of Agricultural Sciences, Bangalore (33 JRF), (iii) Kerala Agricultural University (30 JRF), (iv) CSAUT Kanpur (27 JRF), and TNVASU Chennai (25 JRF).

Admission of Foreign Students

During the year 2006–2007, 290 students from 25 countries were given admissions. To meet quality residential needs of foreign students support has been provided to eleven Agricultural Universities for construction of international students hostels. The students come from different countries namely: Nepal, Afghanistan, Bhutan, Kenya, Ethiopia, Sri Lanka, Namibia, Syria, Finland, Thailand, Mauritius, Bangladesh, Yemen, Uganda, Turkey, Spain, Iran, Libya, Vietnam, Malaysia, Iraq, Indonesia, Oman, Egypt and Sudan.

Summer/Winter Schools and Short Courses

To provide continuing education and training in highly specialized subjects to teaching faculty, 87 Summer and Winter Schools and Short Courses of 10 to 21 day duration were supported by ICAR. In all 2,200 scientists engaged in teaching, research and

Scholarships and other Financial Assistance Schemes

Merit-cum-Means Scholarship (MCM): This Scholarship is granted to the students belonging to economically weaker sections of the society to undertake UG 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 at the rate of Rs 170 per month.

Internship Assistance: This assistance is being provided to all the final year students of B.V.Sc and A.H. programme during their Internship @ Rs 400 per month besides Rs 400 for undertaking to-and-fro journey to the place of internship for a period of six months.

Junior Research Fellowship (JRF): This prestigious fellowship is awarded to meritorious students (judged on merit rank secured by them in the ICAR's All India Competitive Examination for Admissions to PG Programmes and Award of JRF conducted every year during May–June). There are total 475 Fellowships in 19 subject groups (90 subjects). The amount is Rs 5,760 per month for non-veterinary and Rs 8,000 per month for veterinary students to pursue PG degree programme. Besides, a contingency grant of Rs 6,000 per year is payable to all the awardees.



extension education in diverse disciplines of agriculture and allied sciences benefited from these programmes.

Centres of Advanced Studies

The 31 Centres of Advanced Studies (CAS), sponsored and supported by the Council, offer facilities for continuing capacity building of faculty engaged in teaching. This year all the Centres initiated analysis of the trainings conducted by them. 58 training programmes covering various disciplines of agriculture and allied sciences benefited 1,035 faculty members/scientists of SAUs and ICAR Institutes.

PROFESSIONAL EXCELLENCE RECOGNITION

ICAR National Professor Scheme

The scheme is for conducting basic research in the disciplines of agriculture and allied sciences. There are ten positions of ICAR National Professors. Of these, five have been in position during the year 2006–2007. The major objectives of the Scheme have been: (i) To carry out lead researches in new directions on basic aspects of agricultural sciences, veterinary, and fisheries, (ii) to provide national leadership in R&D on frontier areas of agricultural sciences, (iii) development of human resources through research guidance, and teaching, (iv) creation of lead facilities—state of the art laboratories, and (5) contribute in the process of planning, monitoring and control of R&D. In pursuance with the recommendations of Dr Jain's Committee and approval of the Governing Body of ICAR Society, the following have joined as ICAR National Professors during the year 2006–2007 for a period of five years.

Dr Ramesh Chandra (NCAP New Delhi). Project title: Analysing impact of agriculture policy, technology, institutions and trade on agriculture growth, farm income, sustainability and urban poverty. Date of start: 10/04/2006.

Dr V K Gupta (IASRI New Delhi). Project Title: Designs for single factor and multi-factor experiments and their applications in agricultural systems research. Date of start: 05/04/2006.

Dr Bijay Singh (PAU Ludhiana). Project title: Plant need-based nitrogen management in rice and wheat. Date of start: 12/05/2006.

Dr T C Thakur (GBPUA&T Pantnagar). Project title: Technologies development for subsoil structure modification, deep placement of fertilizers (P&K) and micronutrients, and controlled field traffic for different cropping systems of Indo-Gangetic Plains. Date of start: 11/05/2006.

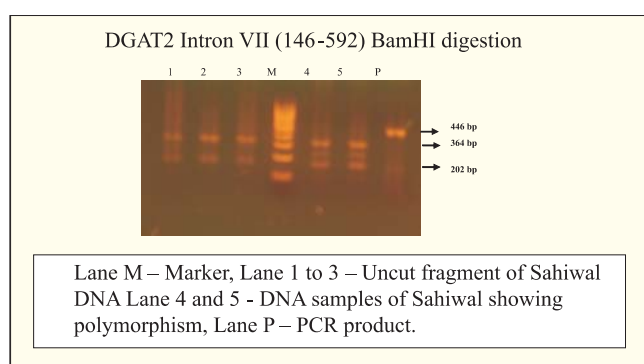
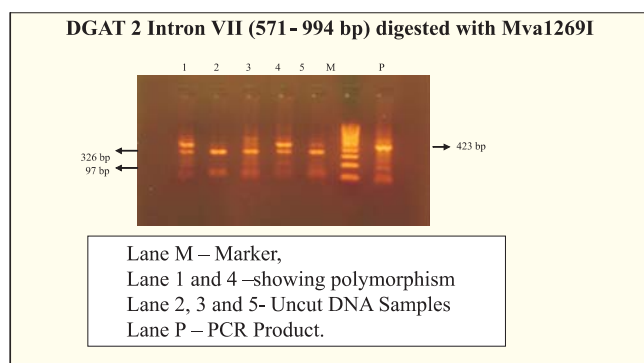
Dr I. Karunasagar (KVAFSU Bidar; Station: Mangalore). Project title: Patho-genomics of two important fish associated pathogens—*Salmonella Weltevreden* and *Vibrio harveyi*. Date of start: 15/05/2006.

In order to fill up the vacant positions, the process has been in progress.

ICAR National Fellow Scheme

A total of 25 positions of National Fellows exist in ICAR under the "Scheme for Creation of Professorial Chairs". Of these, 22 have been in position during the year 2006–2007. The progress reports of the projects undertaken by the ICAR's National Fellows have been given below.

- Dr A V N Paul, at IARI New Delhi under the research project entitled "Chemical Ecology, Strain Development and Novel Methods of Species/Strain Determination for Enhancement of Efficiency of *Trichogramma* spp." studied the synomonal effect of cotton crop ecosystem on the foraging capacity of *Trichogramma brasiliensis*, *T. chilonis* and *T. bactrae* in 11 cotton varieties. In late vegetative phase irrespective of the *Trichogramma* species, the cotton variety Pusa 8-6-68-29 showed highest response. In flowering phase, irrespective of the three *Trichogrammatids*, the cotton variety Pusa 6263 showed maximum response. Among three *Trichogrammatids*, *T. chilonis* showed highest response in the cotton ecosystem both in late vegetative and flowering phase.
- Dr Ravinder Kaur, at IARI, New Delhi worked on the project "Developing Regional Plans For Managing Poor Quality Irrigation Waters for Soil/Water Conservation and Agricultural Sustainability of National Capital Region". The natural resources of NCT, Delhi were characterized. It was observed that application of saline/alkali irrigation waters in paddy-based crop rotations of Najafgarh, Kanjhawala and Alipur blocks were responsible for development of salt affected soils. Excepting chromium concentrations in Alipur and Shahdara blocks, concentrations of most other heavy metal in irrigation waters of NCT, Delhi were well within permissible limits. It was further observed that there is acute zinc (Zn) deficiency (<0.6 ppm) in paddy growing soils of north Kanjhawala, Alipur and some parts of Najafgarh and Shahdara blocks.
- Dr B R Yadav at NDRI, Karnal has studied on "Identification of Quantitative Trait Loci in the Genome of Indigenous Breeds of Cattle and Buffaloes and their propagation through Marker Assisted Selection". He carried out research work in cattle and buffaloes on genotyping β -casein, β -lactoglobulin, α S2 casein, DGAT1 and DGAT2 gene polymorphism. Possible association has been seen in genetic variants and milk protein polymorphism. The ARMS-PCR analysis in Sahiwal cattle showed two allelic variants A and B. AA genotype was observed in high frequencies (0.964) whereas AB genotype had the frequency of 0.0364 in the



population. The genotype BB could not be found in any of the Sahiwal animals in the population. However, in Murrah buffaloes only BB genotype was found. The β -lactoglobulin is a major whey protein. PCR-RFLP analysis revealed two allelic variants A and B in Sahiwal. The variant A differs from B by a single amino acid substitution of Valine (Val) for Alanine (Ala) at position 118. The digestion of 262 bp amplified fragment with *Hae*III (GG/CC) yielded two types of restriction pattern due to underlying change in codon 10 and respective genotypes were identified accordingly.

- Dr D.K. Sharma at the Assam Agricultural University, Guwahati has been working on the project entitled “Development of ELISA based immunodiagnosics for classical swine fever”. A double sandwich ELISA test was standardized for detection of CSF viral antigen in tissues of pigs slaughtered for human consumption and died of suspected cases of CSF. 20.17% of the samples from slaughtered pigs were found to be positive for CSF viral antigen. Seven ELISA positive tissue samples selected were tested for CSF viral RNA by RT PCR. using primers specific to E 2 region of the virus and amplicons of 271 bp could be generated from 4 of the samples. Nine ELISA positive samples, which reacted with BVDV monoclonal antibodies were characterized by RT PCR. From two of the samples the DNA was cloned and sequenced. The sequence study also confirm that the samples contain CSF virus and not BVDV.

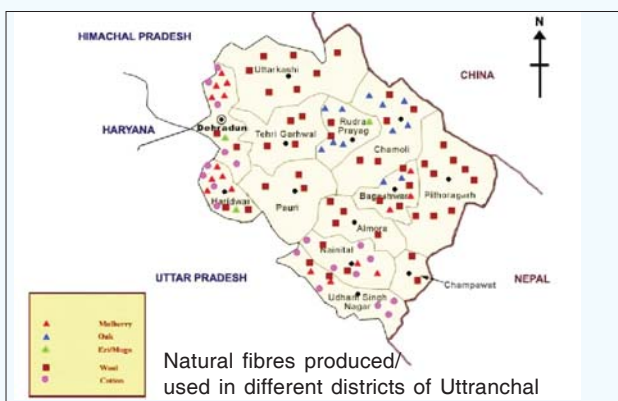
- Dr I M Santha at IARI, New Delhi has been approved the project entitled “Exploitation of Metabolic diversity for isolation of genes involved in lipid biosynthesis”. Triacyl glycerol (TAG) is synthesized by the Kennedy pathway and DGAT is the terminal enzyme and is the only one committed to TAG synthesis. RNA isolated from developing seeds of *Brassica juncea* was subjected to RT_PCR using designed DGAT specific primers and the PCR product of 1.5 kb was cloned and analysed. Two different types of cDNA clones were identified among the recombinants analysed.
- Dr K Alagusundaram at TNAU, Kumulur has been working on the project “Identifying Technologies for Using Modified Atmosphere Gases to Extend Shelf Life of Selected Tropical Fruits and Vegetables for Export Markets”. A high-tech modified atmosphere packaging research laboratory has been established. To determine the gas permeability through polythene based packs, a permeability apparatus was designed and fabricated. An evaporative cooler was designed and is being fabricated for on-farm cooling of fruits and vegetables. This cooler will be essential to retard the ageing process of fruits and vegetables immediately after harvest. Further studies are in progress.
- Dr Kausalya Ramachandran at CRIDA, Hyderabad worked on the project “Assessment of Sustainability of Treated/Development Watersheds in Rainfed Agro-eco-sub-regions of Peninsular India using GIS and Remote Sensing”. The evaluation work is being undertaken in a modular fashion pertaining to five aspects of the study—Use of Geomatics technologies, viz. GIS, GPS and Remote Sensing for mapping, temporal study, land cover change studies (LCCS), change in normalized differential vegetative index (NDVI) etc. A Sustainability Matrix was generated to compare the various aspects of sustainability, viz. productivity, viability, security, protection and acceptability in the selected micro-watersheds.
- Dr (Mrs) Renu Khanna-Chopra at IARI has been working on the project entitled Senescence: Mechanism in crops in relation to abiotic stresses, sink strength and their interaction. She has characterized the thermostability of the SOD isozymes from *Chenopodium murale in vitro*. The leaf protein extracts, thylakoidal and stromal fractions were subjected to elevated temperatures ranging from 50°C to boiling and analyzed for activity and isoform pattern of SOD. Out of six SOD isoforms, SOD V showed stability even after boiling the extract for 10 min. Under high temperature treatment (> 60°C) there was an appearance of a new SOD band with higher electrophoretic mobility. An unusual, constitutive thermostable chloroplastic Cu/Zn SOD from *C.*



murale is reported, which may contribute towards its heat tolerance.

- Dr D C Uprety at IARI, New Delhi has been working on the project “Effect of rising atmospheric CO₂ on the photosynthesis and productivity of crop plants”. The interaction of elevated CO₂ and temperature changes experienced by the *Brassica* plant was studied using leaves at different canopy positions in FACE (Free air CO₂ enrichment technology) in two cultivars namely *B. campestris* cv. Pusa gold (V1) and *B. juncea* cv. RH 30. Elevated CO₂ significantly increased the rate of photosynthesis in the leaves irrespective of their position, stress treatment and variety. The CO₂ induced increase in photosynthesis was significantly greater in top leaves followed by middle and lower leaves irrespective of variety and treatment. The interaction studies indicated that the effect of elevated CO₂ on photosynthesis was influenced maximum by temperature changes compared to other environmental factors.

- Dr Alka Goel at GBPUA&T, Pantnagar carried out work on the project “Evolution of Textiles Articles through Processing of Wool with Silk Waste Cotton to Create Entrepreneurial Skills in Rural Women”. Major textile work in Uttaranchal is carried out with wool fibres (rearing, processing and product formation) (Bhotia tribe) were preparing *dun*, *asan*, *chutka*, *namda*, and *thulma* etc. Combination of naturalistic, geometrical, stylized and abstract designs were used on their textile articles. All the fibres were processed by using different methods to improve their performance and aesthetic appearance and also to find out the best suitable and less expensive method of processing. Physical and chemical properties of all the selected fibres, viz. cotton, merinowool, tussar silk and mulberry silk were evaluated to judge their quality and also to decide their suitability for particular end use.
- Dr B M Prasanna at IARI, New Delhi carried out research on Molecular Characterization of Indian Maize Landraces and Allele Mining for Agronomically Important Traits. A set of



Use of wool with silk waste cotton by rural women



96 maize landraces, were analyzed using 100 microsatellite/SSR markers covering the maize genome. The study led to identification of 50 informative SSR markers suitable for fluorescent-labelled fingerprinting assays and population genetic analysis. Phenotypic evaluation of 126 landraces, including 73 from NEH region and 52 landraces from other agro-ecological regions in India, at two locations (New Delhi and Hyderabad) led to identification of 31 highly promising landraces for various agronomically important traits.

- Dr Rashmi Aggarwal at IARI has been working on the project “Improvement of strain of *Chaetomium globosum*, a potential antagonist of fungal plant pathogens for enhanced bioefficacy and developing molecular markers for its identification”. Fifteen isolates of *Chaetomium globosum* and one isolate each of *C. reflexum* and *C. perlucidum* have been established for molecular studies. Strain improvement through hybridization yielded eight hybrid cultures, out of which hybrid 6 and hybrid 8 showed superiority in terms of antagonism and antifungal metabolite production over parent cultures. The antifungal metabolites have been purified and one of the purified compounds showed 100% inhibition in growth of *Bipolaris sorokiniana* and *Fusarium* spp. at 100 ppm under *in vitro*. *C. globosum* also showed potentiality in detoxifying the toxin produced by the plant pathogen, *Bipolaris sorokiniana*. *C. globosum* produced xylanase and b 1, 3-glucanase which play role in antagonism.

EMERITUS SCIENTISTS

Dr T Maharana at the Orissa University of Agriculture and Technology, Bhubaneswar worked on standardisation of propagule production in *Dioscorea* of Orissa through various methods including tissue culture, *D. alata* performed the best out of the three species of *Dioscorea* tried with 20 cm size sets from tail end (13.87 tonnes/ha) and grown with okara as staking material with a spacing of 30 cm × 30 cm (12 tonnes/ha) and application of 90 : 90 : 90 kg NPK per hectare (15.66 tonnes/ha) under high density planting. *De novo* budding study in *D. alata* showed that keeping tubers in black polythene in vertical position yields the highest multiplication rate of 12.5. Vine cuttings of all the three *Dioscorea* responded well to rooting. *D. alata* can be propagated through out the year whereas *D. hispida* from June to October and *D. oppositifolia* from June to December. Rooting was best under yellow light during winter. Microtubers can be produced in all the three species but *D. oppositifolia* responded best to microtuber production while heaviest microtubers were produced in *D. hispida*. Rooted cuttings of *D. alata* produced 18.5 tonnes/ha tubers with the application of vermicompost at the time of planting. High

density planting of rooted cuttings of *D. alata* in a spacing of 30 cm × 30 cm produced 30 tonnes/ha. Use of 200 g whole tubers as planting material produced in previous year from the cut pieces under high density planting gave the highest yield of 61 tonnes/ha. All the three *Dioscorea* responded well to *in vitro* culture. Use of 0.1% HgCl₂ for 6 minutes followed by NaOCl 1% for 5 min was best sterilant. Shoot proliferation was best with BAP 92.5 mg/litre) and NAA (0.5 mg/litre). Root formation was best under MS medium supplemented with NAA (2 mg or 2.5 mg/litre) with BAP 0.5 mg/litre.

Dr M.S. Shaktawat at the Maharana Pratap University of Agriculture and Technology, MPUAT Udaipur conducted experiments on farmers' field during *kharif*-2004 and 2005 and *rabi*, 2004–05 and 2005–06. Results indicated application of phosphorus @ 60 kg P₂O₅/ha through PROM (Phosphate Rich Organic Manure) in maize and wheat to be highly beneficial as it gave the highest yield attributes of maize and wheat, grain yield of maize and wheat (31.74 and 39.84 q/ha), stover/straw yield of maize and wheat (54.96 and 55.74 q/ha), net returns of maize and wheat (Rs 18,088 and 29,152/ha) and benefit : cost ratio of maize and wheat (1.90 and 2.65). PROM being organic in nature gave additional benefit to crop in the form of moisture conservation and prevented phosphorus fixation and PROM P is available to more than one crop in succession. The phosphorus supplied through PROM cost only Rs 12/kg whereas phosphorus supplied through DAP cost Rs 18/kg at subsidized rate of fertilizer (DAP). Thus, use of PROM is beneficial to soil and crop under sustainable crop production. It is cheaper to farmers and environment friendly.

Professor S N Sharma worked on late-sown wheat crop (after rice) to evolve most economic, suitable and sustainable weed management practice under a study on weed management under conservation tillage in rice-wheat cropping system. *Phalaris minor* Retz., *Rumex denticulata* L., and *Cyperus rotundus* L. were the most common grassy, broad-leaved and sedge weeds respectively. In late-sown wheat, increasing seed rate up to 150% of normal practice helped check weed growth. Maximum crop yield was obtained with 125 kg seed/ha. Mechanical weeding (twice) resulted in highest crop yield.

Dr R P S Tomer undertook a study on seed testing procedures and seed quality tests for medicinal and aromatic plants. The weight of submitted and working sample for physical purity analysis in case of Satawar (*Asparagus racemosus*) was worked out to be 1,000 g and 100 g, respectively. Amongst the substrata (BP, TP, S) were tested for seed germination, BP (between paper) substrata was the best after applying the dormancy breaking treatment (PEG, imbibition for 72 h in water and hot water (80°C, 5 min) at 30°C to study seed viability, longitudinal cut and dipping seed in 1% Tetrazolium salt solution were found better to



differentiate between viable and non viable seed. The accelerated ageing seed vigour test was standardized (at 40°C, 72 h). In three seed lots of satawar, 0.23% saponin content was worked out. Hard seededness decreased with increase in storage periods resulting in higher germination.

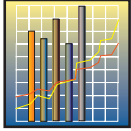
Dr G S Sethi experimented on improvement of tolerance to abiotic stresses in wheat through doubled haploidy breeding at Palampur. Doubled haploid (DH) breeding was undertaken in winter × spring wheat crosses to develop elite DH lines with tolerance to biotic (rusts and powdery mildew) and abiotic stresses (drought and cold). In order to combine the desirable traits of winter wheat (drought and cold tolerance) with the desirable spring wheat traits such as adaptability and amber grain colour, winter × spring wheat hybridization followed by wheat × maize system for the production of doubled haploids was exercised. The doubled haploid lines so obtained exhibit a wide range of variability for these traits. The DH lines, DH 31A and DH 33R were found to be fairly resistant to powdery mildew under natural epiphytotic conditions over the locations. The promising DH lines resulting from the project combining the desirable traits from winter wheat and rye can be directly used as cultivars.

Dr G D Sharma in a study on assessment and mapping of genetic diversity in natural populations of *Jatropha* spp. in Central and Western India, undertook surveys of four states, i.e. Gujarat, Maharashtra, Chhattisgarh and Jharkhand for study of genetic diversity for plant height, branches, stem girth, seed size and seed weight. Maximum seed yield (1.66 kg/plant) was recorded at Raipur followed by Deesa and Ahmad Nagar (1.64 kg/plant) while

the seed yield was lowest at Akola (1.56 kg/plant). Maximum plant height was recorded at Anand Nagar (2.79 m) followed by Sangli (2.76 m) and Raipur (2.74 m) whereas minimum plant height was observed at Deesa (2.48 m) and Akola (2.55 m).

Dr (Mrs) B A Talvelkar: Haematological profile during gestation and lactation and their influence on milk production and reproductive efficiency was studied in buffaloes (*Bubalus bubalis*) in Maharashtra. The results did not indicate physiological anaemia during gestation in buffaloes. When both the groups were compared, in Early Lactation group, there was a drop in erythrocyte number and haemoglobin in early lactation group. The results of the present study indicated significantly ($P < 0.05$) higher platelet count on 0 day when compared with 4 week, 3 week and 1 week. Total leucocytes were higher in 1 week when compared with 0 day and reduced in 1week postpartum.

Dr P.C. Ravi has been working on the project Institutional Arrangements for Agricultural Marketing in Karnataka—a policy perspective. The present system of handling commodities in the state and other post harvest practices, especially, in the case of perishables such as pre-cooling, storage, packing and transportation were observed to be primitive leading to colossal loss of valuable produces besides affecting the quality. Disintermediation and reducing costs by way of direct procurement through vertical integration will avoid multiple handling, reduction in levies, fees, commission and to improve the efficiency. In promoting vertical integration and private sector participation, the government needs to examine the existing policies, rules and regulations with a view to minimize conflict in successful private sector participation.



Social Sciences and Policies

AGRICULTURAL ECONOMICS

Seed system of 'low value and high volume' seed crop

The public sector has several keyroles in seed system development. The greater part of seed sold in India is based on public germplasm, hence it is important to understand how the public sector should interact with the private and local level seed production. Groundnut and potato provide a perfect example of 'orphan' crops with low seed multiplication rate and high seed requirements. Seed systems of these crops were studied in Andhra Pradesh and Uttar Pradesh, respectively.

Farm level seed management

There is a bit concentration of varieties grown – more than 80% of the area under both the crops is sown with their dominant two varieties. In groundnut, TMV 2 is the most popular variety, covering 54% of the area. This is a very old variety preferred by farmers because of its ability to perform well in drought conditions. JL 24, Polachi and TAG 24 are other dominant varieties. In potato,

- Study on groundnut and potato seed production, revealed that proper farm level seed management and supply chain could fulfill the quality seed requirement
- Fast growth high value agriculture provided a cushion to agricultural growth
- Diversification with high value crops has to planned in a manner that it maximizes farm income without much damage to natural resource
- Faster growth in livestock sector has considerable potential to reduce poverty
- ICT saves 90-95% farmers time as well their money spent on acquiring agricultural technology information
- Prices showed positive effects while price risks negative effects on oilseed production

Kufri Bahar 3797 is the top variety with 75% crop area. Rajendra 1 is another popular variety in eastern part of Uttar Pradesh.

Farmers acquired 35% fresh groundnut seed from commercial sources, and 65% of seed requirement was met from the traditional sources, viz. own farm-saved seed exchange. In potato, however, the share of farm-saved seed (60%) is much higher compared to the commercial seed. Farmers multiply fresh commercial seed on their farm and use it for a few cropping seasons. This is offered for sale in the next season after meeting his requirements, resulting in comparatively low (21%) proportion of area planted with commercial seed. The farmers buy fresh seed mostly to get pure seed of the popular varieties. The percentage of potato farmers acquiring seed because of exhaustion of all the stock is also quite high (30%). Only 12–15% farmers acquire seed to change the variety. These are the farmers who have got commercial interests as well as resources (mainly irrigation) for seed production and multiplication. Seed quality is the most important criterion for the farmer while going for fresh/new seed.

Extension agencies are expected to play an important role in the two-way flow of information between farmers and plant breeders but results indicate a very poor performance of these agencies. In the absence of effective extension mechanism, majority of the farmers (80% or more) get to know about a new variety from fellow farmers. As plant breeding is still in the public sector and both the crops do not attract commercial interests at present, there is a case to strengthen information flow though public extension machinery. Most of the farmers demand variety by name, suitable soil type,

Variety adoption and source of commercial seed

Particulars	Potato (Uttar Pradesh)	Groundnut (Andhra Pradesh)
Proportion of net sown area under the crop	58	80
Proportion of area under top one variety	75	54
Proportion of seed acquired off-farm in 2003–04	40	58
Sources of seed (% of quantity)		
Commercial	21	35
Other farmer	19	23
Farm saved	60	42
Reasons for acquiring off-farm seed (% of cases)		
To get pure seed of same variety	58	67
To change variety	12	15
Consumed or sold all stock	30	18



weather condition and market requirements. They also insist on physical examination of seed to ensure seed quality. Price is, however, an important criterion to buy groundnut seed.

Supply chain and private seed

Supply chains in potato are evolving rapidly. This increased the demand for improved varieties and quality seeds, and has also offered incentives to commercial seed sector to participate in the supply chain. There is increasing demand for potato varieties suitable for processing, and private seed producers have tied up with the processing industry to supply seed to their contract growers. This activity has attracted lot of private interest. Tissue-culture based private seed companies are selling source and commercial seeds. The tissue-culture based seed is not yet approved for certification, hence, these seed companies are not able to take advantage of benefits (of certification and tax incentives) provided to other commercial seed producers. Despite this problem, the share of this hi-tech potato seed is likely to increase substantially in future and potato could soon be out of the category of 'orphan' crops.

Options for seed system development

More than half of the seed is acquired off-farm, so formal seed system must meet this demand, which is quite high by any standard. Public seed corporations should take lead in the seed supply to farmers, and complete the seed chain. They should focus on seed multiplication in favourable conditions, so as to increase seed yield. Much of this could be realized by coordination of seed activities of different states. Private seed producers, with little extra investment and efforts to maintain seed quality, can play a significant role in augmenting the seed supply. The expanding markets for quality products are providing major opportunity for

private sector's participation. This is visible noticed in potato. For groundnut, the markets are for table purpose kernels in domestic and export market, high oil content groundnut, and groundnut cake. These markets enjoy considerable price premium that provides incentive to maintain product quality, as quality of seed has an important role to play in this. The government should link marginal production regions with the national and global markets. This would help develop supply chain, especially for premium market, which may eventually attract corporate sector in the product, as well as seed market.

Demand for urea towards 2011

Demand for urea by the year 2011 was projected under different scenarios. The first scenario is Business-as-usual (BAU), in which it was assumed that area under irrigation and HYV, and real price of urea would change at the same rate as witnessed from 1992–93 to 2001–02. In addition to these factors, one more factor is added to account for increase in demand for urea due to change in total cropped area. Demand for urea under BAU scenario is projected to increase annually by 3.29%, but by adding residual effect of all other factors then demand for urea is projected to increase by 3.41%. Total demand for urea in year 2011 is projected to be 24.96 million tonnes as against 19.06 million tonnes during triennium ending 2002–03. This scenario includes decline in real price of urea by 1.28% per year as witnessed during the reform period, which in turn implies either increase in nominal and real subsidies on urea or much faster increase in crop price relative to price of urea.

Owing to serious resource constraint there is a strong likelihood that real subsidies on urea does not increase in the country. This can happen if urea prices are increased at the same rate as the increase in prices of crops. This scenario shows that demand for

Demand projections for urea under various scenarios

Variables	Elasticity	Scenarios: growth rates (%)			
		BAU	BAU and freeze on subsidy	Freeze on subsidy, exploit irrigation	Attain 4% growth
Area under irrigation	0.843	1.27	1.27	2.13	2.13
Area under HYV	0.797	2.05	2.05	2.05	2.05
Gross cropped area	1.000	0.15	0.15	0.55	0.55
Real price of urea	-0.344	-1.28	0	0	-2.00
		Increase in real term	Urea price increase at same rate as crop price increase		
Growth rate in demand for urea due to 1 to 4		3.29	2.85	3.97	4.53
Growth rate including residual		3.42	2.98	4.10	4.66
Projected demand for urea in 2010–11 ('000 tonnes)		24,959.00	24,122.00	26,303.00	27,452.00



High-value Agriculture for a Faster and More Equitable Growth

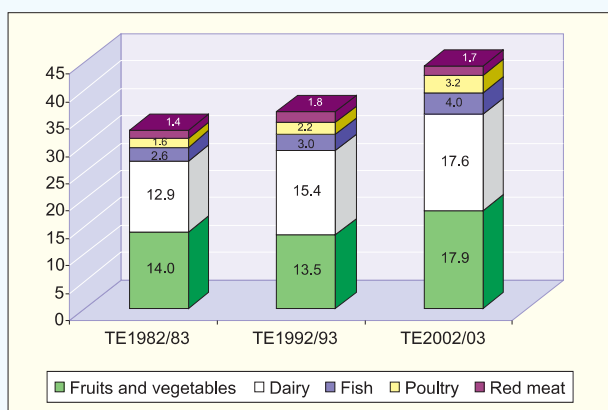
The growth in agriculture and its allied activities, the main source of livelihood for a majority of the rural population in India, has started decelerating in recent years. This trend has to be arrested, otherwise it would have serious social and economic repercussions. High value agriculture may provide a cushion to agricultural growth.

Share of high value food commodities (fruits, vegetables, milk, poultry products, meat and fish) in the value of agricultural output increased from 33% in 1982–83 to 45% in 2002–03. At a disaggregated level fruits and vegetables account for about 18% of the agricultural sector output, and is closely followed by dairy products. Fish share is 4% and poultry 3% in the agricultural sector output. The increasing share of high value food commodities in agricultural sector output is a clear indication of out of staple diversification of Indian agriculture.

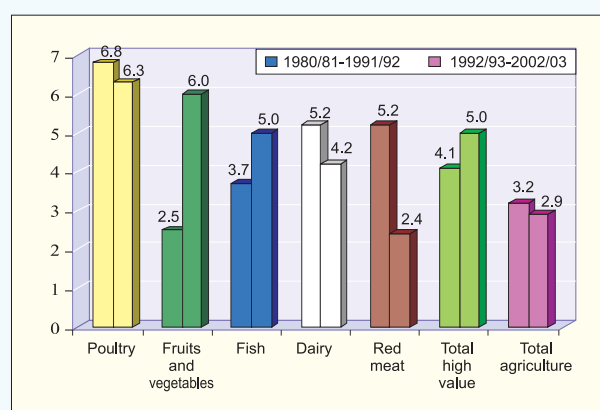
Growth in high-value agriculture was more prominent since the initiation of economic reforms programme in 1991. Fruits

and vegetable production increased at an annual rate of about 6% a year between 1992–93 and 2002–03, much faster than in 1980s. Dairy production increased consistently over 4% a year despite a marginal deceleration in the economic reforms period. Poultry production increased consistently over 6% a year throughout the last two decades.

Fish production accelerated from 3.7 to 5% during same period. High value segment of Indian agriculture grew faster, compared to rest of the agriculture over the last two decades. The deceleration in agricultural growth in the recent decades is largely because of significant fall in growth of rest of the agriculture from 2.7% during 1980s to 1.5% during 1992/93 – 2002/03. On the other hand, growth in high-value segment accelerated from 4.1% during 1980s to 5% during 1992/93 – 2002/03. Thus the fast growth high value segment provided a cushion to agricultural growth which otherwise would have decelerated at a faster rate.



Share of high value food commodities in agricultural sector output (1993-94 prices)



Annual compound growth rate in high value food production (%)

urea increases @ close to 3%, which would generate total demand of 24.12 million tonnes.

In third scenario it is assumed that the increase in urea price would match with increase in crop price, along with 2.13% annual growth in area under irrigation. This expansion of irrigation corresponds to full exploitation of India's irrigation potential by the year 2020. It is also assumed that expansion of irrigation would increase crop intensity. Empirical evidence on this indicated that 1% increase in irrigation results in 0.25% increase in gross cropped area. Under this scenario demand for urea grows to about 4% per annum which corresponds to 26.3 million tonnes of urea by the year 2011.

Under another scenario assumptions were 4% growth rate in output, full exploitation of irrigation potential, expansion of HYV by 2% per annum, and small increase in crop intensity because of

increase in irrigation facility. Since growth rate in output is contributed by several factors, this scenario assumes 0.62% growth in output due to TFP and 0.51% growth in output due to diversification. On balance this scenario requires 4.6% annual growth in application of urea. This growth requires decline in real price of urea by 2% per year, which in turn requires growth in subsidies at a much higher rate than what was witnessed during the reforms period. Demand for urea under this scenario is projected to be 27.4 million tonnes toward by 2011.

Demand projections for urea based on positive approach are quite close to the projections based on normative approach. A synthesis of two approaches revealed that demand for urea towards 2011 would vary between 24 million tonnes at low output growth scenario to 27.6 million tonnes corresponding to relatively high growth scenario.



Promoting Growth in Livestock Sector for Poverty Alleviation

Growth in agriculture is more poverty reducing than the growth in other economic sectors in developing countries. Nearly 72% of India's population lives in rural areas, and 75% of it depends on agriculture and allied activities for livelihood. Further, of 261 million poor in the country, 75% are from rural areas. Accelerating agricultural growth is thus important to reduce rural poverty. The National Agricultural Policy targets a 4% growth in agricultural sector over the next two decades and envisages an important role for livestock sector in achieving this projected growth rate.

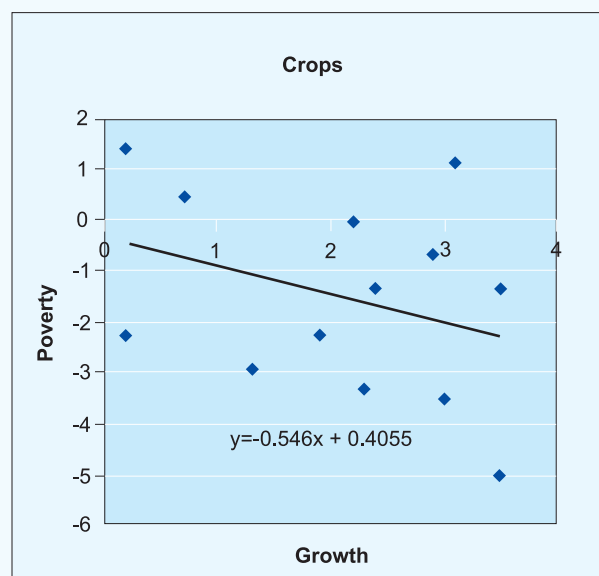
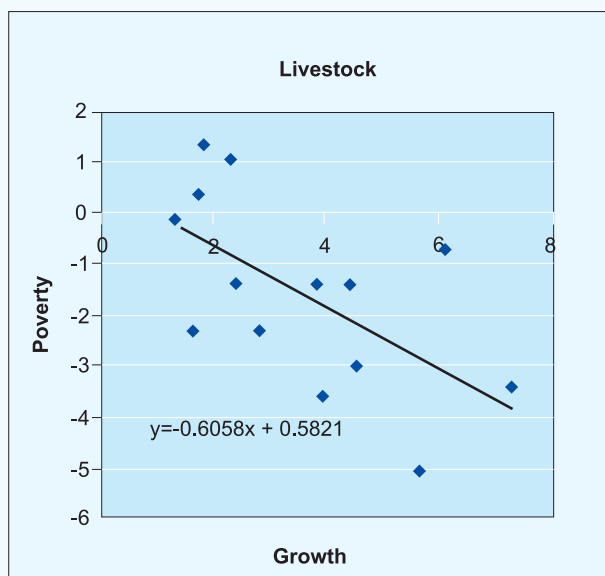
Livestock accounts for over a quarter of the agricultural gross domestic product and its growth was always faster than the agricultural sector as a whole. Besides, distribution of livestock resources is more egalitarian compared to land. In 2002–03 the small farm households (< 2 ha) that comprised 60% rural households controlled 76% cattle, 72% buffalo 80% small ruminants, 83% poultry and 90% pigs. Thus faster growth in livestock sector has considerable potential to contribute to agricultural growth and thereby poverty reduction.

Study on growth in head count rural poverty ratio vis-à-vis growth in livestock and crop sub sectors for major Indian states

Annual growth rate (%) in the value of output of various agricultural activities

Periods	Crops	Livestock	Fishery	Forestry
1970–71 to 1979–80	1.8	3.9	2.9	-0.6
1980–81 to 1989–90	2.5	5.0	5.7	-0.7
1990–91 to 2002–03	2.2	3.8	4.7	1.3

for the period 1983–84 to 1997–98 revealed a faster reduction in rural poverty where growth in livestock sector had been robust. Livestock production as well as poverty reduction performance in West Bengal, Tamil Nadu, Kerala, Karnataka, Haryana, Punjab and Maharashtra was better. Andhra Pradesh too witnessed high growth in livestock production but its impact on poverty reduction was not as high. This is because industrialization of poultry production that accounts for nearly half of the livestock income in the state. On the other hand, Assam, Madhya Pradesh, Rajasthan and Uttar Pradesh experienced low growth in livestock production as well as in poverty reduction.



Relationship between growth and rural poverty in various states in India

Exploring possibilities of achieving four percent growth rate in Indian agriculture

Sources and growth prospects at state level were studied to find the possibilities to put agriculture on targeted growth trajectory. The study involved estimation of output elasticity with respect to fertilizer and irrigation, scope of irrigation expansion and increase in fertilizer use, scope of diversification through high value crops, improvement in TFP, and estimation of prospects of output growth

through expansion of irrigation, increase in application of fertilizer, diversification and growth in TFP.

Feasible growth rate in Punjab was the lowest and less than 1%. Bihar has the scope to raise crop output annually by 6.64% in medium term, which is the highest among all states. Growth prospects seem to be low in Haryana and Rajasthan, which are projected to achieve 1.66 and 2.33% growth in crop output. Maharashtra, Himachal Pradesh and West Bengal possess potential



Sources of output growth (per cent) in 2011

States	Diversi- fication	Irriga- tion	Fertilizer	TFP	Total
Andhra Pradesh	0.25	1.71	1.14	0.40	3.50
Assam	0.27	1.42	1.33	0.88	3.89
Bihar	0.18	3.36	0.85	2.24	6.64
Gujarat	0.78	0.65	1.79	0.47	3.69
Haryana	0.33	0.00	0.68	0.65	1.66
Himachal Pradesh	0.69	3.02	0.70	1.08	5.49
Jammu & Kashmir	0.90	2.88	2.03	0.42	6.23
Karnataka	0.19	1.75	1.16	0.86	3.96
Kerala	0.00	1.54	1.46	0.60	3.60
Madhya Pradesh	0.75	1.62	0.81	0.26	3.44
Maharashtra	0.99	1.95	1.35	0.88	5.18
Orissa	1.05	2.33	0.92	0.14	4.44
Punjab	0.17	0.00	0.40	0.36	0.94
Rajasthan	0.46	0.00	1.61	0.25	2.33
Tamil Nadu	0.40	0.82	1.60	0.35	3.17
Uttar Pradesh	0.37	1.49	1.45	0.60	3.90
West Bengal	0.78	1.22	2.34	1.16	5.49
All India	0.49	1.43	1.32	0.72	3.96

for more than 5% growth rate. Growth prospects are also high for Orissa. Output growth rate in the remaining states is projected to be between 3 to 4%.

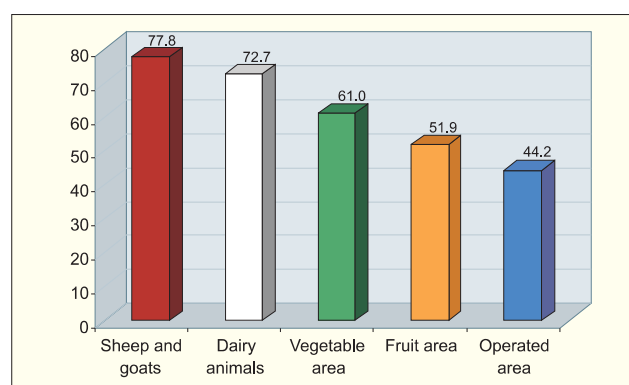
State-wise growth (per cent) in various factors needed to achieve 4% output growth at national level

State	Fertilizer	Irrigation	Area shift to other than foodgrain	TFP
Andhra Pradesh	3.15	2.39	0.555	0.40
Assam	6.94	3.00	0.166	0.88
Bihar	5.11	4.87	0.074	2.24
Gujarat	4.61	1.36	1.136	0.47
Haryana	2.42	0.00	0.500	0.65
Himachal Pradesh	1.75	3.13	0.146	1.08
Jammu & Kashmir	5.11	2.98	0.283	0.42
Karnataka	4.61	1.86	0.116	0.86
Kerala	4.61	1.98	0.000	0.60
Madhya Pradesh	4.40	3.88	0.854	0.26
Maharashtra	4.59	3.34	0.664	0.88
Orissa	6.89	4.93	0.884	0.14
Punjab	1.74	0.00	0.500	0.36
Rajasthan	4.44	0.00	0.640	0.25
Tamil Nadu	2.28	0.82	0.374	0.35
Uttar Pradesh	4.39	1.80	0.213	0.60
West Bengal	5.19	4.01	0.559	1.16
All India	4.35	1.95	0.497	0.72

India need to increase fertilizer consumption in agriculture by 4.35% and area under irrigation annually by 1.95% to achieve 4% output growth. There is also a need to shift about 0.5% area from foodgrains to non-foodgrains every year. Growth in TFP in India is projected to be 0.72% per year at all India level. TFP consists of contribution of several factors; most important being technology and its dissemination. Improvement in infrastructure and farmer's knowledge and skill applied to farming are other contributions to TFP.

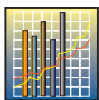
High value agriculture and the poor

High value agriculture is more appealing from the perspective of poverty reduction. Most high value commodities require as much as 2–4 times more labour and generate 6–8 times more returns compared to cereals. The smallholders (< 2 ha) have sufficient labour of their own. Production of high value food commodities thus is a perfect opportunity for them to augment their income and utilize family labour more effectively.



Share of smallholders in high value agriculture (2002/03)

Smallholders' participation in the production of high value commodities was estimated by examining their share in area under horticultural crops, dairy animals and small ruminants. Smallholders account for 61% area under vegetables and 52% area under fruits, which is more than their share in total operated area. Their share in dairy animals and small ruminants is much higher, indicating that distribution of animals is more equitable as compared to land. On the assumption of identical productivity across farms, the share of smallholders in area under horticultural crops and animal population could be treated as their contribution to high value agricultural production. This, however, could be an underestimate of their contribution, because several studies showed that small farms are more efficient compared to large farms. Given that agricultural growth is pro-poor, and faster growth and higher participation of smallholders in the high value agricultural production it can be concluded that growth in high value agriculture would contribute more to poverty reduction than a similar growth in non-high value agricultural production.



However, it is often argued that because of their commercial orientation high value crops may endanger household food security especially of the smallholder households. Proportionately smallholders put large cropped area under foodgrains as do the large farmers who relatively participate less in production of fruits and vegetables because of their labour-intensive nature. As per ha income from high value crops is large, so smallholders may utilize this for purchase of foodgrains. It is also argued that many a high value food crops require more of chemical fertilizers, pesticides and irrigation and therefore may degrade land and water resources. It may be noted that excessive use of resources or inputs in any crop will deteriorate the quality of natural resources; high value crops are no exception to this. Nevertheless, leguminous vegetable crops peas and beans add to soil fertility. Water requirement of most high value crops, on per ha or per unit of output is much less as compared to rice, cotton and maize. The need is to plan diversification with high value crops in a manner that maximize farm income without much damage to natural resources.

Role of ICT-based institutional innovations in reducing transaction cost of farmers

The new economic forces, including globalization of agriculture, are leading to transition of subsistence farming to commercial one. Farm diversification, value addition, and recycling are the integrated farm approaches having the potential risk minimization capacity. The success of the approach depends on access to latest technical knowledge to the farmers. Acquiring relevant knowledge from the extension agents entails high cost and time, which influence the farmers' decision making. The information and communication technology (ICT) is one of the potential options available to access information by the farmers.

The ICT based initiatives in agriculture are in take-off stage in India. The study revealed that ICT made positive impact on reducing the transaction cost in accessing information. Segregating the exclusive impact of ICT is difficult but it broadly indicated that

ICT is one of the significant sources for accessing information.

Traditionally for farmers go to nearby taluk headquarters and meet officials in department of agriculture getting information or any technical knowledge on crop cultivation, or get the suggestions while purchasing agro-inputs from private dealers. Usually private dealers do not spend enough time in offering technical advice to a farmer unless otherwise the latter purchase some agro-inputs, as well as decades also not have the required level of technical knowledge. In fact they give product-oriented advice rather than farmer/farm oriented advice. As a result, farmers in general are rarely benefited. The ICT initiatives change this scenario and save transaction costs of the farmers as they got technical advice by visiting kiosks located in the village or nearby village. The components of transaction cost incurred by the farmers covered 'distance traveled', cost equivalent of labour hours foregone, and traveling cost per visit. A farmer by using ICT services could save his traveling time and inturn transaction costs by more than 90–95%. ICT-based initiatives, viz. e-choupal by ITC, I-kisan by Nagarjuana group and Helpline by Chandra Sekhar Azad University of Agriculture and Technology, Kanpur were studied. e-choupal focuses on dissemination of price information while the rest 2 on dissemination of information on technologies.

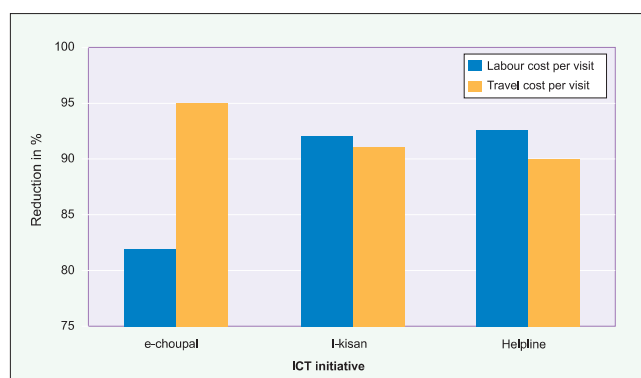
Apart from information on technologies or farm inputs, farmers spend considerable time and money for marketing of the produce and price discovery. In this context, e-choupal (soy-choupal) sets a good model of ICT as a mechanism to overcome these difficulties of the farmers, i.e. add value to the time of the farmers. As per ITC estimates, by using soy-choupal, the farmers could save an average 68% of the transaction costs due to information led decision making and efficient marketing of farm produce (soybean). Therefore, it is appropriate to draw lessons from the ICT-based initiatives and derive means of minimizing transaction costs so as to enhance overall profitability.

Instability and supply response in oilseeds production in India

Oilseed is an important component of crop production in Indian agriculture. The continued production shortfall of oilseed after mid 1990s and yield fluctuations has critical macro-economic implications in the country. Presently, India meets its large parts of domestic demand (about 40%) of edible oils through import and this may go up.

Instability in oilseeds yield and prices

Average yield levels of edible oilseeds have increased in most of the states over the years, while its variability declined. In most cases average prices of oilseeds and its variability have declined. The imports of cheaper edible oilseeds and oils during 2001–02 might have helped in declining prices of oilseeds.



Reduction in transaction cost for accessing information



Instability in yield and prices of major oilseeds in selected states of India

Crop/State	Periods	Yield (kg/ha)		Price (Rs/q)	
		Mean	CV (%)	Mean	CV (%)
Groundnut					
Andhra Pradesh	I	938	9.00	883	8.5
	II	909	24.8	805	23.0
Gujarat	I	705	71.4	1030	84.5
	II	935	49.8	964	50.2
Rapeseed and Mustard					
Punjab	I	1010	7.6	1069	13.3
	II	1099	13.0	926	13.7
Rajasthan	I	832	10.4	948	16.5
	II	871	12.1	872	15.7
Sunflower					
Karnataka	I	473	24.8	856	48.3
	II	518	19.2	904	25.1
Maharashtra	I	373	15.0	973	19.1
	II	390	9.6	898	15.7
Soybean					
Madhya Pradesh	I	854	18.6	774	23.8
	II	977	12.8	660	25.4

*Indicates period I: 1986–87 to 1993–94, and period II: 1994–95 to 2001–02.

- Method developed for estimating acreage under important crops in difficult terrains of Meghalaya
- Study was conducted on statistical algorithmic approach for improved estimation of treatment effects in repeated measurements designs
- Statistical method developed for analysis of long-term fertilizer experiments
- Role of balanced nutrition in long-term sustained productivity, studied
- Instability index studied for several crops
- 'Agricultural Rural Database 2006' released.

A study '**Developing Remote Sensing Based Methodology for Collection of Agricultural Statistics in Meghalaya**' was initiated by IASRI, New Delhi, in collaboration with Space Applications Center, Ahmedabad and NESAC, Shillong, Meghalaya. Meghalaya—mainly consists of hilly region with thick forest cover, has undulating topography and non-accessibility of vast area, the relative percentage area under the crops is very less, mostly terraced farming and jhum cultivation is practiced in these regions, is covered by clouds most of the time. Hence use of remote sensing satellite data also may not be able to provide reliable information. The major problem of optical remote sensing is availability of cloud free data which is very difficult for this region. Therefore, this project was developed. It has scientific methodology with strong

Effects of price and price risk on oilseed production

The economic environment and incentives are changing rapidly and farmers are responsive to these changes in oilseed sector. Mixed response was observed for instability in yield and prices, while covariate risks have increased. Expected price and price risk are important determinants of oilseeds production. The prices have positive effects while price risks have negative effects on oilseed production. The price elasticity of oilseed production varied between 0.26 and 0.88, while price risk elasticity was negligible. These results imply economic significance of prices and price risks, which may play important role in policy decisions to improve oilseeds production in the country.

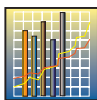
AGRICULTURAL STATISTICS AND COMPUTER APPLICATIONS

Research achievements

Availability of reliable and timely agricultural statistics is of paramount importance to the planners, administrators, policy makers and research scholars as India is predominantly an agrarian economy.

Assessment of survey capabilities of private sector

The primary objective of the study "Assessment of survey capabilities of private sector", was to gather information on private organizations/agencies engaged in statistical surveys and studies, and to assess the survey capabilities of such agencies. Majority of the states and union territories of India are covered by way of headquarters and branches of the responding agencies. Some states like Tripura, Mizoram, Sikkim and Himachal Pradesh do not have either the headquarter or the branches of any of the agencies. Similarly, union territories like Andaman and Nicobar, Daman and Diu and Nagar Haveli, Pondicherry and Lakshadweep do not have representation by way of headquarters as well as branch office of any agency. Many of the agencies have wide range of experience having completed projects in socio-economic, agriculture, industry, infrastructure, service sector etc. Only 35 agencies satisfy the non-negotiable criteria. Only 10 agencies can be classified as potential agencies having the capability to conduct surveys at the national level. Only 9 agencies can be classified as potential agencies having the capability to conduct surveys at the regional level. There are 3 agencies which can be classified as operating up to state level having capability to take up complete survey.



Agricultural Research Data Book 2006

Information pertaining to agricultural research, education and related aspects available from different sources is scattered over various types of published and unpublished records. The Agricultural Research Data Book 2006, which is tenth in the series, is an attempt to put together main components/indicators of such information. The Data Book comprising 260 tables, is organized, for the purpose of convenience of the users into 11 sections, viz. Natural Resources, Environment, Agricultural Inputs, Fisheries, Horticulture, Production and Productivity, Produce Management, Export and Import, India's Position in World Agriculture, Investment in Agricultural Research and Education and Human Resources under National Agricultural Research System (NARS). It also contains at the end, list of important National and International Agricultural Research Institutions associated with agricultural research and education along with their addresses, telephone numbers and e-mail addresses. The Data Book was compiled through the joint efforts of the Indian Agricultural Statistics Research Institute (IASRI) and Indian Council of Agricultural Research (ICAR).

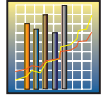
statistical background, which is capable of providing reliable estimates of area under the crop. Under this project an integrated methodology based on remote sensing satellite data, GIS and sample survey data was proposed. In the absence of any satisfactory objective technique for this situation, this study was divided in 2 stages. In the first stage, field problems were studied by conducting pilot study in Ri-Bhoi district of Meghalaya, which is considered to be the rice bowl of the state. In the second phase, to validate the methodology developed during the pilot study, the study was repeated in the same district and also applied in Jantia Hills district. In the first approach ratio estimator is applied to find the paddy area under cloud based on the pixel value of current year image and previous year image. The paddy area is estimated as 8,075 ha. In the second case the paddy area was estimated using grid sampling based on previous year data. The total area under paddy came out to be 8,143 ha. Now this study needs to be further extended for estimating acreage under other important crops of the state. Potato, ginger, pineapple, banana, maize and paddy were identified for this purpose.

Under study on **“Some investigations on design and analysis of agro-forestry experiments”**, the experiment consists of tree and crop combination in a plot, and the opinion is that the trees species grown in one plot may affect the performance of treatments applied on the neighbouring plots. For such situations, the concept of strongly neighbour balanced design was defined and some methods of constructing complete block designs for 2 factors (tree and crop) in a plot strongly neighbour balanced for 1

factor (tree) were obtained. These designs were variance balanced for estimating the direct effects of contrasts in the combinations of levels of both the factors (tree and crop). Some series of incomplete block designs balanced for adjacent tree effects were also obtained. These designs were partially variance balanced for direct effects.

In the study on **“Statistical and algorithmic approach for improved estimation of treatment effects in repeated measurements designs (RMDs)”**, a class of reference balanced RMDs for estimating direct effects of formulations useful for bioequivalence trials has been obtained using Williams Square RMDs. Designs with each experimental unit receiving some or all of the treatments, one at a time, over a period of time are called repeated measurements designs (RMDs). The distinguishing feature of these designs is that the treatments applied in a particular period influence the responses of the experimental unit not only in that period but also leaves residual effects in the succeeding periods. In an RMD, a sequence of treatments is applied to an experimental unit and observations are recorded over the periods hence it is very much possible to observe interaction between treatments and experimental units. A non-additive model with interaction effects is used to deal with such situations as these effects also contribute significantly to the response measured. Considering a non-additive model, a balanced, uniform and non-circular class of RMDs with a pre-period was shown as universally optimal for the estimation of direct effects using calculus for factorial arrangements. Further, computer programs were developed in Visual Basic 6.0 for generation and randomization of different classes of RMDs catalogued from literature. Since it is very difficult to get real data for desired experimental situations, computer programmes were also written for simulating RMD data under different models of RMDs. Again, application potential of RMDs in bioequivalence trials was studied and some new classes of RMDs were obtained, which were reference balanced for residual effects. Database containing a catalogue of RMDs was developed and parameters {number of treatments (v), number of periods (p), number of experimental units (n), total number of observations (N), and source/type of the design} of RMDs catalogued from literature were entered into it. This catalogue contains total 206 RMDs falling under different classes for $v \leq 20$, $p \leq 20$ and $n \leq 100$. User has the privilege to view the catalogue for particular number of input parameter(s) (for fixed number of treatment or period or units or total number of observations or combination of treatment, period and unit) besides viewing all designs option. Further, the database was linked to corresponding user interface to view the particular design as well as randomized layout of that design.

In **‘Planning, designing and statistical analysis of data relating to experiments conducted under AICRP on long-term fertilizer experiments’**, the revised data after reanalyzing



the plant samples for Cu and Mn content for rice and wheat crop and available P in the soil were analyzed. In this data their contents were abnormally high. The results were provided to the centre incharge. The pooled analysis of super-imposed treatments data for Ludhiana centre, indicated that the reduction of P application by half over its optimal level continuously for 12 years under optimal and super optimal NPK treatments continued to sustain the maize yield levels under both the treatments at 34.3 q/ha and for wheat productivity levels at 47 q/ha and 50.4 q/ha, respectively, and were at par as obtained with the respective original treatments. The complete omission of P application under optimal NPK (-S) treatment resulted in a significant decline in the average yields of maize and wheat crops by 2 q/ha and 3 q/ha from their corresponding average yields of 33.1 q/ha and 46.2 q/ha under original treatment.

In the study on '**Combined analysis of experiments on long range effect of continuous cropping and manuring on soil fertility and yield stability**' the total factor productivity (TFP) index was calculated using Divisia-Tornqvist method which indicated that in most of the centres, treatments with N : P : K-80 : 80 : 40 and N : P : K-120 : 80 : 40, were the most sustainable. This showed the role of balanced nutrition in long-term sustained productivity.

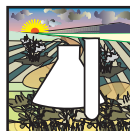
The **instability index** using Cuddy Delta Valle approach as well as premium rates at different indemnity levels for different

crops for Uttar Pradesh and Karnataka were estimated using yield approach methodologies, viz. MPD and normal curve technique and crop revenue insurance approach. Results showed that the premium rates by crop revenue insurance were low as compared to other techniques.

In a consultancy project following manuals, viz. the (i) Area and Crop Production Statistics, (ii) Animal Husbandry Statistics, (iii) Agricultural Prices and Marketing, (iv) Cost of Cultivation Surveys, and (v) Horticulture and Spices Statistics, were prepared and submitted to the funding agency.

Human resource development

Several training programmes and refreshing courses were organized at the IASRI for agricultural researchers, senior and middle level officers. Training programme on Design and Analysis of Experiments for Rapeseed-Mustard Varietal Trials.; several training programmes, refreshing courses were organized at the IASRI for agricultural researchers, senior and middle level officers; training course on Small Area Estimation Techniques; workshop on PERMISNET and Intelligent Reporting System (IRS); refreshing course on "On-line Library Information System; Workshop-cum-training programme on 'Design and Analysis of Farmers Participatory Research Trials'; Summer School on "Sample Survey Techniques in Agricultural Research"; and training programme on Statistical Methods for Agricultural Research.



Technology Assessment, Refinement and Transfer

A number of activities were taken up for technology assessment, refinement and demonstration of technology/product and its dissemination through training of farmers and extension personnel. At present, there are 541 Krishi Vigyan Kendras (KVK) sanctioned by the ICAR which include 364 under State Agricultural Universities, 37 under ICAR Institutes, 89 under NGOs, 32 under State Governments and the remaining 19 under various other organizations.

KRISHI VIGYAN KENDRAS

The activities of the KVK are enumerated here.

On-farm trials

The KVKs took up 4,109 on-farm trials (OFT) involving 537



Treatment of animals

On-farm trials by KVKs

Crops/ enterprises	Varietal/ feed evaluation	Nutrient management	Cropping system/ farming system	Resource conservation*	Weed management	Insect/ disease management	Farm implements and tools	Total
Cereals	28 (354)	33 (322)	24 (165)	2 (76)	11 (74)	24 (123)	1 (9)	123 (1,123)
Oilseeds	13 (80)	25 (155)	15 (53)	–	5 (54)	12 (118)	1 (6)	71 (466)
Pulses	13 (86)	19 (91)	9 (42)	1 (20)	3 (9)	17 (196)	–	642 (444)
Commercial crops	7 (75)	10 (43)	3 (11)	–	1 (1)	14 (169)	2 (13)	35 (312)
Vegetables, fruits and flowers	31 (278)	40 (290)	35 (145)	2 (13)	7 (37)	72 (628)	–	187 (1,391)
Livestock production and management	8 (25)	27 (187)	3 (10)	–	–	5 (38)	–	43 (260)
Fishery	–	–	4(17)	–	–	–	–	4 (17)
Home science	–	10 (96)	–	–	–	–	–	10 (96)
Total	100 (898)	164 (1,184)	93 (443)	5 (109)	27 (175)	144 (1,272)	4(28) (28)	537 (4,109)

*Resource conservation also includes zero-tillage; figures in parenthesis indicate the number of trials.



technologies on various aspects of agriculture including varietal evaluation (100), nutrient management (164), cropping system/farming system (93), resource conservation (5), weed management (27), insect/disease management (144), and farm implements and tools (4).

Varietal evaluation

Performance of improved wheat varieties in Jharkhand:

KVK, West Singhbhum conducted on-farm trial to evaluate the performance of wheat variety K 9170 over Sonalika presently cultivated by the farmers. K 9170 with seed rate of 150 kg/ha produced significantly higher grain yield (35.08 q/ha), highest net return (Rs 15,581/ha) and highest B : C ratio of 2.56.

Assessment of salt tolerant rice varieties in tsunami affected low-lying valley areas of Andaman and Nicobar Islands: KVK, Port Blair conducted on-farm trial on three improved varieties of rice—BTS 24, Sumathi, and CSR 7-1 with the popular variety C 14-8 for their performance in tsunami affected low lying locations in Andamans. BTS 24 registered 61% increase in yield over farmer's adopted variety C 14-8 and 7% increase over Sumathi, another improved variety.

Performance of potato varieties for yield and late blight incidence in Bihar: Performance of potato varieties (Kufri Puskar, Kufri Arun, and Kufri Jawahar) for higher yield and tolerance to late blight was assessed in 0.12 ha area by involving 10 farmers in surrounding villages of KVK, Darbhanga during *rabi* season. Both Puskar and Arun varieties were tolerant to late blight. Puskar recorded highest yield level of 228 q/ha resulting in an increase of 36% over Arun and 52% over locally adopted variety. There was no incidence of late blight in Kufri Puskar and Kufri Arun, while Kufri Jawahar and locally adopted variety had disease score of 2 and 3 respectively.

Performance of tomato varieties in Andhra Pradesh: KVK, Kadapa conducted on-farm trial on three varieties of tomato at three different locations under protective irrigation system. The yield of improved variety (US 618) was 50.87 tonnes/ha, which was 30% higher than locally adopted non-descriptive variety, with highest B : C ratio of 1.96.

- KVKs conducted 4,109 on-farm trials involving 537 technologies on varietal evaluation, nutrient management, insect and pest management, cropping system, weed management, resource conservation, and farm implements and tools.
- The performance of wheat variety K 9170 with seed rate of 150 kg/ha over Sonalika produced higher grain yield (35.08 q/ha), highest net return (Rs 15,581/ha) and highest B : C ratio of 2.56.
- Both the potato varieties Puskar and Arun were tolerant to late blight, while kufri Jawahar and locally adopted variety had disease score of 2 and 3 respectively.

Performance of okra varieties in Himachal Pradesh: KVK, Hamirpur evaluated the performance of three improved varieties of okra, viz. Prabhani Kranti, P 8 and Tulsi against the non-descriptive locally adopted variety. Tulsi variety yielded highest (140 q/ha) followed by Parbhani Kranti (135 q/ha) and P 8 (120 q/ha) with 52, 47 and 30% increase in yield over local variety respectively.

Performance of capsicum varieties in Himachal Pradesh: The performance of two varieties of capsicum, Bomby and Orebelle against the non descriptive variety in use in the fields of 10 farmers was evaluated for yield by KVK, Solan. Orebelle variety yielded highest (1,160 q/ha) followed by Bomby (1,015 q/ha), which was 231 and 190% higher than locally adopted variety. B: C ratio of Orebelle was the highest. KVK, Kinnaur (Himachal Pradesh) evaluated the performance of four hybrids/varieties of capsicum, California Wonder, Solan Hybrid II, Bharat and Capsicum Hybrid 041 against the non descriptive variety in use, at the fields of four farmers. Capsicum Hybrid 041 and Solan Hybrid II yielded 211.2 q/ha and 210.3 q/ha respectively, followed by Bharat (205.4 q/ha) and California Wonder (170.7 q/ha). The increase in yield over farmers adopted non-descriptive variety was 91.1% for Capsicum Hybrid 041, 90.3% for Solan Hybrid II, 85.9% for Bharat and 54.5% for California Wonder.

Performance of cucumber varieties in Himachal Pradesh: KVK, Kinnaur evaluated the performance of four varieties of cucumber, Khira 75, Khira 90, Khira Hybrid 1 and Amrit Hybrid against the non-descriptive variety in use at the fields of three

Performance of US 618 and NS 5005 on yield and income of tomato

Variety	Duration (days)	Plant height (cm)	No. of fruits/plant	Yield (tonnes/ha)	% increase in yield	B : C ratio
Local variety	125	90	22	39.12	–	1.34
US 618	155	165	35	50.87	30.03	1.96
NS 5005	125	120	27	43.56	11.34	1.54



farmers covering 1.25 ha. The yield was in the order of Amrit Hybrid > Khira Hybrid 1 > Khira 90 > Khira 75 > local Khira (Control). The yield of Amrit hybrid was double than the locally adopted variety.

Performance of different varieties of broccoli in Himachal Pradesh: KVK, Kinnaur evaluated the performance of three varieties of broccoli namely Palam Samridhi, Fiesta Hybrid and Calabrese Hybrid against the variety in use (Green Head) at the fields of two farmers. Fiesta Hybrid yielded 207.3 q/ha followed by Palam Samridhi (196.7 q/ha) and Calabrese Hybrid (190.8 q/ha) with Fiesta Hybrid showing highest increase in yield over control.

Performance of brinjal varieties in Bihar: KVK, Jamui undertook on-farm trial with three hybrids of brinjal, viz. Swarna Shyamli, Swarna Shakti, and Pusa Hybrid 9 on farmer's field in Nawadeeh village of Khaira block. The locally adopted variety Pusa Kranti was taken as control. Pusa Hybrid 9 achieved 50% flowering in 48 days with average fruit weight of 149 g and was the highest yielder. The highest yield was recorded in Pusa Hybrid 9 (610 q/ha). Swarna Shyamli was an early flowering variety with bigger fruits, but less number of fruits per plant.

Performance of maize varieties in Himachal Pradesh: The performance of four varieties of maize, viz. Plant gene, Ganga Kaveri, Bio Seed and Polo against the non-descriptive variety in use at farmers' fields was evaluated by the KVK, Hamirpur. Ganga Kaveri yielded highest followed by Bio Seed, Polo and Plant Gene respectively. Ganga Kaveri also yielded 44% more than the locally adopted variety.

Performance of rice cultivars under upland situation in Bihar: KVK, Sheikhpura conducted on-farm trial on rice to assess the performance of three rice cultivars along with non-descriptive variety adopted by the farmers under upland situation, the results show that Prabhat gave the highest yield, which was 50% more than the non-descriptive variety adopted by the farmers.

Performance of rice cultivars in Bihar

Variety	Yield (q/ha)	Increase in yield (%)
Farmers variety	20	–
Prabhat	30	50
Gautam	28	40
Richaria	18	–

Performance of mustard (*raya*) varieties under rainfed condition in Bihar: KVK, Sheikhpura conducted on-farm trial to assess the performance of three mustard varieties, viz. Pusa Jai

Yield performance of cultivars of mustard under rainfed condition

Variety	Yield (q/ha)	Increase in yield over control (%)
Local variety	8	–
Pusa Jai Kisan	12	50.0
Pusa Bahar	10	25.0
Pusa Bold	11	37.5

Kisan, Pusa Bahar, and Pusa Bold with locally grown non-descriptive variety as check under rainfed condition. Pusa Jai Kisan gave the highest yield (12 q/ha) which was 50% more than the locally grown, non descriptive variety.

Yield evaluation of sunflower hybrids in Punjab: KVK, Nawanshahar evaluated the yield performance of two new hybrids of sunflower, PSFH 652 and PSFH 569 against PSFH 118 at farmers'

Performance of varieties of sunflower

Variety	Yield (q/ha)	(%) Increase in yield over control
PSFH 118 (Locally grown)	27.16	–
PSFH 652 (Improved)	30.43	12
PSFH 569 (Improved)	28.76	5.8

fields. PSFH 652 yielded (30.43 q/ha) and PSFH 569 (28.76 q/ha), being 12 and 6% higher over PSFH 118 (locally grown variety) respectively.

Nutrient management

Performance of rice varieties under different nutrient levels in Jharkhand: On-farm trial was conducted by KVK, West Singhbhum on performance of rice variety IR 64 under different nutrient levels against the local variety Bhojana. The grain yield of

- Integrated nutrient management not only reduced 60% infestation of coconut mite but also increased yield by 98% compared to farmers' practice.
- Line-sowing of sunflower gave 15% higher yield over farmers' practice of broadcasting and ridge sowing.
- The productivity of low land rice can be enhanced by soil application of *Azospirillum* 7.5 kg/ha + 40 kg N/ha in the form of urea through mud ball in two equal splits.
- Application of NAA @ 20 ppm + 10 ppm GA resulted in higher yield (98.4 q/ha) besides reducing fruit and flower drop.



Performance of IR 64 variety of rice at different nutrient levels

Level of nutrients	Tillers/ m ²	Grain yield (q/ha)	Cost of production (Rs/ha)	Net return (Rs/ha)	B : C ratio
Bhojana + farmers' practice of nutrient application (40 kg N: 20 kg P/ha)	18	16.30	7,650	2205	1.29
IR 64 + farmers' practice (40 kg N: 20 kg P/ha)	26	24.70	7,850	6,745	1.86
Bhojana + balanced dose of nutrients (80 : 40 : 20 kg NPK kg/ha)	28	26.40	9,225	6,375	1.69
IR 64 + Balanced dose of nutrients (80 : 40 : 20 kg NPK kg/ha)	34	36.80	9,425	11,335	2.20
CD at 5%		8.65		4,585	0.33

Selling price of grain: @ Rs 450/q.

IR 64 was found to be 36.8 q/ha when grown with balanced dose of nutrients (80 : 40 : 20 kg NPK/ha). It also gave significantly higher net returns (Rs 11,355/ha) and B : C ratio of 2.20.

Enhancing productivity of low land rice using *Azospirillum* and mode of urea application in West Bengal: The farmers of South 24 Parganas use 40 kg N/ha as top dressing through urea by broadcasting method in rice, leading to loss in nitrogenous fertilizer through leaching as well as flooding. KVK, South 24 Parganas conducted on-farm trial on soil application of *Azospirillum* in combination with urea through mud balls. The soil application of *Azospirillum* (7.5 kg/ha) along with the farmer's practice increased yield by 5.5% over farmers' practice of top dressing of 40 kg N/ha. The maximum yield was recorded under the treatment of soil application of *Azospirillum* 7.5 kg/ha + 40 kg N/ha in the form of urea through mud ball in two equal splits. Thus through judicious application of nitrogenous fertilizer in combination with biofertilizer, the productivity of low land rice can be enhanced.

Optimum combination of inorganic and organic sources of nutrients for rice in Uttar Pradesh: KVK, Raebareli conducted on-farm trial on rice crop grown through combination

Optimum combinations of inorganic and organic sources of nutrients for higher rice yield

Nutrient combination	Yield (q/ha)
Farmers' practice (Non application of vermicompost)	32.0
NPK @ 120 : 60 : 60 kg/ha (inorganic source)	40.0
NPK @ 120 : 60 : 60 kg/ha (vermicompost)	36.8
NPK @ 120 : 60 : 60 kg/ha(50% inorganic and 50% vermicompost)	41.5

of inorganic and organic nutrients. The highest grain yield (41.5 q/ha) as well as highest net returns were recorded with N : P : K @ 120 : 60 : 60 kg/ha when applied in 50 : 50 ratio through inorganic fertilizers and vermicomposting.

Effect of nitrogen on yield of *gobbi sarson* (mustard) in Punjab: KVK, Faridkot conducted on-farm trial to assess the effect of different levels of nitrogen on the yield of *gobbi sarson*. The results indicate that 125 kg/ha of nitrogen gave highest yield (22.62 q/ha) of *gobbi sarson*.

Effect of Boron application in cauliflower in Bihar: KVK, Banka conducted on-farm trial on effect of application of boron on cauliflower at different levels. The application of boron @ 10 kg/ha along with other recommended practices gave yield of 282 q/ha as compared to 277 q/ha by application of boron @ 7.5 kg/ha.

Effect of nutrient sources on yield of garlic bulb in Maharashtra: KVK, Jalna conducted on-farm trial on yield of garlic bulb. Application of 50% recommended dose of fertilizers with 800 kg vermicompost and 400 g PSB/ha resulted in increase

Effect of nutrient application through different sources on size and yield of garlic bulb

Sources of nutrients	Bulb size (mm)	Yield of bulb (q/ha)
Application of 10 cartloads of FYM + 40 kg N and 20 kg P through chemical fertilizer/ha	13.56	18.69
Application of 25 cartloads of FYM + 50 kg each NPK/ha	24.44	20.87
50% dose of T2 + 800 kg vermicompost + 400 g PSB/ha	29.60	22.61
SE ± (P=0.05)	0.944	0.530
CD 5% level	2.175	1.224



of bulb size (29.6 mm) and higher bulk yield of 22.61 q/ha.

Effect of micronutrient spray on yield of sweet orange in Maharashtra: KVK, Jalna conducted on-farm trial to assess the effect of micronutrients spray on yield of sweet orange. Two sprayings of NAA 2 ml/10 litre of water at the stage of pea size fruit

Micronutrients	No. of fruits/tree	Yield (kg/(kg/tree))
No control measures for management of fruit drop	443.96	94.83
Spraying of NAA 2 ml/10 litre at pea size fruits followed by second spray after 15 days	660.92	153.41
Spraying of NAA 2 ml/10 litre at pea size fruits followed by second spray after 15 days + spraying of micronutrient (micnelf-32) solution 40 g/10 litre of water	744.72	177.23
SE ± (P=0.05)	18.77	4.452
CD 5% level	43.29	10.267

and 15 days after first spray followed by micronutrient (micnelf-32) 40 g/10 litre resulted in increase number of fruits (744/tree) and higher yield (177 kg/tree)

Effect of humic acid on yield of sugarcane in Maharashtra: KVK, Ahmednagar conducted on-farm trial at 10 locations to assess the efficacy of application of humic acid on growth of root and cane yield of sugarcane in alkali soils with three treatment combinations. Application of recommended dose of fertilizer (250 : 115 : 115 NPK kg/ha) + 25 tonnes/ha FYM + 3.75 kg/ha humic acid resulted in higher tillering (6.63) and cane yield (17.76%) besides increased internodal length (18.64%) compared to other treatments.

Management of fruit and flower drop in chilli in Maharashtra: KVK, Sholapur conducted on-farm trial to assess the effect of growth regulators on fruit and flower drop in chilli at

three locations. Application of NAA @ 20 ppm + 10 ppm GA resulted in higher yield (98.4 q/ha) besides reducing the fruit and flower drop.

Insect and pest management

Management of complex disease problem in green pea during off season in Himachal Pradesh: Farmers in Mandi district cultivate vegetables in the off-season to get better price, however, the yield is low due to complex disease problems. KVK, Mandi conducted on-farm trial to control complex disease

Control measures	Yield (q/ha)	Increase (%)	B : C ratio
Farmers' practice (No control measure)	38.3	–	4.1
Seed treatment with fungicide (carbendazim @ 2.5 g/kg)	52.6	37	5.9
Soil application of bioagent (<i>Trichoderma viridae</i>) @ 2.5 kg/62 kg FYM/ha	50.5	32	5.2
Seed treatment with bioagent (<i>Trichoderma viride</i>) @ 4 g/kg seed	40.6	6	4.3
Seed treatment with fungicide (carbendazim @ 2.5 g/kg) and Soil application of bioagent (<i>Trichoderma viride</i>) @ 2.5 kg/62 kg FYM/ha	68.5	79	7.1

problems in green pea with five treatments. Seed treatment with fungicide (Carbendazim @ 2.5 g/kg) + Soil application of bioagent @ 2.5 kg/62 kg FYM/ha was found to be most effective with a yield of 68.5 q/ha, which was 79% higher than the yield

Growth regulator	Plant height (cm)	Average branches (number)	Fruits (No.)	Fruit length (cm)	Fruit weight (g)	Fruit/flower drop (%)		Yield (q/ha)
						Fruit	Flower	
No use of growth regulators	62	7	155	7	1.86	9	17	80
Use of NAA @20 ppm	62	7	163	7	1.87	2	3	88
Use of T ₂ + GA @ 10 ppm	70	7	163	9	2.10	2	3	98



obtained through farmers' practice of no control measure (38.3 q/ha).

Management of shoot and fruit borer (*Leucinode orbonalis*) and yield of brinjal in Pakur district of Jharkhand: KVK, Pakur conducted on-farm trial on management of shoot and fruit borer in brinjal. Results revealed that the low infestation 4% and highest yield (239 q/ha) was obtained by spraying Imidachloprid at the interval of 15 days.

Effect of practices on control of shoot and fruit borer (<i>Leucinode orbonalis</i>) and brinjal yield			
Control measures	Yield (q/ha)	Extent of infestation (%)	B : C ratio
Dimethoate spray @ 2 ml/litre, 2–3 times (farmer's practice)	120	20	4.2
Carbaryl or Malathion spray @ 2 ml/litre and spray with Cypermethrin @ 1 ml/litre of water (before fruit setting) —recommended practice	280	12	5.6
Soil application of neem cake, 8% @ 500 kg/ha during transplanting, repeated during flowering stage, spray of neem oil @ 2 ml/litre of water and spray of monocrotophos @ 1.5 ml/litre of water 15 days later-refined practice	291	8	6.1

KVK, Gadag in Karnataka conducted a similar trial on control of shoot and fruit borer of brinjal resulting in drastic reduction in infestation to 8% and extra yield of 171 kg/ha over farmers' practice.

Performance of rice varieties for Pest/disease tolerance in Nellore district of Andhra Pradesh: KVK, Nellore conducted on-farm trial for identification of suitable blast resistance rice varieties for *rabi* season. Among the varieties, NLR 34449 gave highest average yield of 7.82 q/ha with lowest incidence of blast. Among the BPH tolerance varieties tested, NDLR 7 gave highest average yield of 82.95 q/ha followed by NDLR 8 (74.40 q/ha). The locally popular BPT 5204 appears to be tolerant to both blast as well as brown plant hopper and could be replaced by NLR 34449 in blast endemic areas and by NDLR 7 or 8 in BPH prone areas.

Management of gram pod borer by intercropping of coriander with chickpea in Karnataka: KVK, Chitradurga conducted on-farm trial on management of gram pod borer

Effect of intercropping of coriander with chickpea on control of pod borer and yield

Intercrops	Yield (q/ha)		Pest infestation	B : C ratio
	Chickpea	Coriander		
Chick pea as sole crop (Local practice)	8.20	–	36	1.55
Chick pea + Coriander (6 : 1)	7.50	0.8	30	1.63
Chick pea + Coriander (6 : 2)	7.12	1.2	25	1.66

through intercropping of coriander with chickpea. Growing coriander with chickpea is an indigenous practice that needed standardization in terms of proportion of rows between main crop and the intercrop. Intercropping at 6 : 2 ratio gave better control of gram pod borer as well as a better B : C ratio. Pod borer infestation reduced to 25% and 24 kg/ha more yield equivalent was obtained without any additional cost.

Assessment of appropriate control measure on control of pod borer in chickpea in Bihar: On farm-trial was conducted by KVK, Banka to assess the performance of intercropping and spray schedule for control of gram pod borer. The intercropping was compared with that of insecticide application [Methyl Parathion (2%) 20 kg/ha]. The intercropping of gram + coriander

Performance of intercropping and insecticide spray on control of gram pod borer

Treatment	Yield (q/ha)	Increase in yield over control%
Endosulphan (2%) (farmers' practice)	7.26	–
Methyl Parathion (2%) 20 kg/ha	9.60	32
Gram + Coriander (6 : 1)	9.71	34

CD at 5% level 0.116
CV (%) 1.53

(6 : 1) was equally effective like application of methyl parathion in controlling pod borer. It is therefore advisable to grow for intercropping of gram + coriander (6 : 1) as it is biological control and sustainable.



Control of coconut mite through nutrient management in Karnataka: Two on-farm trials were conducted in Udipi district located in high rainfall coastal agro-eco system, and in Hassan, located in the transitional zone of Karnataka. Because of the management practices by farmers, the yield under farmers' practice

of three practices, including farmers' practice, recommended practice, and further refined practice. Spraying of Spinosad 48 SC (0.1 ml/litre) gave better control of borer (incidence reduced from 26.4% in farmers practice to 8.5% in the treated plots) and gave about 34.3% increased yield.

Effect of nutrient management on control of coconut mite and yield in Udupi dist				Effect of nutrient management on control of coconut mite and yield in Hassan district			
Level of nutrients	Yield (nuts/tree/year)	Infestation (%)	B : C ratio	Level of nutrients	Yield (nuts/tree/year)	Infestation (%)	B : C ratio
50 kg FYM + 1 kg complex fertilizer/tree/year NPK 170 : 120 : 400 g/plant (May and June)	52	82	1.76	Farmers' Practice (Non-use of fertilizer and plant protection chemicals)	32	87	1.06
NPK 330 : 200 : 800 g/plant (September and October) + 2 kg of lime + 0.5 kg of Mg SO ₄ + 50 kg FYM/plant	85	46	2.60	Application of FYM 50 kg/palm, 500: 320: 1200 g of NPK/tree	58	60	1.82
NPK 170 : 120 : 400 g/plant (May and June) NPK 330 : 200 : 800 g/plant (September and October) + 2 kg of lime + 0.5kg of Mg SO ₄ + 50 kg FYM/plant + Neem cake@ 2kg/plant	103	22	3.07	Growing of field bean as intercrop and application of FYM 50 kg/palm + RDF + neem cake 2 kg + Borax 50 g and spraying of neem oil + garlic extract on bunches for short trees and root feeding of 5% Azadirachtin.	86	27	2.86

is higher in Udipi than in Hassan district. Three different nutrients management approaches were assessed for control of coconut mite and to enhance yield. Integrated nutrient management not only imparted resistance against mite and reduced about 60% infestation at both the locations but also increased yield by 98% as compared to farmers' practice.

Management of tomato fruit borer (*Helicoverpa armigera*) in Karnataka: KVK, Haveri conducted on-farm trial on management of fruit borer in tomato and compared the effect

Assessment of different control measures of Alternaria leaf blight in chrysanthemum in Karnataka: KVK, Haveri conducted on-farm trial to compare the efficiency of Propiconazole (0.1%) with the farmers' practice, and presently recommended spraying of Mancozeb (0.2%) to manage the Alternaria leaf blight in chrysanthemum. The refined practice of spray of Propiconazole (0.1%) reduced the incidence of disease in comparison of the recommended practice and farmers' practice and had 52.1% less disease incidence and 34.3% higher yield than farmers' practice.

Effect of Spinosad 48 SC in control of tomato fruit borer (<i>Helicoverpa armigera</i>) and tomato yield				
Treatments	Borer damage (%)	Yield (q/ha)	% increase in yield over farmers' practice	B : C ratio
Endosulfan spray individually and in combination with other insecticides, 4 times (farmers' practice)	26.4	84	–	2.32
Carbaryl (4 g/l)/Endosulfan (2 ml/litre)/Fenvelerate (0.5 ml/litre)/Dimethoate @ 1.7 ml/litre (recommended Practice)	12.6	103	22.3	2.60
Spinosad 48 SC (0.1 ml/litre) - refined practice	8.5	111	34.3	2.80



Cropping system

System of Rice Intensification (SRI): The system of rice intensification, popularly known as SRI method was assessed in different locations with different treatment combination. Farmers in Kerala often face the shortage of irrigation water in several crops, particularly in upper valleys, and also shortage of labour at various critical stages of crop. KVK, Kollam, Kerala conducted on-farm trial on SRI in rice. SRI method is labour intensive in the beginning stages but not so in the later stages of the crop growth,

Comparison of paddy seeder sowing at 20 × 20 cm and rotary weeding with SRI method in Kerala

Treatments	Rice yield (q/ha)	B : C ratio
Transplanting of 25 day old seedlings, hand weeding, continuous submergence (traditional practice)	35	1.05
Transplanting of 10 day old seedlings, one per hill at 30 × 30 cm spacing, rotary weeding, irrigation) at hair line cracking stage (SRI practice)	57	1.36
Sowing with paddy seeder at 20 × 20 cm spacing, rotary weeding, irrigation at hair line cracking stage	65	1.45

while the direct seeding of rice is comparatively labour saving as well as productive. Results show that in Kollam district use of paddy seeder gave highest yield of 65 q/ha. If paddy seeder is not possible to be used, farmers could take up SRI method.

KVK, Koppal, Karnataka conducted similar on-farm trial to evaluate the effects of SRI method in comparison to improved practice and farmer's present practice and found that SRI method was more promising than the regular transplanting method of rice cultivation with highest yield and B : C ratio.

Performance of intercropping of potato with maize/mustard in Bihar: KVK, Jamui conducted on-farm trial on

- System of Rice Intensification (SRI) was more promising than the regular transplanting method of rice cultivation with higher yield and B : C ratio.
- Line sowing in sunflower was found to be most beneficial with about 15% higher yield over farmers' practice of broadcasting.
- Sowing of pigeon pea at 120 × 120 cm spacing resulted in 34% increased yield over farmers' practice besides substantial reduction in seed rate.

intercropping in potato/maize and potato/mustard against the farmers' practice of sole cropping of potato. Both the intercropping system was found to be better than the sole crop of potato in terms of total income, net income and benefit: cost ratio. The results show that potato + mustard (4 : 1) intercropping was more profitable for Jamui district based on highest net return and benefit: cost ratio of 1.65.

Assessment of different sowing methods of sunflower in Haryana: KVK, Ambala conducted an on-farm trial to assess the performance of three different sowing methods, i.e. line sowing, ridge sowing and broadcasting (farmers' practice) on yield of sunflower. Farmers in Ambala district sow sunflower crop by broadcasting, thereby causing difficulty in adoption of appropriate plant protection and intercultural operations. Line sowing was found to be most beneficial with about 15% higher yield over farmers' practice of broadcasting (17 q/ha).

Performance of different tillage methods on wheat yield in Punjab: KVK, Faridkot conducted on-farm trial on the effect of different tillage methods (Conventional, Zero tillage and Rotary tillage) on yield of wheat (variety PBW 343) in rice-wheat rotation. Rotary tillage practice gave around 19% higher yield (48 q/ha) while zero tillage practice gave around 14% higher yield (46 q/ha) against the conventional practice (40 q/ha).

Performance of intercropping of banana with vegetables in West Bengal: KVK, Dakshin Dinajpur conducted on-farm trial to assess the sole cropping of banana compared to intercropping of vegetables like tomato, cucumber and green pea, as it was expected to give more profit from optimum utilization of time and space. Among the three vegetables assessed, green pea was found to be

Effect of intercropping of potato with maize/mustard on yield and net return

Cropping system	Average yield (q/ha)		Cost of cultivation (Rs/ha)	Total income (Rs/ha)	Net income (Rs/ha)	B : C ratio
	Potato	Maize				
Potato sole crop	242	–	35,200	82,348	47,148	1.34
Potato + Maize (2 : 1)	214	39	36,600	92,060	55,460	1.53
Potato + Mustard (4 : 1)	233	11	35,700	94,504	58,804	1.65



best with a B : C ratio of 2.1. Further, it was compatible with the banana canopy and showed no effect on plant height and girth of the pseudostem. Tomato was found to be least compatible.

Effect of different crop geometry on yield of pigeonpea in Andhra Pradesh: KVK, Karimnagar, conducted on-farm trial on spacing in pigeonpea to maintain optimum plant population through line and square methods of sowing. Sowing of pigeon pea at 120 × 120 cm spacing resulted in 34% increased yield over farmers' practice besides substantial reduction in seed rate.

Weed management

Assessment of different chemical weed control measures on onion yield in Karnataka: Though both KVK, Chitradurga

Effect of Butachlor and Oxyfluorfen on weed control and yield of onion in Karnataka

Level of nutrients	Yield (q/ha)	Increase in yield (%)	Extent of weed control (%)
Two hand weeding (farmers practice)	179	–	67.64
Butachlor 50 EC (2 litre in 1,000 litre/ha) Recommended practice	206	15	72.25
Oxyfluorfen 23.5% EC (1.1 litre in 1,000 litre/ha) Refinement	227	26	83.50

Effect of Pendimethalin and Oxyflurofen on weed control and yield of onion in Karnataka

Weed control measure	Yield (q/ha)	Increase in yield (%)	Cost of weeding (Rs/ha)	Extent of weed control (%)
Two hand weeding (farmers' practice)	230	–	2,300	100
Pendimethalin @ 1.0 a.i./ha	210	(–) 10.0	800	90
Oxyflurofen @ 0.06 a.i./ha	230	–	900	100

and KVK, Haveri have taken up the same on-farm trial, the agroclimatic situations were different as Haveri district is located in Transitional zone and Chitradurga in dry zone of Karnataka. While hand weeding gave good control of weeds in Chitradurga district, but not in Haveri district due to continuous rains. Use of Oxyfluorfen 23.5% EC (1.1 litre in 1,000 litre/ha) gave 26% increase in yield over hand weeding in Haveri, but there is no difference in Chitradurga district.

- Zero tillage not only lowers the cost of land preparation, irrigation, herbicides and labour but also facilitates timely sowing.

Zero-tillage

Effect of zero-tillage on wheat yield and economics under rice-wheat system: Zero-tillage has become popular among the farmers due to increase in productivity under rice-wheat system. In zero-tillage, wheat is directly sown without disturbing the soil, thereby lowering the cost of land preparation, irrigation, herbicides and labour; besides facilitating timely sowing.

KVK, Kaithal, Haryana conducted on-farm trial on the fields of

Effect of zero-tillage practice on wheat yield (PBW 343) and cost of cultivation in Haryana

Treatments	Grain yield (q/ha)	<i>Phalaris</i> population (no/m ²)	Advancement of sowing (days)	Saving (Rs/ha)
Conventional practice	39	57	–	–
Zero-tillage practice	41	47	5	3,975

six farmers covering 9.6 ha to assess the performance of PBW 343 variety of wheat sown by conventional method and by zero-tillage-cum-fertilizer-seed drill. Zero-tillage practice gave around 5% higher yield (41 q/ha) than that obtained by conventional practice (39 q/ha) in Kaithal, and 6.6% higher yield in Sirmaur. It also

saved Rs 3,975/ha in field preparation and sowing, besides, reducing the population of *Phalaris minor* considerably, thus saving the cost of weedicide.

KVK, Sirmaur conducted on-farm trial in 25 farmers fields (15 ha) to evaluate the performance of wheat sown by conventional method and by zero-tillage-cum-fertilizer-seed drill. Zero-tillage practice gave around 7% higher yield (32 q/ha) than that obtained by conventional practice (30 q/ha).



Nursery Management

Assessment of Nursery management of chilli in Andhra Pradesh: KVK, Guntur conducted on-farm trial on chilli to assess the effect of two nursery management practices in relation to farmers' practice. Chilli nursery raised in pro-trays under shade net resulted in higher germination (90–95%) with no seedling mortality.

Soil and water conservation

Effect of soil/water conservation measures on growth and yield of cotton in Maharashtra: KVK, Akola, conducted on-farm trial to assess the effect of soil and moisture conservation practices on productivity of rainfed cotton. Results indicated that

Fishery

Assessment of pond preparation and stocking density on yield and income of fish farmers in West Bengal: Absence of proper stocking of fish and other management practices reduced productivity of fish ponds. Farmers' practice of improper pond preparation, high stocking density and minimum post stocking care was assessed against the scientific pond preparation and optimum stocking density (50 lakhs/ha) and proper post stocking care by the KVK, South 24 Parganas, West Bengal. It was found that by optimizing stocking, enhancing natural productivity (i.e. production of natural fish food organisms) of pond and maintaining an alkaline pH of pond water by regular liming—the production can be increased by up to 22.5% over the farmers'

Effect of contour bunds on plant growth and yield of cotton

Soil conservation practice	Plant height (cm)	No. of branches/plant		Seed cotton yield (q/ha)
		Monopodia	Sympodia	
Sowing along the slope without soil and water conservation measure	36.3	2	8.6	8.59
<i>In situ</i> soil and water conservation practices	39.6	3	11	9.82
Contour bunding for conservation of run-off water	43.5	4	12	10.68

the cotton yield was 24% higher by formation of contour bunds compared to local practice of sowing along the slope without any soil conservation measures.

Farm implements

Efficiency of harvesting tools for rice in Orissa: KVK, Kalahandi conducted on-farm trial to assess various harvesting tools for rice in terms of efficiency. The field capacity of reaper was significantly higher than *desi* sickle and improved sickle for harvesting of rice. The average field capacity of reaper was found to be 0.2 ha/hr compared to 0.006 ha/hr of improved sickle and 0.005 ha/hr of *desi* sickle.

Evaluation of different harvesting tools

Harvesting tool	Field capacity (ha/hr)	Saving in time (%)	Cost of harvesting (Rs/ha)	Saving in cost (%)
<i>Desi</i> sickle	0.005	–	1,500	–
Reaper	0.2	97.5	485	68
Improved sickle	0.006	20	1,250	17

practice. In addition, daily application of supplementary feed throughout the culture period further boosted production up to 55% more than the farmers' practice.

Effect of pond preparation, optimum stocking density and post stocking care on yield of table size fish from medium sized ponds

Treatments	Yield (q/ha)	Increase (%)
Improper pond preparation, high stocking density and minimum post stocking care (farmers' practices)	10.00	–
Scientific pond preparation and optimum stocking density (50 lakh/ha)	12.25	22.5
Scientific pond preparation, optimum stocking density (50 lakh/ha) and recommended post stocking care	15.50	55.0

Poultry

Assessment of poultry strains under backyard condition in Andaman and Nicobar Islands: KVK, Port Blair conducted on-farm trial on backyard poultry rearing by comparing *desi* Nicobari fowl with improved Nicobari fowl and Nico rock for their



Performance of improved poultry strain under backyard poultry production

Parameters	Improved Nicorbari fowl	Desi Nicorbari fowl	Nico rock
Body weight at 8 weeks (g)	424 ± 5.35	305 ± 4.5	409 ± 6.15
Body weight at 20 weeks (g)	1120 ± 9.39	1050 ± 8.37	1050 ± 8.37
Age of sexual maturity (days)	174 ± 1.9	185 ± 1.3	172 ± 1.65
Weight at sexual maturity (g)	1425 ± 11.75	1387 ± 11.7	1574 ± 10.12
Annual egg production (No.)	156 ± 6.2	145 ± 3.17	179 ± 5.8
Mortality (%)	5.7	4.9	5.3
Net return (Rs/bird/annum)	347	310	427

productivity in terms of body weight, egg production and net return. The performance of Nico rock was rated to be the best with higher egg production (179 eggs/year), 1.574 kg body weight and net returns of Rs 427/bird/year.

Small ruminants

Assessment feeding systems on body weight gain in beetal goat in Haryana: KVK, Ambala conducted on-farm trial to assess the effect of different feeding systems on body weight gain of beetal goat. Intensive grazing (farmers' practice) was compared with grazing + partial feeding and stall feeding (backyard system).

Effect of stall feeding and grazing on body weight gain of beetal goat

Treatments	No. of goats/farmer	Body weight gain (kg at 5 months age)	Increase in weight over control
Intensive grazing	2	15.0	–
Grazing + Partial feeding	2	18.0	20%
Stall feeding (backyard system)	2	16.5	10%

Results show that grazing + partial feeding was most effective method of feeding of beetal goats based on body weight at the age of 5 months.

Child nutrition

Management of malnutrition in children in Maharashtra: KVK, Jalna, conducted on-farm trial to assess diet for increase in weight gain of child. Normal diet with soybean supplements for 60 days resulted in increase in child weight (525 g) and reduced illness by 31.25%.

- KVKs organized 53,974 frontline demonstrations including 52,412 on oilseeds, pulses, cotton and other important crops besides 1,562 demonstrations.

Frontline demonstrations

During the year, 53,974 frontline demonstrations were organized including 52,412 on oilseeds, pulses, cotton and other important crops covering an area of 24,969.8 ha; besides 1,562 demonstrations on various enterprises.

Pulses: During the year, 9,055 demonstrations were conducted covering 2,745.3 ha. The percentage increase in yield varied from 34.4 in bengalgram to 62.9 in frenchbean and on an average pulse



Frontline demonstrations on pea at KVK, Pulwama, Jammu & Kashmir

- Normal diet with soybean supplements for 60 days resulted in gain in child weight (525 g) and reduced illness by 31.25%.



Frontline demonstration on pulses

Crop	No. of farmers	Area (ha)	Yield (q/ha)		Increase (%)
			Demonstration	Local	
Bengalgram	2,582	906.9	16.8	12.6	34.4
Redgram	1,590	509.2	14.6	10.8	38.6
Greengram	1,596	503.2	11.6	8.4	40.7
Blackgram	1,395	432.6	9.2	6.6	42.8
Lentil	781	171.8	12.5	8.3	47.5
Field pea	312	83.4	18.1	11.6	60.4
Rajmash	503	75.8	11.5	7.6	58.3
Mothbean	70	35.0	4.9	3.1	56.3
Cowpea	77	14.0	9.8	6.6	47.9
Horsegram	93	6.5	7.0	4.6	51.5
Frenchbean	52	5.0	13.9	8.5	62.9
Lathyrus	4	2.0	11.7	7.3	60.3
Total/weight average	9,055	2,745.3	13.6	9.9	37.1

Publications

Two hundred and sixty two KVKs have started publication of quarterly newsletters in local languages as well as in English and Hindi for the benefit of the farming community. These newsletters contain information on agricultural operations for the coming quarter, besides useful articles on improved practices related to crop production, fruits and vegetable cultivation, livestock production and management, home science, use of improved tools and implements, etc. The newsletters also carry the schedule of training programmes of the KVK in the ensuing quarter and are widely circulated to the farmers, gram panchayats and development departments.

participants, 26 kisan mela with 7,094 participants, and publication of 686 extension literatures. In addition, 391 other extension activities (3,784 participants) were undertaken, viz. radio/TV talk, newspaper coverage, exhibitions, group discussion, etc.

Oilseeds: During the year, 17,064 demonstrations were conducted covering 5,969.9 ha on different oilseed crops including

Frontline demonstrations on oilseeds

Crop	No. of farmers	Area (ha)	Yield (q/ha)		Increase (%)
			Demonstration	Local	
Mustard	4,065	1431.0	16.1	11.9	37.3
Groundnut (kharif)	1,669	527.3	18.8	13.8	40.3
Groundnut (rabi)	2,315	988.0	18.7	14.6	29.5
Soybean	2,418	659.3	19.8	13.8	66.8
Sesame	1,562	543.1	7.1	5.1	39.1
Sunflower	1,204	542.2	15.0	11.1	37.4
Toria	1,184	344.2	12.2	8.8	45.4
Castor	520	232.9	15.2	11.1	40.7
raya	433	177.0	23.8	18.8	26.9
Niger	551	159.2	4.5	2.8	63.0
Linseed	465	154.6	8.5	6.1	46.6
Safflower	228	106.1	8.8	6.9	32.8
Gobhi Sarson	450	105.0	25.8	19.8	30.6
Total/weight average	17,064	5,969.9	15.8	11.7	34.8

crops under demonstration gave 37.1% more yield than farmers' practice.

Cotton: A total of 2,347 demonstrations covering an area of 1,800.3 ha were conducted. This includes 35 high yielding and pest-tolerant varieties and hybrids, INM and IPM technologies, and farm implements. Training programmes (166) covering 6,391 farmers and 57 training programmes for 1,836 extension functionaries were organized, besides 55 field days with 5,556



IPM demonstration of alternate host (marigold) on cotton at KVK, Jalna, Maharashtra



castor, groundnut, niger, sesame, soybean, sunflower, linseed, mustard, safflower and toria. The percentage increase in yield varied from 26.9 in raya to 66.8 in soybean and on an average oilseed crops under demonstration gave 34.8% more yield than farmers' practice.

Other crops: During the year, 23,946 demonstrations were conducted covering 14,454.4 ha on different cereals, horticultural and other commercial crops.

Frontline demonstrations on other crops

Crop	Number of demonstrations	Area (ha)
Cereals	11,522	4,418.9
Millets	1,210	433.6
Cash crops	1,219	671.4
Fodder crops	157	25.0
Fruits	892	1,898.1
Vegetables	6,859	5,841.7
Plantation crops	420	183.1
Spices	618	140.5
Flower crops	236	35.0
Tuber crops	256	36.7
Green manure crops	13	5.5
Farm implements	215	340.4
Pisculture	164	175.8
Fish production	152	243.3
Others*	13	5.4
Total	23,946	14,454.4

*include water recharging, bio-fuel etc.

Other enterprises: 1,562 demonstrations were conducted on 10,200 units of various enterprises including apiculture, dairy, duckery, piggery, poultry, mushroom, etc.



Frontline demonstration on backyard poultry

Second National Conference on KVK

The Second National Conference on KVK was organized on 26–27 November 2006 at Acharya N.G.Ranga Agricultural University, Hyderabad which was participated by the Programme Co-ordinators of the KVKs, Vice Chancellors and Directors of Extension Education of State Agricultural Universities, Directors of ICAR Institutes, Senior Officers of the Department of Agriculture and Co-operation, Secretaries of major states, representatives from ATMA, besides Chairman/ Secretaries of the NGOs having KVKs. The conference was inaugurated by the Hon'ble Union Minister of Agriculture on 26 November. Three KVKs namely, KVK, Chitrakoot (Uttar Pradesh), KVK, Gadag (Karnataka), and KVK, Jhunjhunu (Rajasthan) were conferred upon the Best KVK Award for the year 2005. The technical sessions of the conference were Strategic technological interventions, Policy frame work for technology development and delivery system, and Knowledge management at the KVK. An exhibition was organized with the participation of State Agricultural Universities, ICAR Institutes, KVKs, and various input agencies. As a follow-up of the recommendations of the First National Conference, three sensitization workshops, each of four days duration, were organized on Process of Knowledge Management for Programme Co-ordinators at Punjab Agricultural University, Ludhiana, Punjab (13–16 July); Zonal Co-ordinating Unit, Kanpur, Uttar Pradesh (28–31 August); and KVK, Trivandrum, Kerala (12–15 September); in which nearly 100 Programmes Co-ordinators, 12 Scientists from the Zonal Co-ordinating Units, and 2 Scientists from the ICAR Headquarters participated.



Second National Conference on KVK at Acharya N.G. Ranga Agricultural University, Hyderabad

Frontline demonstrations on various enterprises

Enterprise	Number of demonstrations	Units (No)
Apiculture	48	76
Biofeed (Azolla)	36	51
Dairying	371	2,097
Duckery	77	545
Mushroom	55	49
Piggery	6	7
Poultry	696	5,792
Quail farming	130	1,303
Sheep and goat production	143	280
Total	1,562	10,200



Training programmes

During the year, 40,672 training programmes were organized with the participation of 10, 71,657 farmers including rural youth and in-service extension personnel.

Farmers' training: A total of 29,836 training programmes were organized benefitting 8.16 lakh farmers and farmwomen on various aspects of crop production, horticulture, livestock production and management, group dynamics, farm implements and machinery, agroforestry, fishery, biotechnology, plant protection, soil fertility, women in agriculture and others.

Training programmes for farmers and farmwomen

Areas of training	No. of courses	No. of participants		
		Male	Female	Total
Crop production	7,494	190,881	32,862	223,743
Horticulture	5,305	119,623	30,703	150,326
Plant protection	4,640	99,087	21,758	120,845
Home science	3,589	10,885	79,182	90,067
Livestock production and management	3,189	57,263	23,258	80,521
Soil fertility management	1,459	31,736	6,139	37,875
Farm implements and machinery	1,113	21,142	6,515	27,657
Group dynamics	1,095	27,516	9,010	36,526
Fishery	539	9,596	2,888	12,484
Agroforestry	441	8,311	1,688	9,999
Women in agriculture	309	226	6,343	6,569
Mushroom production	55	1,020	414	1,434
Apiculture	47	729	245	974
Sericulture	30	501	106	607
Food technology	25	104	471	575
Medicinal and aromatic plants	23	450	114	564
Vermicomposting	22	498	233	731
Biotechnology	10	265	60	325
Others	451	9,076	4,990	14,066
Total	29,836	588,909	226,979	815,888



Training on Bee-keeping at KVK, U.S. Nagar, Uttarakhand

Training for rural youths: The training programmes for rural youth were organized. Use of farm power and machinery, group mobilization, agroforestry, biotechnology, crop production, fisheries, horticulture, hybrid seed production, Livestock production and management, cultivation of medicinal plants, plant protection,



Training course for rural women on bee-keeping at KVK, Pulwama, Jammu and Kashmir



Training course for rural youth on soft-wood grafting



Training programmes for rural youth

Areas of training	No. of courses	No. of participants		
		Male	Female	Total
Horticulture	1,319	20,935	9,026	29,961
Home science	1,290	3,255	25,984	29,239
Crop production	1,020	19,484	4,451	23,935
Livestock production and management	851	13,250	5,525	18,775
Plant protection	825	15,912	4,083	19,995
Farm implements and machinery	336	6,343	1,284	7,627
Group dynamics	296	5,210	1,946	7,156
Soil fertility and management	232	4,648	1,258	5,906
Fisheries	168	2,581	978	3,559
Agroforestry	108	1,423	541	1,964
Women in agriculture	87	116	1,809	1,925
Apiculture	67	1,377	236	1,613
Mushroom production	47	835	134	969
Vermicomposting	22	455	51	506
Sericulture	10	181	31	212
Others	188	3,080	2,528	5,608
Total	6,866	99,085	59,865	158,950

post harvest technology, soil-fertility management, women in agriculture and other income generating activities. As many as 6,866 skill oriented training programmes were organized for 1.59 lakhs rural youth.

Training programmes for in-service extension personnel: A total of 3,970 training programmes were conducted covering 96,819 participants. These training programmes were



Extension functionaries are being trained on paneer preparation at KVK, Sikar, Rajasthan

Training programmes for in-service extension personnel

Areas of training	No. of courses	No. of participants		
		Male	Female	Total
Crop production	1,027	24,450	3,240	27,690
Plant protection	635	12,793	1,988	14,781
Horticulture	567	10,533	1,841	12,374
Home science	430	2,251	9,195	11,446
Group dynamics	377	7,589	1,564	9,153
Livestock production and management	274	4,777	709	5,486
Farm implements and machinery	192	3,485	753	4,238
Soil fertility and management	203	4,543	790	5,333
Agroforestry	58	1,147	121	1,268
Fisheries	45	726	72	798
Women in agriculture	33	115	597	712
Others	129	3,071	469	3,540

organized mainly for extension functionaries working in government and non-governmental organizations related directly or indirectly with the development of agriculture. The training was imparted to upgrade their knowledge and skills in horticulture, animal husbandry, soil conservation, biotechnology, fishery, etc. through participatory training methodologies, field visits and other interactive methods.

Sponsored training programmes: Out of a total 40,672 training programmes (10.72 lakh participants) conducted by the KVKs for the farmers and farm women, rural youth, and in-service extension personnel; 5,879 training programmes were conducted on sponsorship by various organizations covering 1.94 lakh participants. The participants were from various government and

- KVKs organized 29,836 training programmes for farmers, 6,866 skill-oriented programmes for rural youth and 3,970 training programmes for in-service personnel. Out of total 40,672 training programmes; 5,879 were sponsored by various organizations.



TECHNOLOGY ASSESSMENT, REFINEMENT AND TRANSFER

Sponsored training programme

Areas of training	No. of courses	No. of participants		
		Male	Female	Total
Crop production	1,820	63,268	9,206	72,474
Horticulture	1,294	34,718	7,727	42,445
Plant protection	725	16,910	3,821	20,731
Home science	486	1,545	11,120	12,665
Livestock production and management	450	8,535	3,197	11,732
Farm implements and machinery	272	5,218	730	5,948
Group dynamics	264	7,337	2,089	9,426
Soil fertility management	189	7,186	1,318	8,504
Fishery	60	1,168	285	1,453
Rural crafts	30	7	467	474
Agroforestry	23	1,035	214	1,249
Women in agriculture	20	347	491	838
Mushroom cultivation	18	274	265	539
Apiculture	16	256	154	410
Vermicomposting	11	187	138	325
Others	201	4,610	762	5,372
Grand Total	5,879	152,601	41,984	194,585

Extension activities

Activities	No. of programmes	Beneficiaries
Advisory services	48,048	104,479
Diagnostic visits	14,386	36,782
Field days	2,459	144,085
Group discussions	2,239	98,297
Kisan goshties	2,104	179,106
Film shows	1,673	60,355
Self-help groups	1,791	5,630
Kisan melas	839	2,013,882
Exhibitions	788	1,309,582
Scientist's visit to farmers' field	775	4,457
Plant/Animal health camp	1,744	53,643
Farm science club	419	5,809
Farmer's field school	345	1,250
Agricultural exhibition	284	107,661
Ex-trainee sammelan	163	5,338
Farmers seminar	186	22,629
Demonstrations method	101	2,331
Special day celebration	99	12,069
Exposure visit	46	1,422
Others	59	21,113
Total	78,548	4,189,920

non-governmental organizations associated directly or indirectly with the development of agriculture, sponsored by NABARD, DRDA, CAPART, ATMA, DBT, DST, State Department of Animal Husbandry, State Department of Agriculture, State Department of Women and Child Welfare and State Department of Horticulture.

Extension activities

The KVKs organized 78,548 extension activities covering 41.90 lakh farmers and others to create awareness about improved agricultural technologies. The activities include field days, kisan melas, kisan goshties, exhibitions, ex-trainees sammelan, advisory services, film shows, diagnostic services, agro-clinics, organizing farm science club, and formation of self-help groups (SHGs).

- KVKs organized 78,548 extension activities to create awareness about improved agricultural technologies.

In addition, 8,482 newspaper coverages, publication of 2,231 popular articles and 6,075 extension literatures, 90 bulletins, 1,800 telephone advices, 3786 radio and TV talks were taken up by the KVKs.



Farmers to farmers interaction organized at KVK, Akola, Maharashtra



Production of seeds by the KVKs

Crop	Seed (q)
Cereals	56,666.74
Oilseeds	10,165.39
Pulses	5,391.64
Commercial crops	1,954.41
Vegetables	8,473.62
Spices	69.90
Fodder crops	32.59
Green manure crops	22.02
Mushroom spawn	4.88
Medicinal crops	2.05
Total	82,783.24

Production of planting materials, livestock strains and fingerlings by the KVKs

Categories	Number	Categories	Number
Vegetables	3,054,603	Mulberry	310,751
Fruits	1,842,943	Tobacco	50,000
Ornamentals	255,486	Medicinal	21,302
Spices	219,596	Aromatic	1,500
Fodder slips	829,500	Livestock strains	2,966,205
Plantation	338,030	Fingerlings	31,990
Forestry	210,111	Total	10,196,308
Biofuel	64,291		



Seed production – Onion, Hybrid Castor (RHC-1) and Chillies (RCH-1)

Production of Bioproducts

The KVKs produced 492,150 kg biofertilizer, 62,421 kg biopesticide, 5,780 litres baculoviruses, 100 litres neem oil, and 49,000 bioagents (Cards) for availability to the farmers.

Products	Quantity	Products	Quantity
Biofertilizers (kg)		Baculoviruses (litres)	
Acetobacter	100	<i>Trichoderma viride</i>	40,977
<i>Aspergillus</i> sp.	751	<i>Verticillium</i>	10
Azotobacter	2,950	Total	62,421
Azolla	15,852	Botanical Pesticides	
<i>Azospirillum</i>	4,641	Neem oil	100
<i>Phosphobacterium</i>	6,261	Bioagents (Number)	
<i>Rhizobium</i>	5,170	<i>Chrysoperla carnea</i> (Cards)	45,000
Vermicompost	456,425	<i>Trichogramma chilonis</i> (Cards)	4,000
Total	492,150	Total	49,000
Biopesticides (kg)			
<i>Beauveria bassiana</i>	225		
<i>Pseudomonas</i> sp.	7,619		
<i>Trichoderma harzianum</i>	13,590		

**Production of seed/planting material**

The KVKs produced 82,783.24 quintal of seeds of cereals, oilseeds, pulses and vegetables. In addition, 71.98 lakh saplings/seedlings of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species were produced. Also 29.98 lakh livestock strains and fingerlings were produced for availability to the farmers.

Monitoring mechanism

During the year, Zonal Workshops (11) were organized with the participation of KVKs to review the action plan, achievements and formulation of plan of action for the next year. Similarly 18 State-level Workshops were organized to review the frontline

demonstrations on oilseeds and pulses. To upgrade the knowledge and skills of KVK staff, Workshops (25) were organized under HRD Programme and 7 travelling workshops were also organized.

Interface at district level

To strengthen research extension linkages the KVKs organized 334 interface meetings involving scientist and development officials at the district level.

Scientific advisory committee

During the year, 326 Scientific Advisory Committee Meetings were organized in KVKs to review the work done during the year and formulation of action plan for the next year.



Gender Issues for Technological Empowerment of Women in Agriculture

The National Research Centre for Women in Agriculture has been established 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 farm women and capacity building of scientists, planners and policy makers to respond to the needs of farm women. Accordingly research projects and activities were taken up during the year under report.

The broad areas of activities related to research and extension were focused on developing database on gender, training modules on engendering research and extension, resource management by women agricultural labourers, mobilization of rural women through women Self Help Groups, ergonomical evaluation of farm equipments, ecofriendly weed and pest management, standardization of weaning mix for children, introduction of low cost structure for storage of vegetables and fruits, farm tools and implements, training of trainers in emerging areas of agriculture, and training of farm women.

Research

One of the important research thrusts of the NRCWA is to develop **database on various gender issues**. Data collected from 130 households in five villages indicated different pattern of gender participation in five agriculture of scheduled caste (SC) and non scheduled caste (non-SC) families. In case of SC families, young

- Access and control over resources were studied in SC and non-SC families
- A training module for gender sensitization in agriculture prepared
- Skill training needs and interests of women SHGs were identified for their entrepreneurial development
- Eco-friendly pest management resulted in maximum benefit : cost ratio
- Zero energy cool chamber proved very useful during summer
- Different trainings were provided to farm women to upgrade their knowledge and skills in agriculture technology

and middle aged men–women, and elderly women were mostly engaged in agricultural works both as family labourers and wage labourers. The elderly men who were not involved in any economic pursuit looked after the livestock and homestead activities. In non-SC families, men had higher participation in farm related activities, compared to women. While the elderly women looked after the livestock and other activities related to household and homestead, the elderly men were involved in different social, economic and political activities. As far as the access and control over resources is concerned, it was found that majority (68.5%) of the wage earning SC women deposited their earnings with their male counterparts, many of whom did not have any say in the way their income was spent. In non-SC families, majority of the women (84%) who in spite of not having any direct involvement in income generating activities had access and control over part of the earnings of their men counterpart. About 68% of the men respondents had joint accounts with their wives. Majority of women from land owning households could manage to retain part of the income from sale of farm produces which gave them the control over financial resources.

As a part of the **Network Project on Approaches to Engendering Agricultural Research and Extension** data have been collected from 380 households of Orissa, Kerala and Haryana. A training module for Gender Sensitization in Agriculture has been prepared and published for use of the stakeholders. The findings of respondents from Orissa engaged in rice, vegetable and livestock based farming systems indicated that the farmers in rice based farming systems spent 16 hours 53 minutes per day for farming

Training of rural women on use of improved farm implements





Women friendly farm tools and equipment

Farm women (250) from villages, Nipania Jat, Aadampur Chhawani, Dobra Jagir and Sagonikala of Bhopal district, were identified for introduction of women friendly farm tools and equipment. Training programmes on women friendly improved farm tools and equipment were carried out with the participation of 200 farm women. Tubular maize shellers and improved sickles were provided as training material so that they can use these equipment. A set of manually operated improved farm tools and equipment, viz. seed treatment drum, hand ridger, seed drill, fertilizer broadcaster, wheel hoe, grubber weeder, hanging type cleaner were provided to identified group leaders for use by trained farm women of these villages.

Evaluation of CIAE Cono Weeder, improved sickle, and rice transplanter for drudgery reduction in farm women. →



activities compared to 8 hours 32 minutes by the farmers in vegetable-based farming systems. The women in livestock based farming systems spent more time in farming activities than women of other two systems; however the women from all farming systems were exclusively responsible for home management activity.

The access of men as well as their control over the productive resources was much higher than women in most of the farming systems. The situation for women in vegetable and livestock based farming systems was better than that of rice based. The fairly accessible resources to women were the income from FYM (farm yard manure), animal produce, vegetable produce and being members of SHGs and Mahila Mandals. Men had full involvement in feed collection, cutting of fodder, preparation of feed, collection of feed, transportation, chaff cutting in rice based farming systems. Whereas both men and women were involved in vegetable and livestock based farming systems and women had greater role in preparation of feed. In livestock based farming system chaff cutting was done more by women than men.

To understand the differences in nature and extent of engagement of women agricultural labour in Orissa and Andhra Pradesh, project was undertaken on **Efficient Resource Management of Women Agricultural labourers**. Data were collected from 200 women agricultural labourers, 100 each from two states. Comparative analysis showed that women agricultural labourers in non-irrigated districts of Orissa were less involved in

agricultural work in a year compared to their counterparts in Andhra Pradesh. During a pilot study, 16 preferences were identified which may influence agricultural labour employment. In Orissa 42% women agricultural labourers wanted training in livestock management, vegetable production, backyard poultry farming and tailoring and stitching. In Andhra Pradesh, however, 44% women agricultural labourers perceived need for training on vegetable production, improved agricultural practices, livestock management and vocational training for self-employment.

Under the project **Development of Modules for Mobilization of Rural Women for Sustainable Livelihood through Women Self Help Groups**, the entrepreneurial activities of women SHGs were investigated by strength-weakness-opportunity-threats (SWOT) analysis. This analysis of the successful groups showed that that the group having good inter-linkages with other SHGs, government departments, and local businessmen found it easier to sustain and increase the business. Besides, a group with the ability to form partnerships for marketing, product information and technology backstopping was in a better position to develop its business. Skill training needs and interests of women of SHGs were identified for their entrepreneurial development through participatory approach.

Under the project on **Ergonomical Evaluation of Rice Farming Equipment for Farm Women**, CRRRI two row rice transplanter, CIAE-IEP cono weeder, and improved sickles, were



SUCCESS STORY

Empowerment of Women

- Bhopal sub-centre of National Research Centre for Women in Agriculture (NRCWA) conducted a survey to assess the involvement of women in agriculture and found that women devote 43.7% of their time in agriculture.
- Ergonomical evaluation of manually operated two-row drum seeder, TNAU four row drum seeder and CRRRI four row rice transplanter was carried out with women workers. It was found that the physiological load in terms of heart rate and pulse rate was higher than the acceptable limits of 110 and 40 beats/min, respectively. The working heart rate and pulse rate for operation of CIAE sickle, KKV Dapoli sickle, improved sickle and local sickles were within the acceptable limit.
- Training of woman workers on woman-friendly tools and implements were conducted at Village Chawani Pathar, Adampur and Nepania Jhat, attended by 52 and 103 women workers, respectively. The training was imparted on fertilizer broadcaster, 2-wheel seed drill, one-wheel seed drill, twin-wheel weeder, groundnut decorticator, hanging type grain cleaner, naven dibbler, seed treating drum and furrow and bund makers.
- During September 2005 to October 2006, the SPU centre of CIAE organized seven training programme for 115 rural women from nearby Bhopal district of Madhya Pradesh on various aspects of soybean processing and production soy milk, soy paneer, bakery items and soy snacks for use of soy foods in daily diet for nutrition and health benefits. Awareness camps and demonstrations were also held at different places like Seoni, Guna, Shajapur and Baramati.

evaluated. The mean heart rate of women workers in operation of CRRRI two row rice transplanter using mat type nursery was 148.1 beats/min and the increase in heart rate over rest was 61.5 beats/min. The area covered per hour was 96 m² at an operating speed of 0.26 km/h. The equipment needed refinement with regard to mounting of seedling tray so as to provide trouble free movement. Women workers could operate this equipment with suitable rest pauses during day long work.

Mean heart rate of women workers in operation of CIAE-IEP cono weeder was 153 beats/min and the increase in heart rate over rest was 70 beats/min. Through this weeder, the area covered per hour was 160 m² at an operating speed of 1.3 km/h. Women workers could operate this equipment with suitable rest pauses during day long work. As regards the improved sickles, it was found that the mean heart rate in operation of sickle developed by the CIAE, Bhopal, and local sickles for harvesting rice crop was 103.4 beats/min and 105.8 beats/min, respectively. Corresponding values for increase in heart rate over rest was 18.7 beats/min and 20.3 beats/min, respectively.

Using single factor experiment with repeated measures, there was no significant difference in working heart rate and heart rate at rest for CIAE Bhopal sickle and local sickles.

The study on **Popularization of Eco-Friendly Pest Management Technologies for Vegetables among Farm women in Homestead Land** revealed that in brinjal, CV BB 44 was preferred by farm women because of its suitability for transportation, tomato var. Kumari (BT 10) was preferred because of its good keeping quality, while cabbage var. Gold Star (Hybrid) was preferred because of solid heads and non-bursting even after several days of maturity. Maximum benefit : cost ratio was obtained when eco-friendly methods of pest management were adopted as compared to conventional methods. Thirty-nine eco-friendly pest management technologies and ITKs related to vegetables collected from different villages of Orissa as well as from organizations located at Bhubaneswar were documented.

Under the project **Technological Empowerment of Farm Women for Family Sustenance**, the problems of men and women in rainfed areas of Orissa were identified through participatory rapid appraisal (PRA) technique. Trainings and exposure visits were conducted on use of improved agricultural implements and tools, production technique including insect pest management of vegetable nursery and production of vermin-compost. Besides, documentation of these activities was taken up to develop educational materials for gender mainstreaming in extension programmes.

Studies showed that proper child weaning practices were not followed irrespective of different localities. Under the project on **Standardization of Weaning Mix Using Different Proportions of Sweet Potato**, standardization of a low cost weaning mix by utilizing locally available food materials was carried out. Dehydrated materials from sweet potato, green leaves and potato were prepared and kept in air-tight containers and polythene bags for evaluating its shelf-life. The base containing roasted flake powder, roasted wheat powder, pulses (0.50 greengram

SUCCESS STORY

Farm mechanization for tribal region in Southern Rajasthan

The equipments demonstrated in Udaipur, Chittorgarh and Banswara districts were tractor mounted rotavator (42 ha), CIAE multipurpose tool frame (22 ha), power weeder (14 ha), PAU tractor mounted multicrop planter (40 ha), self-propelled vertical conveyor reaper (65 ha), manual garlic planter (5 ha), CIAE power operated groundnut thresher (102 hr), CIAE high capacity thresher (89 hr), multicrop thresher 5 hp Amar make (166 hr).



dal + 0.50 bengal gram *dal*) and sesame seeds powder in the ratio of 2 : 1 : 1 : 0.25 was most preferred as weaning mix. The base and dehydrated sweet potato powder in the proportion of 75 : 25 were ranked first. Weaning mixes, which were rich in protein, energy and beta-carotene required for growth and development of the children were most preferred. The unit cost of such weaning mix was very low (Rs 23.90/kg).

Nutrient composition of standardized weaning mix (per 100 g)

Nutrients	Level
Moisture (%)	5.81
Crude protein (%)	10.86
Crude fat (%)	5.89
Total ash (%)	1.95
Crude fibre (%)	2.78
Energy value (Kcal/100 g)	456.00
Beta carotene	84.54
Dry matter (%)	94.19

A low cost storage structure- **Zero Energy Cool Chamber (ZECC)** was constructed and storage studies of fruits/vegetables like tomato, french bean, carrot, spinach, orange and mango were carried out at ambient temperature, low temperature, and in the ZECC. The shelf-life and quality of the perishables (fruits and vegetables) in ZECC was at par with the quality at low temperature (refrigerator). The ZECC was very useful for small farmers during summer as it maintained a temperature of 25–28°C with a relative humidity of 85–90%. A structure of 170 cm × 115 cm × 70 cm costing approximately Rs 3,500 could store 100 kg of vegetables. Training programmes were organized to empower 120 farm women of different villages for use of ZECC.

As a part of a project on **Family Based Economic Security of Backward Communities through Ornamental and Integrated Fish Farming**, involving 194 families and eight ponds covering 0.22 ha were taken up for seed production. Fish-cum-duck, fish-cum-poultry, fish-cum-horticulture, and fish-cum-mushroom were introduced. Khaki-Campbell and *desi* strains of duck and Grama Priya and Vanaraja breeds of poultry were introduced under fish-cum-duck and fish-cum-poultry system respectively.

Ornamental fish production units were established in 6 villages involving 37 scheduled caste beneficiaries. Continuous production of guppy, molly, sword tail, and rosy barb were successfully achieved. Economic gain per unit was Rs 200–500/month. During the year 2005–06, the income generated by the groups from fish and different integrations was Rs 6.25 lakh. Different aquaculture technologies like nursery rearing, carp poly culture, fish-cum-duck

Economic evaluation of aquaculture integration during 2005–06

Integration	Ponds	Total	Total	Economic
Fish-cum-duck	3	0.20	23,000	115,000
Fish-cum-poultry	7	0.57	42,000	73,685

integration, and fish-cum-poultry integration were disseminated to 240 farm women and a model for production of fingerlings at village level was developed. Some of the significant impacts were that healthy and desired species of fry were available up to 40 km in and around the adopted villages. The average fish yield of the ponds under project had gone up to 2.88 tonnes/ha from an average of 0.125 tonnes/ha. It has also brought in economic security from sale of fry and fishes.

Training Programme

The Krishi Vigyan Kendras (KVKs) organized 3,970 training programmes for in-service extension personnel to upgrade their knowledge and skills in frontier areas of agriculture technology including horticulture, animal husbandry, soil conservation, biotechnology, fishery etc in which 21,339 women in-service extension

Trainings

Short Course on Drainage Technologies

A training programme on drainage technologies for enhancing agricultural productivity in vertisols was organized during 2–11 August 2006 for 27 participants at CIAE Bhopal.

Advanced Instrumentation

A 6 days training programme on Advanced Instrumentation for R&D in Agricultural Engineering was organised at CIAE, Bhopal for faculty members of the SAU's during 21–26 August 2006.

Agro based Products

CIAE organized entrepreneurship development training programme on agro-based products for 29 participants of District Poverty Initiative Programme (DPIP) during 12–17 June 2006 and 10–17 July 2006.

Manufacturing Technology

A 11-day Training programme on Manufacturing Technology for Fabrication of Agricultural Implements for Teachers/Instructors of Farm Machinery Vocational Education was organized in collaboration with PSSCIVE, Bhopal at CIAE, Bhopal during 18–28 September 2006. Eighteen instructors from different vocational training institutes from Punjab, Haryana and Madhya Pradesh participated in the programme.



SUCCESS STORY

Farm Mechanization Research in NEH Region

NEH, Barapani centre of AICRP on FIM evaluated 4-row manual paddy seeder (15 kg weight). It was pulled by single-person which provided field capacity from 0.04 to 0.06 ha/hr. The seed rate used between 60 and 80 kg/hr in seeder (overall dimensions 1,700 × 940 × 600 mm). The net saving with the use of seeder was Rs 2,000/ha. The labour requirement was 30–40 man-h/ha.

NEH, Barapani centre of AICRP on FIM has developed manual seed drill (13.80 kg weight). The overall dimensions of seed drill are 87 cm × 44 cm × 110 cm. The drive ratio from ground wheel (diameter 40 cm) to metering shaft is 1 : 1. The V-shaped furrow openers; seed hopper (capacity 2 kg) and cup feed type seed metering are salient features of machine. The balanced machine operated by two persons proved boom for farmers for sowing maize and pigeonpea.

NEH, Barapani centre of AICRP on FIM adopted light weight power tiller powered by 3.7 kW diesel engine (Amar make). In valley farmers appreciated its use on narrow terraced lands. The shifting of unit from one terrace to other was easy due to small turning radius and light weight. During field test, the field capacity varied from 0.06 to 0.08 ha/hr in tilling. The fuel consumption was from 1 to 1.25 litre/hr.

Self-propelled vertical conveyor reaper has been demonstrated on farmers' fields on large scale for rice crop in valley land of the region. Total 5.0 ha was covered during harvesting season of 2004 and 6.0 ha in 2005. The average field capacity of the machine was observed around 0.05 ha/hr.

A motorized paddy thresher has been developed and

promoted in the region, which helps in completion of operation in time. In this operation, threshing of paddy crop can be done by holding paddy bundles against moving cylinder and blower helps to throw the broken chaff at some distance away from grain. Thus grain obtained have less chaff and broken straw than pedal type thresher. Overall dimensions of thresher are 850 cm × 750 cm × 750 mm (lxbxh) and total weight excluding prime mover is 50 kg. Two persons are employed to perform threshing operation. One person holds paddy bundle against moving cylinder and second person is required for supplying paddy bundles. Threshing cylinder and prime mover can easily be detached (if necessary) from the frame to enable easy transportation of thresher in hilly area.

Grain output capacity was about 4–5 times more in power thresher as compared to pedal type depending upon crop condition and variety. Labour requirement in per quintal of threshed grain was only one man-hr in power thresher and 5 man-hr in pedal thresher. Thus there is about 80% saving in labour requirement and cost of threshing grain can be saved up to 74% by using power thresher as compared to pedal type paddy thresher.

For the purpose of winnowing, the farmers of north east region are mainly dependent on natural wind. The average output of the manual winnower was observed from 2.5 to 3.5 q/hr. Due to timeliness of operation, it is gaining much popularity among the farmers of this region. Equipment has been demonstrated for 200 hr during last two years.

personnel participated. The KVKs also organized training programmes for farm women in various areas like crop production, horticulture, home science, livestock production and management, farm implements and machinery, mushroom production, sericulture, and vermin-composting etc. Through these training

programmes 2.87 lakh farm women were trained. In addition 41,984 farm women participated in the training programmes organized by the KVKs on sponsorship by NABARD, DRDA, CAPART, ATMA, DBT, DST, and State Departments of Agriculture, Animal Husbandry, Horticulture Development Board, etc. The NRCW, Bhubaneswar also

Participatory evaluation workshop with farm women.



Women in Agriculture Day.





GENDER ISSUES FOR TECHNOLOGY EMPOWERMENT OF WOMEN IN AGRICULTURE



Training on increasing income generation of farm women.

organized a trainers' training programme on Entrepreneurship Development among Farm Women. Another training on techniques for improving extension services for farm women was organized in sponsorship by the Directorate of Extension, Government of India.



Demonstration on SRI method of rice cultivation.

The KVKs organized 78,548 farmers' fair, farm day, advisory visits, agri-exhibitions and several other such activities for dissemination of agriculture technology, in which 41.90 lakh farmers and farm women participated.



3. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through the Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, the ICAR Research Complex for North-Eastern Hills Region, Umiam, Meghalaya and the Central Agricultural Research Institute (CARI), Port Blair, 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, agroforestry, apiculture, sericulture, horticulture, animal husbandry, poultry and fisheries.

VIVEKANANDA PARVATIYA KRISHI ANUSANDHAN SANSTHAN, ALMORA

Released new varieties

During the reported year, 9 varieties of different crops were released for Uttarakhand, Himachal Pradesh, Jammu and Kashmir, and North-eastern hills.

First extra-early yellow quality protein maize hybrid 'FQH 4567' (Vivek Mahashakti 1) identified

The extra-early, yellow, quality protein maize (QPM) single cross hybrid FQH 4567 was identified by Varietal Identification Committee. It is the first extra-early quality protein maize single

First extra early QPM hybrid



- Released nine varieties of different crops for cultivation
- Developed first extra-early yellow quality protein maize single cross hybrid in country through marker-assisted selection
- Registered two land races—one each of wheat and soybean

SUCCESS STORY

Water resource development and protected cultivation in Bhagartola village

Development of water resource by harvesting surface runoff and perennial hill streams in LDPE lined poly-tanks and protected cultivation of off-season vegetables utilizing the harvested water have helped in transforming the hill economy of Bhagartola village, located around 60 km away from District HQ Almora (Uttarakhand State). In this village, 20 low-cost poly-tanks and 22 low-cost poly-houses were



Protected cultivation under polyhouses at Bhagartola village

constructed with full partnership of farmers. Cultivation of off-season vegetables (tomato, capsicum, cauliflower, french bean, vegetable pea, summer squash) utilizing the water harvested in these poly-tanks resulted in net return of Rs 10,000 to 12,000 per year from each poly-house of 100 m² size.



New varieties released

Variety (yield, tonnes/ha)	Adaptation region/ Agro-ecology	Duration	Other salient features
'VL Dhan 85' (4.0–4.5)	Irrigated valley and hilly areas of Uttarakhand	Early maturing (118–120 days)	Resistant to leaf blast, neck blast, brown leaf spot and tolerant to leaf scald, leaf folder and stem-borer
'VL Dhan 207' (2.0–2.4)	Rainfed upland areas of Uttarakhand for direct seeded condition	Medium maturity (160–165 days)	Spring-sown variety, resistant to stem-borer and leaf-folder
'VL Dhan 208' (2.0–2.5)	Spring-sown rainfed upland conditions in Uttarakhand	Medium maturity (160–165 days)	It is resistant to stem-borer and leaf-folder, major insects of the area. It outyielded checks Majhera 7 and VL Dhan 206
'VL Gahat 8' (1.2–1.4)	Timely sown conditions of Uttarakhand	Medium maturity (120–125 days)	Shows significant yield superiority of 24.89% to check VL Gahat 1 and higher degree of resistance to anthracnose disease and stem-borer
'VL Matar 42' (1.2–1.4)	Timely sown conditions of Uttarakhand	Full season maturity (146–155 days)	It (25.8%) has higher protein content than VL Matar 1 and shows higher degree of resistance against pea rust and powdery mildew
'VL Mandua 324' (2.0–2.1)	Mid-hills, rainfed conditions of Uttarakhand	Medium maturity (100–105 days)	It has 20.43% higher fodder yield than check VL Ragi 146. Finger and neck blast incidence is less in this variety than resistant check VL Mandua 149
'VL Chua 44' (1.3–1.4)	Uttarakhand hills	Short-duration maturity (90–120 days)	It has 14.1% protein and 12.2% oil content and is easily threshable. Matures in 116 days thereby escapes from the leaf web infestation
'VL Masoor 125' (1.6–1.7)	Timely sown rainfed conditions of Uttarakhand hills	Medium maturity (140–160 days)	Small black-seeded variety and resistant to wilt
'VL Masoor 507' (1.0–1.2)	Timely sown rainfed conditions of hills of Uttarakhand, Himachal Pradesh, Jammu and Kashmir and north-east hills	Full season maturity (140–209 days)	Bold, brown seeded variety exhibits high degree of resistance to wilt



Field pea variety VL Matar 42 having good looking quality



Medium-maturing variety VL Mandua 324 of finger millet



Amaranth variety VL Chua 44 possesses tolerance to viral disease mosaic



VL Masoor 507, shows high degree of resistance to wilt

cross hybrid developed in the country through marker assisted selection. It is the quality protein maize version of the Vivek Maize Hybrid 9. It possesses 40.7% higher tryptophan than Vivek Maize Hybrid 9. This quality protein maize hybrid was identified for release in zone-I (average yield: 6,118 kg/ha) and zone-IV (average yield: 3,531 kg/ha).

Registration of 2 Land Races

'Tank' - A long awned local land race of wheat not preferred by monkeys (INGR No. 06006; IC 398287)

A local land race 'Tank' was collected from village Godiadhar, Block Kapkot, District Bageshwar, Uttarakhand (30° 00'N,



SUCCESS STORY

Adoption of micro-irrigation system (MIS) in Darim village

Lack of efficient irrigation system is a major hindrance to increase the productivity of hill agriculture. The lift irrigation system demands high investment in the hills, where lift varies between 40 and 80 m. This high cost makes the agriculture in the hills a risky proposition. The frontier technologies like micro-irrigation system (MIS) not only helps in utilizing water efficiently (90–95%) but also minimizes the other problems associated with the flood irrigation system. Such advanced irrigation technique was explicitly installed in 0.64 ha in Darim village of Naini Tal District with farmers' contribution. The farmers' contribution was 47% of total MIS set up cost. The perennial stream (18 litres/min) passes at 1.5 km distance from



LDPE-lined tank (280 m³ size) constructed at Darim village for micro-irrigation system

the field was harvested to the 2 separate LDPE film-lined-tank, gross capacity 280 m³ and 160 m³ respectively. The micro-irrigation system was attached to these tanks separately such that gravity pressure was obtained. The irrigation system was used to provide irrigation to the garden pea. The water-use efficiency of the irrigation system was increased by 69% over the flood irrigation. The saving in the irrigation system was 41.1%. The B : C ratio was 2.62 when only tangible benefits were taken into account. The system was found functionally and economically feasible in the hilly region of north-west Himalaya. Consequent upon the successful operation of the system, several enquiries from the farmers were received. Therefore, additional 20 LDPE tanks were constructed in the village to put another 6 ha land under irrigation. Thus 50% area of the village (total arable land 12 ha) was under irrigation after technology intervention from 5% area. The gravity based MIS technology has vast scope in enhancing water productivity in irrigated hill agriculture.

79° 52' E, 1,270 m amsl). It is exclusively being grown as border rows in wheat fields in this area to save the main wheat crop from monkey damage. This land race has long awns and small grains and due to this, monkeys do not damage wheat field under the impression that whole field is sown with the small-seeded land race 'Tank'. 'Tank' is tall wheat (140-145 cm) with long and thin peduncle (52.7 cm) compared to 35.5 cm of 'VL 829'. Its spikes are small with long awns (7.03 cm), brown glumes, seed is red with intermediate plumpness, small (100 seed weight=3.17) with narrow grain width (2.74 mm) compared to 3.45 mm of 'VL 829'. It has long maturity duration of 200–210 days.

SUCCESS STORY

Management of white grub beetles through light traps

White grubs are the cosmopolitan insect pests of agriculture, forest and pasture lands. The pest causes severe economic loss in upland paddy, finger millet, barnyard millet, maize, potato and many other vegetables, fruits and fodder crops in the hills of north-western Himalayan region, where nearly 40 species of this phytophagous pest were recorded. The beetles emerge from soil from May to October. To combat the problem, VPKAS, Almora, designed a user-friendly low cost (Rs 570), light trap for efficient mass trapping of beetles, to reduce the population of white grubs in soil. Deployment of 61 light traps in different villages of Almora district on community basis led to trapping of beetles 114,000 in



Light trap at farmer's field

Darima, 67,900 in Chausali, 46,600 in Tipola-Tunakot, 88,900 in Daulaghat-Govindpur, 76,100 in Manan and 31,400 in Bhagartola village from June to September 2006. These light traps have become popular amongst the farmers of this region, as a result of which 250 units of the trap were sold to the farmers and other agencies.

VLS 59 - A soybean line

A soybean line (INGR No. 06015; IC 471839) registered for low linolenic acid (3.96%) that improves oxidative stability of soybean oil and hence has high commercial value.

ICAR RESEARCH COMPLEX FOR NEH REGION, UMIAN

Preparation of climatic atlas and Productivity Zoning

A detailed digitized climatic atlas covering all growing seasons was prepared for Meghalaya. Productivity zoning of three categories

- Prepared digitized climatic atlas of all growing seasons for Meghalaya
- Developed a genotype-independent multiple shoot induction protocol for pigeonpea
- Evolved raised and sunken bed technology for increasing cropping intensity using marshy land
- Developed seed drill for high slope condition
- Developed protocol for sex diagnosis of ducks and duck embryos through multiplex method
- Achieved captive breeding of chocolate mahaseer



of rice was also completed. The 'Cumulative Total Method' indicated suitability of climate and soil conditions for rice cultivation in four districts of the state.

Plant regeneration and transformation protocol for pigeonpea

A genotype-independent multiple shoot induction protocol for pigeonpea was developed. The protocol can be successfully combined with *Agrobacterium*-mediated and biolistic transformation protocols for transfer of new genes. Transformation with marker gene using the protocol resulted in transformed shoot buds. A protocol for plant regeneration from petioles of mature leaves was also developed.

Identification and multiplication of suitable Kiwi fruit variety

Kiwi variety Abbott was found suitable for agroclimatic conditions of Sikkim and Arunachal Pradesh. Three varieties were successfully propagated through semi-hard wood cutting with the use of indolebutyric acid (IBA) @ 5,000 ppm and rooting success was 68.2%.

Development of raised and sunken bed technology for increasing cropping intensity using marshy lands

Through research on utilization of marshy land, raised and sunken bed technology at the ratio of 1:4 ratio was found suitable for both rice- and maize-based cropping systems, giving rice and maize-equivalent yield of 35.94 tonnes/ha and 13.48 tonnes/ha respectively.



Rice in sunken and okra in raised bed

Farm implement

A seed drill was developed for high slope condition. The drill can be operated by two persons and is suitable for sowing of maize, pulses and some oilseeds crops. A 4-row pre-germinated paddy



A 4-row pre-germinated paddy seeder



Operation of manual seed drill for hill slope

seeder for wetland paddy in valley and terraces was developed and demonstrated.

Biological control using tree bean extracts

Seed and leaf aqueous extracts (15 – 20% concentration) were found effective against rice root-rot nematode. Exposure for 96 hr caused 100% mortality. Aqueous seed and kernel extracts were also effective against rice blast fungus and showed dose-dependent activity.

Simple multiplex PCR for rapid diagnosis of sex in ducks and duck embryos

Protocol for sex diagnosis of ducks (*Anas platyrhynchos*) and duck embryos through multiplex method was developed. The PCR primers to amplify 335 bp PCR product of *W* chromosome specific DNA sequence in female sex and another set of primers to generate a 468 bp PCR product both in male and female sex as an internal control were designed. Using this protocol sexing of embryos utilizing DNA extracted from embryonic tissue samples and amniotic fluid cells and also ducks of any age using DNA extracted from whole blood could be done.

Captive breeding of chocolate mahaseer

Captive breeding of chocolate mahaseer was achieved using the broodstocks from Umiam river of Meghalaya. Hatching was 85%. Fingerlings raised in ponds attained 150 g weight in a year.

CENTRAL AGRICULTURAL RESEARCH INSTITUTE, PORT BLAIR

Crop sciences

The breeding lines and somaclones of Annada rice developed *in situ* gave yield 6 to 8 tonnes/ha respectively. BTS 24, a salt-tolerant line developed *in situ*, showed 3.7-4.0 tonnes/ha at farmers' fields under large-scale cultivation. F₄ mapping population of IR 28 × Pokkali was pheno-typed under artificially simulated saline soil condition and were molecularly profiled through RAPD and SSR analysis for molecular tagging of salt-tolerant genes.

Molecular characterization of an important endemic medicinal plant species, *Dioscorea vexans* through RAPD analysis revealed



ample genetic divergence among diverse collections. Micropropagation of *Dioscorea vexans* and *Costus speciosus*, collected from different locations of Bay Islands, was done using juvenile shoots as the source of explants.

The developed IPM module for brinjal has reduced the damage 74.52% compared to control plots. There was 2.3-fold increase in yield in IPM practised fields compared to control.

Five local isolates of *Pseudomonas* species, viz. C13, C21, C27, C28, C29, were found effective as biocontrol agent against all the pathogens of solanaceous vegetable crops.

Undisturbed mangrove areas exhibited relatively higher urease content than disturbed mangrove areas.

Energy ratio was best in line method of transplanting, whereas CIAE designed manually operated paddy transplanted method reduced drudgery and saved time and energy for cultivation of rice.

Sesbania aculeata (*dhaincha*) can be recommended for intercropping in wet-seeded rice under island conditions for realizing better productivity, profitability and energetics of rice. The soil health can also be improved through intercropping *dhaincha* and incorporating it using cono weeder. Artificial Neural Network (ANN) has high potential for the application of rice yield forecast.

The maximum benefit : cost ratio was recorded in amaranth-*bhindi*-ratoon *bhindi* (2.4) followed by hybrid Napier.

Cost of drying coconut using low cost solar dryer system was Re 0.64/kg which was one-fourth of conventional mechanical driers.

Enterprise combinations for slopping valley (short and medium duration paddy, vegetables, floriculture, plantations, fodder, backyard poultry, fish-cum-poultry-cum-duckery and cattle) and valley (long and short duration paddy, vegetables, backyard poultry, fish-cum-poultry and cattle) areas were identified.

Rice yield was significantly reduced (59% as compared to the unaffected areas) in areas where the *tsunami* damage was estimated to be severe. Moderate reduction (though significant) was observed in areas delineated as moderately affected (37%).

Animal sciences

The relative humidity (RH) and sunshine hours significantly influenced milk production during dry and monsoon season. Supplementation of propionate chelated organic trace minerals significantly improved the daily milk production in crossbred cows.

In the Islands ecosystem Turkey birds were highly suitable under this hot and humid climate. Successfully produced Boer goat cross kid (F₁ generation) through artificial insemination technology. Population status and phenotypic characterization of Nicobari pig and Terssa goat has been documented.

Controlled breeding programme was found to be a successful reproductive management tool to enhance productivity in a dairy herd. Real time B-mode Ultrasonography proved a valuable

- Five local strains of *Pseudomonas* species proved effective as biocontrol agents against pathogens of solanaceous vegetables
- *Sesbania aculeata* intercropping in wet seeded rice proved beneficial in island
- Propionate chelated organic trace mineral supplementation improved the daily milk production in crossbred cows
- Identified enterprise combinations for slopping valley and valley areas
- Documented diverse fishery resource of Andaman and Nicobar islands

diagnostic tool for early pregnancy diagnosis (25–30 days) in cows and early detection of non-pregnancy state could help in reducing the inter-calving interval. Artificial insemination technology in turkey was standardized and employed as an effective technique for improving the fertility and hatchability. Ultrasonography was found to be valuable diagnostic technique for early pregnancy diagnosis (25 days) in goat.

The prevalence of aflatoxin F₂ was found to be more followed by B1, B2 and G1 in the paddy samples affected with the tsunami waves. Overall analysis of feed revealed that the aflatoxin level was within permissible level.

The survey revealed that the deficiency of mineral was the major cause of infertility in dairy cows. Status of macro- and micro-mineral in soil, water and fodder was found to be varying; however the level of C, Zn P, Co was lower than the normal range.

Azolla (*Azolla pinnata*), an aquatic fern, was introduced and found to be feed supplemented for livestock and poultry. The quail reared under deep litter system fed with protein level of 27% in the starter (0–3 weeks) and 24% in growth (4–5 weeks of age) phase performed better.

Post-tsunami survey revealed that 19.35, 10.3, 37.75 and 83.55% of poultry, cattle, goat and pig, respectively, were lost during tsunami.

Impact assessment studies on mangroves, coral reefs and other coastal resources were carried out. Resource survey in the post-Tsunami scenario was also carried out.

Several production cycles of *Macrobrachium rosenbergii* was done and training programme for farmers were conducted. A hatchery cycle of *Penaeus monodon* was done successfully up to PL 20.

Fisheries Science Division in collaboration with other mainstream Fisheries Research institutes and ICAR, New Delhi prepared 'ANFISH- a road map for the development of fisheries in A&N Islands keeping in view the potential of the resources, the livelihood and employment opportunities of the stakeholders in the islands post-tsunami and current trends in global fisheries



development. Diverse fishery resource of Andaman and Nicobar Islands were documented.

Analysis of economic status and scope of dairy farming in Andaman & Nicobar Islands revealed a negative correlation between the percentage of local cows and farm size and positive correlation between percentage of crossbred cows and farm size.

A study on economics of milk production of dairy cattle revealed that the total cost per day in local cows was Rs 21.45, whereas for crossbred cow it was Rs 39.75. Major constituent of the variable cost was on feed in both the breeds.

Total returns from local cow per day was Rs 39.91 and for crossbred cow Rs 60.86. The major contribution for returns (about 97.74% and 98.88% in local and crossbred cows respectively) was from sale of milk, the remaining through sale of manure. The net returns in dairy farming was Rs 18.47 and Rs 21.10 in local and crossbred cows respectively. In crossbred cows, positive trend was noticed between the net returns and size of farm. Benefit : cost ratio was found to be 1.92 and 1.53 for local and crossbred cows respectively.

The average buffalo holding of the study areas was 3.6. On an average, large farmers owned 8.00 milch animal per farm followed by medium farmers and small farmers with average holding of 2.00 and 1.14 milch animals respectively. The study of economics of buffalo milk production revealed that the total cost of maintaining a milch buffalo was Rs 56.30 per day. Total variable cost was 70.43%, of which feed cost was the major component accounting to the tune of 62.34%. A negative correlation was evident between the size of the farm and cost of milk production, which was highest with small farmers (Rs 14.976/litre) followed by medium farmers (Rs 13.62/litre) and large farmers (Rs 10.93/litre). The major constraint was the lack of fodder in Andaman, more so in non-rainy season followed by rainy season followed by insufficient land/space for dairy farming in their farm household.

Effect of tsunami

Socio-economic impact assessment on Agriculture, Animal Husbandry and Aquaculture in the tsunami-hit Andaman was done to assess the damage to the field and loss to the farming community; to analyze the change in cropping pattern/livestock holdings.

Changes after tsunami are as follows:

- share of income from agriculture reduced drastically for the farmers. Share from animal husbandry and aquaculture increased.
- reduced share of agriculture compensated by the increased contribution from service, which included the cash-for-work programmes.
- the agricultural activities were stand-still but now slowly gaining some momentum.
- percentage of farmers cultivating paddy drastically reduced due to non-availability of land because of inundation and salinity.
- majority of the land dried off in the sample area due to the raising of bunds along the sea shores and in the present scenario, on an average only 1.62 acres of land/farmer is still inundated.
- time spent by the farmers in agriculture, animal husbandry and aquaculture farming activities drastically reduced immediately after tsunami and after a year, their man-hours were again reaching about half the time they used to spend during pre-tsunami days.
- considerable loss of livestock and indigenous poultry birds per farm family during tsunami.
- pasture lands available affected severely, resulting in starvation and reduced yield of livestock enterprises due to non-availability of green fodder.
- significant drop in the production level of milk/day, egg/day and live adult goat sold/month per farmer in the study area.



4. National Agricultural Innovation Project

National Agricultural Innovation Project (NAIP) is the next step towards attaining excellence in science, utilizing science for commerce and using science for enhancing rural livelihood security through integration of technology orientation with agricultural economy orientation. The project thus responds to objectives of Government of India as well as of World Bank, as have been expressed in their main policy documents. The project is planned for 6 years and has been launched on 26 July 2006. The objectives, targets and achievements are given below.

Objectives

The overall objective of the project is to facilitate the accelerated and sustainable transformation of Indian agriculture in support of poverty alleviation and income generation by collaborative development and application of agricultural innovations by the public organizations in partnership with farmers' groups, private sector and other stakeholders. The specific objectives are to:

- build the critical capacity of the NARS as a catalyzing agent for management of change.
- promote production to consumption systems in priority areas/themes to enhance productivity, nutrition, profitability, income and employment.
- improve livelihood security of rural people living in disadvantaged regions through innovation system led by

technology encompassing wider process of social and economic change covering all stakeholders.

- build capacity and undertake basic research in strategic areas to meet technology development challenges in the immediate and predictable future.

Targets

- Completion of pre-project preparation requirements
- Initiation and finalization of a few sponsored programmes/activities
- Initiation of activities to support research consortia under Components 2, 3 and 4 through competitive approach.

Achievements

- Thrust areas of Components 1, 2 and 4 identified.
- Disadvantaged districts (150) of Component 3 identified.
- Environmental and Social Management Framework developed and put on the ICAR website.
- Project Implementation Plan (PIP) developed and put on the ICAR website.
- Project Management Committees, National Steering Committee, Project Management Committee, Research Programme Committee, Organization and Management Programme Committee, constituted and have become functional.

National Agricultural Innovation Project Launching Workshop was attended by Dr Montek Singh Ahluwalia, Shri Sharad Pawar, Dr Mangala Rai and Rachid Benmessoud



Shri Sharad Pawar (Minister of Agriculture) unveiled the NAIP logo





NATIONAL AGRICULTURAL INNOVATION PROJECT (NAIP)



Shri Sharad Pawar (Minister of Agriculture) released the book *National Agricultural Innovation Project*

- Twenty sensitization workshops organized in different parts of the country covering about 1,200 stakeholders.
- FAQs as an outcome of workshops developed and available on the ICAR website.
- Technical Advisory Groups in respect of Research Components 2, 3 and 4 constituted.
- Six concept notes developed, under sponsored mode of NAIP Component 3, were discussed in first RPC meeting and sent for peer review.
- The procurement consultant is in place.
- The progress for undertaking major consultancies is satisfactory.
- The sub-projects under Component 1 are being prepared and discussed in the first O&MPC meeting held on 17 October 2006.
- Organization and Management Advisory Groups (O&MAG) constituted.
- Notification for Concept Note call under NAIP Components 2, 3 and 4 released.



5. Organization and Management

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December 1973; subjects allotted to the DARE as per the Government of India (Allocation of Rules) are specified in Appendix I of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India of the DARE functions as the Director-General of the ICAR. The Additional Secretary of the DARE, functions as the Secretary of the ICAR. The Financial Advisor of the DARE is the Financial Advisor of the ICAR. Generally single-file system is followed between the DARE and the ICAR.

The DARE has 15 Group A, 12 Group B, 16 Group C and 6 Group D employees. The recruitments to the posts in the Groups A, B, C is done 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. Direct recruitments are only for Group D posts, and they 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 8 scheduled caste employees.

A detailed break-up of the posts and the 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 the ICAR (Plan and Non-Plan 2006–2007) respectively. The detailed break-up of these financial figures is given in Appendix III of DARE.

ICAR

The Indian Council of Agricultural Research is an apex organization at the national level for promoting 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 headquarters of the ICAR 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 for Agriculture is the President of the ICAR

- Financial upgradation granted to many eligible employees in various grades, stenographers/LDC and Group D employees
- Organized 3 Hindi workshops
- *Ganesh Shankar Vidyarthi Utkrist Hindi Krishi Patrika Puruskar*, awarded to CMFRI, Kochi (First Prize), and IASRI (Second Prize)
- The First Prize of "*Rajshri Tandon Rajbhasha Puruskar*" awarded to IASRI, New Delhi, under the category of Big Institute; CIRC, Mumbai, under the category of A and B regions; and CIFT, Mumbai, under the category of C region
- A state-of-art video-lab has been set up at Krishi Bhavan for editing and production of short films and multimedia presentation for the ICAR
- The Council received First Prize for best display of exhibits in 'Bangalore Bio-Expo 2006'
- Nine news items related to the ICAR appeared on the front pages of the national dailies
- Added 625 new technical books in the ICAR Library. All books have been entered in Library Software Package. DELNET services have also been provided to readers of the Council as referred and reference service
- To promote excellence in agriculture, a total of 42 scientists and their associates, 6 farmers and 1 journalist honoured in 12 categories of awards. Besides, the contribution of 4 institutions and All-India Co-ordinated Research Projects were also recognized.

and the State Minister for Agriculture is the Vice-President. 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.





ORGANIZATION AND MANAGEMENT

The General Body (GB) of the ICAR Society is the supreme authority of the ICAR, and the Minister for Agriculture, Central/State Governments representatives of India, heads it. The members of the GB are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the Senior Officers of the various state governments, representatives of Parliament, industries, educational institutes, scientific organizations and farmers (Appendix 1).

The Governing Body (Appendix 2) is the chief executive and decision-making authority of the ICAR. It is headed by the Director-General. It consists of eminent agricultural scientists, educationists, legislators and representatives of the farmers. It is assisted by the Standing Finance Committee, Accreditation Board, Regional Committees, 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 Sciences, (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 members of Standing Finance Committee are Director-General (ICAR), Secretary (Ministry of Agriculture), scientists, senior officers, farmers and Members of Parliament (Appendix 3). The senior officers posted at the ICAR (Hq) are listed in Appendix 4 of the ICAR.

The ICAR receives funds from the Government of India and from the proceeds of the Agricultural Produce Cess.

The ICAR develops technologies and disseminates knowledge to farming community not only for increasing yields of crops and maintaining natural resources but also for elevating community's economic status.

The Research set-up of the ICAR includes 48 Institutes (Appendix 5), 5 National Bureaux (Appendix 6), 12 Project Directorates (Appendix 7), 32 National Research Centres (Appendix 8), and 62 All-India Co-ordinated Research Projects (Appendix 9).



The Directorate of Information and Publications of Agriculture is working independently with the approval of the Competent Authority and brings out one publication on every third day. It also creates public awareness by dissemination of Information globally through print media as well as electronic media.

The ICAR promotes research, education and extension education in 39 State Agricultural Universities, 5 Deemed Universities, 1 Central Agricultural University for the North-Eastern Hills Region and 4 Central Universities by giving financial assistance in different forms (Appendix 10).

For effective communication of research findings among farmers, the ICAR maintains an effective network of Krishi Vigyan Kendras and Trainers' and Training Centres along with Zonal Co-ordinating Units.

The total sanctioned as well as existing strength of the employees of the ICAR system, including scheduled castes, scheduled tribes and other backward classes, is given in Appendix 11.

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.

POLICY AND PERSPECTIVE PLANNING

ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization were approved by Governing Body and President, ICAR Society. These were made operative from 2 October 2006.





ADMINISTRATION

Filling up of vacant posts

A good number of vacant posts like Director (Finance, ICAR/ NAIP), Under-Secretaries, Senior Administrative Officers, Administrative Officers, Section Officers, Desk Officers, Private Secretaries, Assistants, Personal Assistants, UDCs, Stenographers, Group 'D' posts have been filled up.

Probation/Confirmation

Probation of the Officers of the Combined Cadre of Administrative Officers has been cleared in a meeting.

Financial upgradation granted under the ACP Scheme

As per the Government of India instructions 'Financial upgradation' has been granted to many eligible stenographers/ LDC and Group D employees.

Total number of gazetted 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 to total employees
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	01	01	100	–	–	–	–
Under Secretary SA to Chairman, ASRB	10000–325–15200	13	13	01	7.69	02	15.38	–	–
Senior F &AO	10000–325–15200	03	03	–	–	–	–	–	–
Law Officer	8000–275–13500	01	01	–	–	–	–	–	–
Finance & Assistant 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	–	–	–	–	–	–	–
Desk Officer	6500–200–10500	06	06	01	16.66	–	–	–	–
Protocol Officer	6500–200–10500	01	–	–	–	–	–	–	–
Finance and Accounts Officer	6500–200–10500	06	05	–	–	–	–	–	–
Section Officer	6500–200–10500	80	63	11	17.46	06	9.52	01	1.58
Private Secretary	6500–200–10500	30	30	04	13.33	–	–	–	–



ORGANIZATION AND MANAGEMENT

Total number of non-gazetted 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 to total employees
Assistant	5500–175–90	164	143	24	16.78	11	07.69	05	03.49
PA (Gr.II)	5500–175–9000	55	48	06	12.50	02	04.16	01	03.33
Steno (Gr.III)	4000–100–6000	47	30	04	13.33	Nil	–	01	02.08
UDC	4000–100–6000	188	186	36	19.35	09	04.84	–	–

Total number of Group C and D employees and number of scheduled castes, scheduled tribes and other backward classes

Posts	Total sanctioned posts	Employees in position	No. of SCs	Percentage to total employees	No. of STs	Percentage to total employees	No. of OBCs	Percentage to total employees
LDC	94	84	18	21.4	4	4.76	11	13.09
Peon	76	72	24	33.3	3	4.16	5	6.9
Farash	11	11	7	63.6	2	18.18	1	9.90
Mali	5	5	–	–	–	–	–	–
Packer	5	4	1	25	–	–	2	50
Studio attendant	1	1	–	–	–	–	–	–
Store attendant	1	1	–	–	–	–	–	–
Daftry	45	45	9	20	1	2.2	–	–
Head packer	1	1	–	–	–	–	–	–
Jamadar	8	8	2	25	–	–	–	–
Jr Gestetner operator	2	2	2	100	–	–	–	–
Franking machine operator	1	1	1	100	–	–	–	–
Library attendant	2	2	–	–	–	–	1	50
Despatch rider	1	1	1	100	–	–	–	–
Record keeper	1	1	1	100	–	–	–	–
Sr Gestetner operator	2	2	–	–	2	100	–	–
Safaiwala	12	12	12	100	–	–	–	–

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 six deceased employees. And financial assistance of Rs 20,000 each was given to the self or the dependents of the employees (6) for medical treatment.
- Scholarships were awarded to meritorious wards of the Council's employees under 'Staff Welfare Fund Scheme'.

PROGRESSIVE USE OF HINDI
DARE

The Department of Agricultural Research and Education has an Official Language Section for the compliance and implementation of the Official Language Policy of the Government of India. It consists of one post each of Assistant Director (Official Language), Junior Hindi Translator and Hindi Typist. The section looks after the Hindi translation of the Budget, and compilation



and preparation of Annual Report of the Department. The other functions of the section include holding Hindi workshops, meetings, reports, organizing *Hindi Pakhwada*.

ICAR

- During reported period, 3 Institutes/Centres of the Council have been notified in the Gazette of the Government of India, thus raising the total number of notified Institutions to 98 under rule 10 (04) 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 thrice during the period under report. Similarly, Official Language Implementation Committees constituted at mostly Institutes/Centres convened their meetings.
- Proceedings of the Official Language Implementation Committee meetings held by the Institutes etc. as well as the quarterly progress reports regarding the use of Official Language Hindi received from various institutes at the ICAR (Hq) were reviewed and proper measures have been suggested to overcome 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 year. This year, 8 stenographers and 8 typists were nominated for Hindi stenography and typing.
- "*Hindi Chetna Maas*" was observed from 01 September to 30 September 2006 at the ICAR (Hq), and many programmes were organized to promote progressive use of Hindi in official business. A message of Hon'ble Minister of Agriculture was issued on this occasion. The Director-General, ICAR, also issued an appeal requesting officers/staff to maximize use of Hindi in official work. Hindi Day/Week/Month were also organized at different Institutes/Centres of the ICAR.
- Three Hindi workshops were organized for officers/staff.
- During 2005–2006 cash awards were given to 8 officials at ICAR (Hq) for doing their maximum official work in Hindi.
- "*Ganesh Shankar Vidyarthi Utkrist Hindi Krishi Patrika Puskar*" was launched last year for the best Hindi House-magazine, being published by various Institutions of the ICAR. Under this scheme, the Central Marine Fisheries Research Institute, Kochi, and Indian Agricultural Statistic Research Institute, Pusa, New Delhi, have been awarded. First and Second prizes respectively.
- 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 Council (Hq) as well as its institutes during 2006, 10 officers were inspected and suggestions were given to them to improve their shortcomings. Secondly sub-Committee of the Parliamentary Official Language Committee inspected 14 Institutes/Centres of the Council during this year.

- "**RAJSHRI TANDON RAJBHASHA PURUSKAR**" was given away to following Institutes for doing maximum work in Hindi.

Institutions	Category of institutions	Prizes
Indian Agricultural Statistic Research Institute, Pusa, New Delhi	Big Institute	First
Indian Agricultural Research Institute Pusa, New Delhi	Big Institute	Second
Central Institute of Research for Cotton, Mumbai	A and B Region	First
National Bureau of Soil Survey and Land Use Planning, Nagpur	A and B Region	Second
Central Institute for Fisheries Technology, Kochi	C Region	First
Sugarcane Breeding Institute, Coimbatore	C Region	Second

- The 9th issue of the magazine entitled "**RAJBHASHA ALOK**" was published, which gives a brief description of the progress made in Hindi at the Council and its institutes. Other institutes also brought out Hindi publications.
- Most of the computers at the ICAR(Hq) are bilingual, and 50% of work is being done in Hindi.
- The Council and its institutes organized regular training programmes for farmers in Hindi and in other regional languages, and remarkable progress has been made at Krishi Vigyan Kendras situated in Hindi-speaking region in use of Hindi and in other regional languages in their day- to- day official work.
- Besides, all the materials regarding Parliament, Annual Plan Report, Review of demands for grants, General Body, Standing Finance Committee, Parliamentary Standing Committee on Agriculture, AGM of the ICAR Society and many other meetings were prepared bilingually. The Hon'ble Agriculture Minister and other higher officials delivered their speeches in Hindi. The drafts of many speeches of Hon'ble Union Agriculture Minister and the other higher officials of the ICAR, were originally prepared in Hindi.



FINANCE AND AUDIT

The Budget Estimate and Revised Estimate(RE) of DARE and ICAR (Plan, Non-Plan) for 2005–06 were Rs 1,942.00 crore and Rs 19,00.00 crore respectively and BE for 2006–2007 (Plan and Non-Plan) is Rs 2,160.00 crore. The detailed break-up of these financial figures is given in Table 1.

Table 1. Budget estimates and revised estimates of DARE

Items	(Rs in lakh)					
	Budget estimates 2005–06		Revised estimates 2005–06		Budget estimates 2006–07	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451' 090 Secretariat	–	145	–	145	–	155
Major Head '2415' 80 General International Co-operation	–	–	–	–	–	–
(010032)-India's membership contribution to commonwealth Agricultural Bureau	–	10	–	10	–	10
(020032) Indias' membership contribution to Consultative Group on International Agricultural Research	–	355	–	355	–	375
(030032)Other Programme	*4550	–	90	–	4550*	–
(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

*Including Rs 45 crore for the National Fund for Strategic Research

AWARENESS CREATION UNIT

The Media and Information Unit carried out the following functions during 2006-07.

Electronic media and Web-based services

- Planned, co-ordinated and provided electronic media and web-based support at Krishi Bhavan, and Conference Facilities at the NASC Complex, New Delhi, including wireless connectivity.
- Co-ordinated internet connectivity at ICAR (Hq) as well as at Institutes/Centres, by maintaining liaison with different ISPs, including NIC, ERNET, MTNL, SIFY etc.
- Planned and co-ordinated setting-up of a video conferencing and VOIP telephony at the ICAR (Hq.) and selected Institutes/Centres, through ERNET backbone and less lines/ISDN services.
- Maintained liaison with the ICAR Institutes as regards to preparations of scientific softwares by respective Institutes/Centres.
- Provided media support to 77th Annual General Meeting of ICAR, General-Body Meeting of the ICAR, Directors' Conference, National Conference of KVKs (held at the ANGRAU, Hyderabad); and Meeting with African Delegation (headed by Professor Essayaed of African Union).
- Provided media and web-based support during Second International Rice Congress (7 to 13 October 2006) and GFAR-APAARI Meeting (held from 6 to 11 November 2006). Photographs, video footages and press briefs were provided to media through ICAR website, as well as digital video tapes.
- Prepared 20-minute stand-alone Multimedia Presentation on Recent Achievements of the ICAR, and presented it before the delegates of GFAR-APAARI. Presentation was prepared on DVD (100 copies) and distributed to the delegates.
- Updated ICAR website, by putting latest circulars, tender notices and advertisements for vacancies in the ICAR; and international agencies, including FAO and CGIAR institutions.
- A state-of-art video lab has been set up at Krishi Bhavan for editing and production of short films and multimedia presentations for the ICAR.

Publicity and public relations

Publicity and Public Relations plays a pivotal role in the dissemination of information pertaining to research and education in agriculture and allied subjects including policy decisions and achievements of the research set-up of the ICAR. It is responsible for publicity of achievements of the ICAR in the country and abroad. It also organizes press conferences/briefings addressed by the Union Agriculture Minister, Minister of State for Agriculture,



Secretary (DARE) and DG (ICAR), Deputy Director-General, and Directors of various research institutes; and projects materials of immediate value to various newspapers, agricultural and current affairs magazines and electronic media from time-to-time to give a wider publicity to the events. Such materials have received adequate coverage in the media. This Unit also runs a feedback service for senior officials of the ICAR, including scanning print media and provides relevant newspaper clippings to the Secretary (DARE) and DG, ICAR, and other senior officers of the Council, on daily basis and maintains relevant records of the same. For the first time, 9 news items, related to the Council, appeared on the front page of the national dailies.

Media tours to the ICAR Institutes were organized for showcasing progress of the ICAR at its research bodies at Meerut, Karnal etc. Video Conferencing was also co-ordinated for scientists/officials at Delhi and US Embassy, Washington, through Ministry of External Affairs and National Informatic Centre.

The Council and its institutes participated in the India International Trade Fair (New Delhi), Bio-Expo 2006 (Bangalore), Krishi Expo, India, R & D Exhibition, etc. And the Council got First Prize for the best display of the exhibits in 'Bangalore Bio-Expo 2006.' And the CIAE, Bhopal, was adjudged best stall in 'Agri-Expo 2006' at Chandigarh among 400 stalls.

Library services

The ICAR (Hq) Library has added 625 new technical books, and about 1,270 readers visited the library for consultation. The library also extended information support for consulting database of the Centre for Agricultural and Biosciences International. The document delivery service was extended to individuals and libraries against specific requests for supply of documents for the AGRIS database. The Hindi library acquired about 400 books and subscribed to a number of magazines. All books were entered in Library Software package. DELNET services have also been provided to readers as reference service.

ICAR AWARDS CEREMONY 2006

The 'Annual ICAR Award Presentation 2006' function was held at the NASC Complex, Pusa, New Delhi, on 18 August 2006. H.E. Shri Kanti Lal Bhuria, Union Minister of State for Agriculture, Dr Akhilesh Prasad Singh, Union Minister of Food and Consumer Affairs (S), Dr Mangala Rai, DG (DARE) and Secretary (ICAR)



attended this function. H. E. Dr Akhilesh Prasad Singh read out the message of the Hon'ble Union Minister for Agriculture, Food, Public Distribution and Consumer Affairs, Shri Sharad Pawar. In his message, H.E. Shri Sharad Pawar, said, "The recognition should lead to enhanced zeal and creative work by the awardees as well as enthuse and encourage others to strive harder for greater accomplishments." During this year, 57 awards under 13 different categories have been conferred, honouring nine institutions, 42 scientists and their 57 associates, six farmers and one journalist. Out of 42 scientists, there are 11 women scientists and one farm woman.

TECHNICAL CO-ORDINATION

The Co-ordination included the work of Financial support to 59 Scientific journals publication, 12 Societies/Associations/Universities for holding National Seminar/Symposia/Conferences, and 7 for holding International Seminars/Symposia/Conferences, and the work related to Best Annual Report Awards, ICAR International Training Programmes, for conducting Seminars/Symposia/Conferences, Technical backstopping, Parliament questions, VIP references and material for papers/talks/replies was also co-ordinated. The preparation of technical notes, Regional Committee Meetings, and monthly summary reports on major breakthroughs of exports, imports, research and other related matters of all the Institutes/Project Directorates, were submitted to Cabinet Government of India and other related departments. And also organized the Annual Conference of Directors of ICAR Institutes/NRCs/PDs/National Bureaux.



6. Partnership and Linkages

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December, 1973. Subjects allotted to the DARE as per the Government of India (Allocation of Rules) are specified in Appendix I of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India in the DARE functions as the Director-General of the ICAR. The Financial Adviser of the DARE is the Financial Adviser of the ICAR. Generally single-file system is followed between DARE and ICAR.

The 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, and its activities are given in this chapter.

The DARE has 15 Group A, 12 Group B, 16 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-Castes employees.

A detailed break up of the posts and names of the important functionaries is given in Appendix II of DARE. The financial requirement (Grant No. 2) includes budget estimates (BE) and revised estimates (RE) of DARE and ICAR (Plan and Non-Plan) 2005–2006 respectively, and BE for 2006–07 (Plan and Non-Plan). The detailed break up of these financial figures is given in Appendix III of DARE.

The International Co-operation in ICAR/DARE has been operating through the MoUs/Work Plans signed with various countries/International organizations with ICAR/DARE as the Nodal Department and through participation of ICAR/DARE in the MoUs/Work Plans signed by the Department of Agriculture and Co-operation as Nodal Department. Besides Ministry of Science and Technology has developed Programme of co-operation with various

- DARE finances Central Agricultural University, Imphal cent per cent. A college, in the faculty of Agricultural Engineering and Post-harvest Technology in Gangtok, Sikkim established in current session.
- Memorandum of Understandings were signed during 2006–07.
- DARE/ICAR signed a Memorandum of Understanding between the Republic of India and the Republic of Argentina in the field of Agricultural Research and Education.
- Work Plans were signed with Namibia, Uzbekistan, Eritrea, Cornell University, USA and Egypt in field of agricultural research and education during the reported year.
- DARE/ICAR has signed Collaborative Projects, viz. Sustainable aquafeeds to maximize the health benefits of farm fish for consumer, Biosaline agro-forestry project (BIOSAFOR), and has in principle agreed to participate in the “International Potato Genome Project,”.
- To strengthen our research programme and intermediate/appropriate technologies research workers visited foreign countries, viz. Australia, Bangkok, Yemen, Thailand, Korea, etc. from different organizations and ICAR (Hq).
- Scientists of different countries, viz. Malawi, Eritrea, Mozambique, Ethiopia etc. also visited India to attend research programmes of different research bodies of the ICAR.
- The ICAR Institutes/State Agricultural Universities/Central Agricultural University deputed scientists abroad, viz. Afghanistan, Israel, USA, Niger, China, Serbia, Moutenegro Egypt etc. for developing competence in Biotechnology and made concerted efforts for Human Resource Development of administrative and finance personnel of the ICAR.
- DARE has hosted delegations from Egypt, Uzbekistan etc.

countries and international organizations in which ICAR/DARE is the participating agency in agricultural research. The Joint Commissions/Working Groups constituted by the Ministry of External Affairs, and the Ministry of Commerce have the component of agriculture/agricultural research in which DARE participates directly or through the Department of Agriculture and Co-operation.



MoUs/Work Plans

The activities of the Division are mainly carried out under Memorandum of Understandings (MoUs)/Agreements/Work Plans signed with different international organizations/ countries etc.

- Work Plan for 2007 was signed between the Department of Agricultural Research and Education, Ministry of Agriculture, Government of the Republic of India, and the Ministry of Agriculture and Water Resources, Government of the Republic of Uzbekistan on 26 April 2006.
- A Memorandum of Understanding was signed between the Ministry of Agriculture of the Government of the Republic of India and the Secretariat of Agriculture, Livestock, Fisheries and Food of the Argentine Republic in Agricultural Research on 5 July 2006.
- ICAR and the Brazilian Agricultural Research Cooperation (EMBRAPA) signed a Work Plan for the years 2006–07 for cooperation in the field of agricultural research at Brazilia on 12.09.2006.
- A Work Plan between India and Namibia for 2007–2008 was signed on 10 November 2006 at Windhoele Namibia for co-operation in the field of Agricultural Research and Training.
- A Memorandum of Understanding was signed between the Government of the Republic of India and the Government of the Republic of Sudan for co-operation in the field of agriculture and allied sectors on 2 June 2006.
- A Work Plan for 2007–2008 was signed between the Government of the Republic of India and the Government of the State of Eriteria under the Memorandum of Understanding for co-operation in the field of agricultural research and education.
- A Memorandum of Understanding was signed between the Indian Council of Agricultural Research and the Chinese Academy of Agricultural Sciences, China, for co-operation in agricultural research on 21 November 2006.

- Work Plan for 2007–08 was signed between the Indian Council of Agricultural Research and the Agricultural Research Centre, Ministry of Agriculture and Land Reclamation, Egypt on 16 December 2006.
- A Work Plan for 2007–08 was signed under the Memorandum of Understanding between the Indian Council of Agricultural Research, New Delhi, India and the College of Agriculture and Life Sciences, Cornell University, Ithaca, New York, USA, for co-operation in agricultural research and education on 22 January 2007.

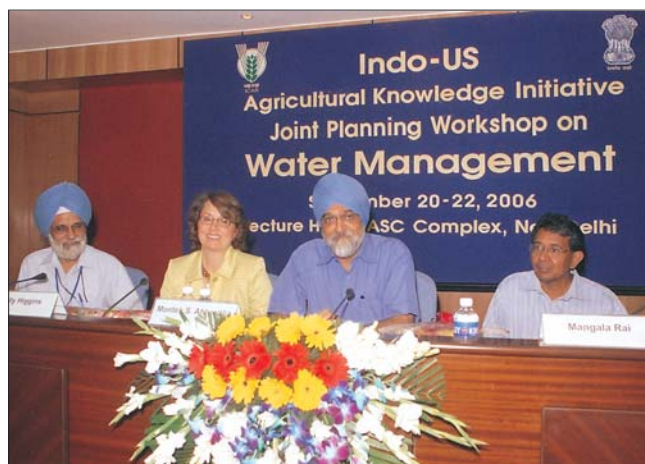
Indo-Foreign Collaborative Projects

During the reported period a number of foreign collaborative projects were received and considered. However, following projects were approved for implementation by the various Institutes of the ICAR.

Under 6 Framework Programme on 'Research Technological Development and Demonstration (FP-6) of the European Union' following two projects were approved for implementation.

"Sustainable aquafeeds to maximize the health benefits of farm fish for consumer": Participation of Central Institute of Freshwater Aquaculture (CIFA) in the above European Union Project was accepted for funding by the European Union. The proposed project is to be executed by a consortium of 32 institutes including CIFA for 48 months w.e.f. 21 September 2006. The objectives of the project were (i) to develop feeds based on sustainable alternative to fish-meal and fish-oil to produce healthy and minimally contaminated fish that are highly nutritious and acceptable to consumers; (ii) to assess health benefits of fish produced on new feeds; (iii) to assess the safety of fish farmed on the new feeds, and (iv) to assess perceptions regarding farmed fish and to advise a framework to communicate the risk and benefits of consuming farmed fish to the public and other stakeholders.

The total outlay for the project is 15,894,307 Euro out of which





PARTNERSHIP AND LINKAGES

EU contribution is 10,500,000 Euro. Funds meant for CIFA are to the tune of Euro 95,000 and counter part contribution of the institute is Euro 99,588 which will be in kind.

Biosaline agro-forestry project—BIOSAFOR: Central Soil Salinity Research Institute, Karnal, and Central Arid Zone Research Institute, Jodhpur, are the participating institutes in the above European Union project from Indian side. Other partners are Holland, Spain, Germany from Europe; and Bangladesh, Pakistan, and India from Asia. The project is being co-ordinated by International Centre for Biosaline Agriculture, Dubai. In India the activities are being co-ordinated by Central Soil Salinity Research Institute, Karnal.

The main objectives of the project were (i) to contribute to the development of bio-saline agro-forestry systems for various saline environments (local/regional approach) and parallel to that; and (ii) to explore the potentials for biomass production in saline environments (globally).

Budget for the Central Soil Salinity Research Institute, Karnal, and Central Arid Zone Research Institute, Jodhpur is EURO 146,520 and the contribution of the institutes is in kind. The project is for 36 months from the date on which the Contract Preparation Forms are signed by all participants. Approval of this department for the participation of the above institutes has already been conveyed.

International potato genome project: It has been, in principle, decided that Central Potato Research Institute, Shimla will participate in the Potato Genome Sequencing Consortium as a partner for sequencing potato chromosome number 2. Financial support to the tune of Rs 888.4 millions will be provided in the XI Five-Year Plan to be launched by next year. By participating in this project India joins a large group of countries including groups from European Union (Ireland, UK and Austria), Brazil, China, New Zealand, Peru, Russia, Turkey and the USA to elucidate the complete sequence of the potato genome. As a member of the consortium India will have direct and immediate access to a wealth of sequence and supplementary data generated by the consortium. The data produced are set to revolutionize plant breeding techniques and open up new avenues to substantially improve potato quality both for nutritional and processing purposes. Further, the sequence will have a profound impact on food security by generating solutions for disease resistance and environmental stress, viz. drought. The project is being co-ordinated by the Netherlands. In this regard a consent letter has been sent at the level of Agriculture Minister to Minister of Agriculture, Nature and Food Quality, the Hague, the Netherlands.

CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL

The Central Agricultural University—established on 26th January, 1993 with its headquarter at Imphal under the Central Agricultural

University Act 1992 of Parliament (Act No. 40 of 1992)—is another autonomous body of DARE that has its jurisdiction over Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim and Tripura, and is wholly financed by Government of India. Like other Agricultural Universities, Central Agricultural University, Imphal has integrated programmes of teaching, research and extension education. Abide by its mandate, the University has established constituent colleges one each in the faculties of Agriculture, Fisheries, Home Sciences, Horticulture and Forestry, and Veterinary Sciences and Animal Husbandry. A college, in the faculty of Agricultural Engineering and Post-harvest Technology in Gangtok (Sikkim), has been established during current academic session. An interdisciplinary college of post-graduate studies at Umiam, Barapani (Meghalaya) is in the process of establishment.

At present, the University offers under-graduate programmes in Agriculture, Fisheries, Home Science, Horticulture and Forestry, and Veterinary Sciences and Animal Husbandry with intake capacity of 58, 22, 32, 43 and 37 respectively. Due to continuous and sincere efforts of teachers and students, majority of the student who passed out during 2006, qualified for admission to post-graduate courses and Junior Research Fellowship based on All India Entrance test conducted by the ICAR.

The post-graduate programmes are offered only in the faculty of Agriculture at the College of Agriculture, Imphal. With limited infrastructure and scientific man-power, the University has handled more than 40 Extramural and Intramural research projects besides teaching and extension commitments

In AICRP on mungbean, urdbean, lentil, lathyrus, *rajmash*, and pea (MULLaRP) crop, trials were conducted to identify high-yielding genotypes under local environment of Manipur. The highest-yielding genotypes of mungbean and urdbean during the year were RGM 34 (1,148.34 kg/ha) and NDU 05-19 (1,463 kg/ha), respectively. Genotype SRC 74 and RSJ 368 of *rajmash* were found highly susceptible to wilt during heavy rains. The research on integrated weed management in urdbean showed that the highest grain yield (2,333.33 kg/ha) days after sowing was found with the treatment of pendimethalin @ 0.75 kg/ha+HW40 days after sowing + normal seed rate. For lentil the genotype L 4680 (193 kg/ha) in IVT and PL 02 (393 kg/ha) were found to be promising under rainfed trials during *rabi* in 2005–06. However, the yield was very low due to the water stress conditions during the vegetative growth stage.

In crop production trials on field pea for spacing and date of sowing, the maximum grain yield was obtained with the treatment combination of Nov. 1 sowing with 15 cm row spacing during *rabi* 2005–06. Nutritional studies in PL 4 lentil variety, the treatment combination involving 5 tonne/ha farmyard manure + 40 kg/ha P₂ O₅ + PSB gave the maximum yield (814.3 kg/ha). As a part of



the integrated nutrient management trial on Sel 9 *rajmash*, the study revealed that the treatment combination involving 5 tonnes/ha farmyard manure + 120 kg/ha N + 20 kg/ha Zn gave the highest yield (954.3 kg/ha).

Trials on mustard genotypes showed that genotypes TCN 05-4 gave maximum yield (1,971.79 kg/ha) and maximum oil-content (41.33%) was obtained from genotypes TCN 05-7, whereas, in AVT 1 two genotypes, the maximum seed yields were recorded from MCH 05-54 (900.97 kg/ha) and MCN 65-05057 A (886.59 kg/ha) respectively.

Among groundnut genotypes, which were tested for their adaptation under local environment of Manipur, ISK 1-2005-8 (3,121 kg/ha pod and 2,287 kg/ha kernel), ISK 1-2005-13 (2,647 kg/ha pod and 1,889 kg/ha kernel) and ISK 1-2005-12 (2,557 kg/ha pod and 1,788 kg/ha kernel) were the 3 best for *kharif*.

During *rabi* 2005–06, in Advanced Varietal Trial (AVT), the test entry, TG 51 significantly out-yielded all the check varieties with 2,591 kg/ha of pod and 1,858 kg/ha of kernel yield. In Initial Varietal Trials (IVT), the entries, INS 2005-11 (3,165 kg/ha kernel) and INA 1-2005-4 (2,900 kg/ha pod and 2,119 kg/ha kernel) were found significantly over checks. Besides these, 2 recommended varieties, ICGS 44 and ICGS 76 received from ICRISAT, Hyderabad, were also evaluated for this region and found that the variety, ICGS 76 was the best both as pod (1,958 kg/ha) and kernel (1,230 kg/ha) yield for summer.

Under AICRP on Soybean, test varieties RKS 15 (1,203 kg/ha) and RKS 18 (1,516 kg/ha) exhibited better performance in grain yield, days to maturity and plant height over the checks. DSb 8 (3,071 kg/ha) and PS 1403 (2,205 kg/ha) were also found superior than the best check RAUS 5 (2,131 kg/ha) in IVT. Maximum seed yield was obtained with 0.3 million/ha plant population of genotype RKS 18. Determination of critical concentration of sulphur in soil for soybean was found to be 40 kg/ha. Maximum net return and B : C ratio were achieved after weed control treatment with Quizalofop ethyl @ 50 g ai/ha + Chlorimuron ethyl @ 9 g/ha as POE. Weed control efficiency at 30 and 60 days after sowing were maximum with polythene mulching (pre-emergence).

In AICRP on Rice improvement, it was observed that variety NK 3355 has the maximum yield performance (6.7 tonnes/ha) followed by MEPH 1 02 (6.5 tonnes/ha). Seven National Agricultural Technology Projects (NATP) on plant biodiversity, household food and nutritional security, castor for rearing eri-silkworm; Integrated Pest Management, major crops of rainfed ecosystem, performance of meat-type goat and indigenous technology for milling, drying and storage of rice were completed during the year. Under Technology Mission for Integrated Development of Horticulture, the work was mainly done on the

production of nucleus/basic seed/planting material in respect of citrus (orange), banana and passion fruit and imparting training to extension functionaries. Main research project from other funding agencies taken up during the year included quail farming in Mizoram (DBT), small indigenous fish for product development (Ministry of Food Processing Industries, Government of India), indigenous natural resource management (National Innovation Foundation), and nutritional values of *Bosmina tripurae* (DST).

Among internally funded project, 12 projects were completed at College of Veterinary Science on various aspects of animal health, production and public health; projects at College of Horticulture and Forestry, Pasighat, on oyster/mushroom production, organic vegetable cultivation, cabbage and tomato genotypes and pest-complex of brinjal and 1 project was completed at College of Fisheries, Lembucherra, on Taxonomy and Ecology of parasites associated with freshwater fishes in Agartala. During the year, the important extension education activities were demonstration, trainings, field trials, village adoption, field visits, interaction meet, participation in Agri-Expo and also the dissemination of information through newspaper, radio-talks and Television presentation and holding *Kisan Melas* under Horticulture Technology Mission. The University also arranged Seminars, Workshops and meetings of National and Regional levels. Interface meeting with the State Departments of all States in the region were also arranged for priority identification. Satellite Workshop of National Agricultural Innovation Project (NAIP) was organized on 23 September 2006.

The University organized 'Indian Agricultural University Association North-East Regional Conference 2006' on 5 and 6 October 2006 where 21 Vice-Chancellors and Directors of Deemed National Agricultural Research Institutes participated to deliberate different aspects of agricultural development in North-East.

PROTOCOL ACTIVITIES

Foreign delegations to India

- H E Mr Daview Katsonga, Minister of Foreign Affairs led a delegation of Ministers of Malawi and visited IARI, New Delhi on 10 May 2006.
- H E Mr Arefaine Berhe Gebhremedhin, Minister of Agriculture of Eritrea along with a 3-member delegation visited IARI, New Delhi on 14 June 2006.
- H E Prof. (Dr) Eng. Venancio Massingua, Minister of S&T, Republic of Mozambique led a 7-member delegation and visited IARI, New Delhi on 27 July 2006.
- Hon. Waithalea Mwangi, M P, led a 5-member delegation of the Agriculture, Lands and Natural Resources Committee of the Kenyan Palimament and visited IARI, New Delhi on 28 July 2006.



PARTNERSHIP AND LINKAGES

- His Excellency, Dr Abera Deresa, State Minister of Agriculture and Rural Development, Ethiopia led a 6-member delegation and visited IARI/NBPGR, New Delhi, NDRI/CSSRI/IARI Regional Station, Karnal from 15 to 19 October 2006.

Delegations hosted in India

- Dr Mahmoud Ibrahim Al-Omeriy, Agricultural Research Centre, Egypt, visited Indian Agricultural Research Institute, New Delhi from 29 May to 10 June 2006, for study in the field of “Seed Technology” under Indo-Egypt Work Plan.
- Dr Mohamed Naguib Mohamed Eid, Agricultural Research Centre, Egypt, visited Central Marine Fisheries Research Institute, Cochin from 3 to 9 June 2006, and to Central Inland Fisheries Research Institute, Barrackpore from 10 to 17 June 2006, for study in the field of “Different Fish Farming Systems” under Indo-Egypt Work Plan.
- Dr Mahmoud Moneer Ali Ragheb, Head, Maize Research Department, Field Crops Research Institute, ARC, Egypt, visited Directorate of Maize Research, New Delhi from 4 to 13 September 2006, for studying “Maize Breeding” under ICAR-ARC, Egypt Work Plan for 2004–2005.
- Dr Mohammed Hussan Al-Masary, Deputy-Director, Horticulture, ARC, Egypt visited NRC for Medicinal and Aromatic Plants, Anand from 16 to 30 September 2006, for studying “Medicinal and Aromatic Plants-Production and Management” under ICAR–ARC, Egypt Work Plan for 2004–05.
- Mr M.S. Mirakhmedov (Senior Research Fellow) Uzbekistan and Mr M. Kim, Specialist both from Uzbek Scientific Research Institute of Cotton Seed Selection, Uzbekistan, and Mr S. Zokirov (Junior Research Fellow, Agriculture Sowing Republican Station for Seed-culturing and Seed-growing, Uzbekistan) visited Central Institute for Cotton Research, Nagpur from 26 to 29 October 2006, for studying “Cotton Growing” under the Work Plan.
- Dr Mangala Rai (Secretary, DARE and Director-General, ICAR) led a delegation and visited USA for participation in the 3rd Board Meeting of the “Knowledge Initiative Board on Agriculture” from 5 to 7 June 2006. The other members of the delegation were Dr Mruthunjaya (National Director, NAIP, New Delhi); Dr C. Ramasamy, (Vice-Chancellor, TNAU, Chennai); Shri S. Sivakumar, (Chief Executive, Agri. Business, ITC Limited, Secunderabad), and Mr Feroze N. Masani (Masani Farm, Nasik).
- Dr Y.S. Ramakrishna (Director, CRIDA, Hyderabad) and Dr M.A. Khan (Head, Division of Integrated Land-Use Management and Farming System, CAZRI, Jodhpur) visited Niger from 15 to 29 June 2006, for preparation of a feasibility study/project report for co-operation between India and Niger in the field of agriculture development/research.
- Dr R.K. Mittal [Principal Scientist (Technical co-ordination), ICAR Headquarter, New Delhi], visited Tagbilaran City, Bohol, Philippines to attend the Special Senior Officials Meeting (SSOM) of the 27th Meeting of the ASEAN Ministers on Agriculture and Forestry (AMAF) from 28 to 31 August 2006.
- Dr N.K. Singh (Principal Scientist, NRC on Plant Biotechnology, IARI, New Delhi), and Dr Subhojit Datta, (Senior Scientist, Department of Biotechnology, IIPR, Kanpur) visited USA, and participated in the International Workshop on ‘Genomics Enable Improvement of Legumes’, organized by the University of California, from 29 August to 1 September 2006.
- Dr T.P. Rajendran [ADG (PP), ICAR, New Delhi], visited Beijing, China for participation in the India-China Joint Working Group Meeting (JWG) and to visit some farms/institutions of excellence from 11 to 12 September 2006.
- Dr S.N. Pandey [ADG (Hort.), ICAR, New Delhi], and Dr R. T. Patil (Director, CIPHRT, Ludhiana) visited Serbia and Montenegro from 25 to 30 September 2006, to make on the spot assessment to areas of co-operation in agriculture between India and Serbia and Montenegro.
- Dr V.J. Shivankar (Principal Scientist, NRC for Citrus, Nagpur) visited Agricultural Research Council, Egypt from 1 to 14 September 2006 for studying in “Controlling and greening of desert areas” under ICAR–ARC Work Plan 2004–2005.
- Dr K.V. Rajendran (Senior Scientist, CIFE, Mumbai) visited Australia from 30 April to 14 May 2006, on deputation as Fish Pathologist at CSIRO, Australia.
- Dr Pitam Chandra [ADG (Agric. Engg., ICAR)], visited for participation and presentation of Status papers in the International Seminar in Bangkok from 18 to 19 May 2006.

Deputation of Indian Scientists

- Dr Nawab Ali [DDG (Agric. Engg.)], Dr Sushil Kumar (Director, NDRI, Karnal), Dr A.K. Singh (Director, IARI), and Dr S.N. Pandey, ADG (Hort.) visited Afghanistan from 23 to 28 April 2006, under the MoU between India and Afghanistan.
- Dr Mangala Rai (Secretary, DARE and Director-General, ICAR), visited Israel from 9 to 11 May 2006, as member of the delegation led by Agriculture Minister to participate in the ‘16th International Exhibition-Israel Agritech 2006’.
- Mrs Sushama Nath (Former Additional Secretary, DARE and Secretary, ICAR) visited USA for participation in meetings on Indo-US-Trade Policy Forum from 4 to 8 June 2006.



APPROVED DEPUTATION CASES FOR THE YEAR 2006

Dr. Suresh Walia, Pri. Scientist, IARI, New Delhi.	Training under INSA's International Scientific Collaboration & Exchange of Scientists Program with Foreign Academies Program in UK for 3 months from 20 March to 17 June 2006.	Local Living by Host Organization in U.K. 50% international by INSA and airfare Remaining 50% by candidate himself.
Dr. Sunil Kumar, Sr. Scientist, IGFRI, Jhansi.	Training Program on Agriculture and Environment Process and Practices in soil and water at CINADCO, Israel (8–29 Nov. 2005).	Local Living by MASHAV, Israel and travel cost by Scientist himself.
Dr. Uma Rao, Sr. Sci., IARI, Pusa, New Delhi.	DBT Biotechnology Overseas Associate ship (Short-term) 2004-05 award at the University of Leeds at UK from 6 th Jan–5 th June 2006.	By DBT
Dr. Rajender Kumar, Sr., Scientist, NRC on Equines, Hisar.	To attend training course on 'Molecular Diagnoses of Protozoa Diseases' at University of Agriculture & Veterinary Medicine, Obhiro, Hokkado, Japan from 10 th Jan. to 23 rd February, 2006.	University of Agri. & Veterinary Medicine, Obhiro, Japan.
Dr. B.P. Mohanty, Scientist (Sr. Scale), CICFRI, Barrackpore.	DBT Overseas Associating (short-term) 2004–2005 at University of Aberdeen, UK in January for six month.	DBT
Dr. A.R. Rao, Scientist (SS), IASRI, New Delhi.	For availing the (Long-term) Biotechnology Overseas Associateship 2004–05 award of the Cold Haiber Laboratory, USA for 12 months w.e.f. 28 th Feb., 06.	DBT
Dr. Anil Khar, Scientist (SS), NRC for Onion & Gaelic, Pune.	For availing the long-term DST BOYSCAST Fellowship Program 2005-2006 at University of Wisconsin, USA for 12 months before 31 st March 2006 & relieved from the Institute.	DST
Dr. A Dhali, Scientist, NRCV on Mithun, Jharnapani.	For availing the long-term DST BOYSCAST Fellowship Program 2005-2006 at Virginia, USA for 12 months before 31 st March & relieved from the Institute.	DST
Dr. Rajesh Kumar, Sr. Scientist, ICAR Res. Complex for NEH Region, Umiam, Meghalay.	To participate in the training program being held at (ICIHOD) Kathmandu, Nepal from 20 th Feb. to 1 st March 06.	ICIHOD
Dr. Lalan Kumar Sinha, Sr. Scientist, CIAE, Bhopal.	For undergoing study on Advance Twin Screw Extension Technology, Washington State University, USA for a period of one year w.e.f. 1 st week of March, 06.	Washington State University, USA.
Sh. Manoranjan Mohanty, Scientist, IISS, Bhopal.	Ph.D., Study in the field of "Simulation of Nitrogen Release from Organic Materials using APSIM in Soybean/Wheat Cropping System on Vertisols" at the University of Queensland, Brisbane, Australia for a period of three years w.e.f. July, 2006.	ACIAR Canberra, Australia.



PARTNERSHIP AND LINKAGES

Dr.Sullip Kumar Majhi, Scientist, ICAR Res. Comp. for NEH Region.	For pursuing Ph.D. course at Tokyo University for Marine Science & Tech., Japan in the field of "Embryo Cry preservation of Highly Endangered Fish Species" for a period of 2 year w.e.f. 1/4/2006 to 31/3/22008.	Japanese Govt. Scholarship 2006.
Dr. M Elangovan, Scientist (SS) NRCS, Hyderabad	Training on 'Conservation Mgt. and use of plant genetic resources in Agriculture at IAC, Wageningen, The Netherlands from 8 th May to 16 th June 2006.	Netherlands Govt. Fellowship Program.
Dr. P.G. Padmaja, Scientist, NRCS, Hyderabad.	Training on 'Pest Mgt. & Food Safety' at IAC, Wageningen, the Netherlands from 29 th May to 23 rd June 2006.	Netherlands Govt. Fellowship Program.
Dr. S.K. Maiti, Sr. Sci., IVRI, Izatnagar.	Training on 'Effects of therapeutic gene delivery during bone & cartilage differentiation' at University of Lipzig, Germany for a period of 3 months w.e.f. 01.5.2006.	Local living cost by Host Institute in Germany, 50% Air fare by INSA & 50% Air fare by Scientist.
Dr. S. Mauria, A.D.G.(IPR&P), ICAR, Krishi Bhawan, N. Delhi	Training in the field of 'life Sciences' at Coonor (Tamil Nadu) and Ithace, New York (USA) during 16–21 July and 10–18 August 2006.	ICAR 'HRD' Training.
Dr. Sadhan Bag, Sr, Scientist IVRI, Izatnagar	For availing Long-Term training at Germany under DBT Biotechnology Overseas Associateship programme.	DBT
Dr. T.K.Bhattacharya Scientist(SS), IVRI, Izatnagar	For Availing training in Canada under DBT, Biotechnology Overseas Associateship Programme.	DBT
Dr. U.B.Chaudhary, Sr. Scientist CIRG, Makhdoom.	For attending 2-day training at M/S Coy Lab Products Inc., USA in Operation techniques of the Scientific equipment USA from 5 to 6 June 2006.	Organizers (M/S Coy).
Dr.C. Ramachandaran, Sci.,(SS)CMFRI, Cochin.	To attend refresher course for Asian Alumni on "Fisheries Management" Organized by IAC, Wapeainger, Philippines w.e.f. 14 to 26 June 06.	IAC, Wagenigen, the Netherlands.
Dr. Laxmilatha, Sr Sci, CMFRI, Cochin.	To attend refresher course for Asian Alumni on "Fisheries Management" Organized by IAC, Wapeainger, Philippines w.e.f. 14 to 26 June 06.	IAC, Wagenigen, the Netherlands.
Dr. Aniket Sanyal, Scientist, PD on FMD, Mukteswar.	For availing Biotechnology Overseas Associateship at CSIRO, Australia.	DBT
Mrs. Poonam Jayant Singh, Scientist (SS), NBFGR, Lucknow.	To participate in the World Intellectual Property Organization (WIPO) Summer School on Intellectual Property. Switzerland from 3–14 July 2006	NBFGR, Lucknow.



Dr. S.B. Barbuddhe, Scientist (SS) (Veterinary Public Health), ICAR Res. Complex for Goa.	To avail DBT Biotechnology Overseas Associate ship (Long-term) 2005-2006 in Germany.	DBT
Dr. Madan Mohan, Sr. Scientist, IVRI, Izatnagar.	To avail DBT Biotechnology Overseas Associate ship (Short-term in U.S.A.	DBT
Dr. (Mrs.) Sohini Dey, Scientist (SS), IVRI, Izatnagar.	To avail DBT Biotechnology Overseas Associate ship (Short-term in U.S.A.	DBT
Dr. Nirupma Dubey, Sr. Scientist, IARI, New Delhi.	To Undergo a training course on 'Carotenoid Detection' Organized by Chinese Academy of Agricultural Science (CAAS), China.	CAAS, China.
Dr. S.K.Nanda, Project Coordinator, AICRP on PHT, CIPHET, Ludhiana.	To attend training in the field of Life Sciences from 16–21 July and 10–18 August 06 respectively at Coonor (Tamil Nadu) and Ithaca in USA respectively.	All expenses by AICRIP, CIPHET, Ludhiana.
Dr. Pallab Choudhary, Sr. Sci., IVRI, Izatnagar.	To avail DBT Short-term training 2005-2006 in USA.	DBT
Dr Arjava Sharma, Pri. Sci., IVRI, Izatnagar.	To avail DBT Short-term training 2005-2006 in USA.	DBT
Dr. P. Jayakumar, Scientist (SS), CICR's Regional Station, Sirsa, Haryana.	To attend training course on 'Integrated Pest Management' Organized by EICA, Egypt.	EICA, Egypt.
Dr. Sewa Ram, Sr. Scientist, DWR, Karnal.	To attend Short-term training at Montana State University, Bozeman, USA for 3 months from Sept., 06 under DBT, Biotechnology Overseas Associateship Program.	DBT
Dr. S.K. Jha, Sr. Sci., NDRI, Karnal.	To Visit Humbolat University in the field of "Research Stays & Study visit for University Academic and Scientists for a period of 14 days w.e.f. 17-30 July 2006, Berlin, Germany.	DAAD, Germany.
Dr. Sumant Vyas, Sr. Sci., NRCC, Bikaner.	To avail the Post doctoral Fellow: Esterus Phermes, INRA, France for a period six months beginning from early Sept. 2006.	INRA, France.
Sh. S.K.Mathanker, Scientist (SS), CIAE, Bhopal.	For pursuing Ph.D at the Oklahoma State university, Stillwater, USA for a period of 3 years w.e.f. 9 th August 2006 to 8 th August 2009. USA	Oklahoma State University, USA
Sh. M.K. Singh, Scientist, CIAE, Bhopal.	For pursuing Ph.D. program at Shizuoka University, Johoku Hamamator, Japan for a period of 3 years w.e.f. 1.10.2006 to 30.9.2009, Japan	Shizuoka University, Japan.
Dr. N.K. Shivakumar Gowda, Sr. Sci., NIANP, Bangalore.	To avail DBT Biotech Overseas Associateship (Short-term) Program 2005–2006. USA.	DBT



PARTNERSHIP AND LINKAGES

Dr. S. Kannappan, Scientist (SS), CIBA, Chennai.	To avail DBT Biotech Overseas Associate ship (Long-term) Program 2005-2006. USA.	DBT
Dr. K.P. Jithendran Sr. Scientist, CIBA, Chennai.	To avail DBT Biotech Overseas Associate ship (Short-term) program 2005-06, Japan	DBT
Dr. A.K. Singh, Sr. Sci., IARI, New Delhi.	To avail DBT Biotechnology Overseas Associate ship (Short-term) program 2005-2006. USA.	DBT
Dr. Mahender Singh Saharan, Sr. Sci., DWR, Karnal.	To Undergo training course on 'Detechon Techniques for Mycotoxins and Toxigenic fungi in the Food Chain, Italy.	MYCo-Globe (Organizers)
Dr. T.K. Behra, Sci., (S-3), IARI, New Delhi.	To avail DBT Biotechnology Overseas Associateship (long-term) Program 2005-06 at the University of Wisconsin, Madison, USA for 12 months from Sept., 06.	DBT
Dr. M. Vanaja, Sr. Sci., CRIDA, Hyderabad.	To avail Commonwealth Academic Staff Fellowship 2006 at the University of Essex, UK for a period of six months w.e.f. 2.10.06 to 1.4.07. UK	Commonwealth Fellowship Commission, UK.
Dr.(Mrs) R. Manimekalai, Scientist, CPCRI, Kasaragod.	To avail DBT Biotechnology Overseas Associateship (long-term) program 2005-06 at Japan.	DBT
Sh. Ranjan Bhattacharya, Scientist, VPKAS, Almora.	For pursuing Ph. D. Program at the School of Applied Sciences, University of Woverhamton, UK for a period of 3 years beginning Sept. 2006 under BORASSUS Project at UK.	University of Woverhamton, UK
Dr. O.P. Yadav, Pri. Sci., CAZRI, Jodhpur.	To avail DBT Biotechnology Overseas Associateship (short-term) in USA	DBT
Shri M. Gunasekharan, Scientist (S.G), CPCRI, Kasaragod.	To undergo training course on Kerala Coconut (WILT) in France from 25 th September to 18 th November 2006.	Organizers
Dr.(Mrs.) Shelly Praveen, Sr. Scientist, IARI, New Delhi.	To attend 3 months training under INSA's International Scientific Collaboration & Exchange of Scientists Program from 22.9.06 to 21.12.06. U.K.	INSA & Scientist concerned Jointly.
Dr Rajsekhar Rao Korada, Scientist (SS), CTCRI's Regl. Stn., Bhubaneshwr (Orissa)	To avail Long-term DBT Biotechnology Overseas Associateship, the Netherlands, 12 months from 25.3.2007.	DBT
Dr. Raveendra N. Gadag, Sr. Scientist, IARI, New Delhi.	To Undergo UGC's Sponsored Commonwealth Academic Staff Fellowship at the John Inne's Centre, Norwich, U.K. for a panel of six months from 2.10.06 to 01.04.2007.	Commonwealth Fellowship Commission UK



Dr. P. Das, Sr. Scientist, CIFA, Bhubaneswar.	For availing DBT's Biotechnology Overseas Associateship (Short-term) program 2005–06 on "Aquaculture and Marine Biotechnology" at Eventual & Genomics Sec., Deptt of Environ Pop Health, Tufts University, USA.	DBT.
Dr. Pious Thomas, Sr. Scientist, IIHR, Bangalore	For availing Biotechnology Overseas Associateship (short-term), 2005–06, in "Molecular Endophytic Microbiology" at Elinders University, Adelaide, Australia	DBT, New Delhi.
Dr. C.P. Balasubramanian, Sr. Scientist, CIBA, Chennai	For availing DBT Biotechnology Overseas Associateship (short-term), 2005–06 at California State University in USA for a period of 6 months from Feb., 2007.	DBT, New Delhi.
Dr. K.K. Vijayan, Head, PNP Div., CMFRI, Cochin	For availing Biotechnology Overseas Associateship (short-term), 05-06 in Belgium for a period of 5 months and 3 weeks from last week of March, 07.	DBT, New Delhi.
Dr. V.P. Chaudhary, Scientist, PDCSR, Modipuram	For attending training on "Research & Development of Agricultural Engineering Technologies" in Israel from 18-31 October, 2006	Local Living cost by Govt. of Israel 50% international air-fare by INSA & 50% international air fare by applicant himself

- Dr Rajeev Kumar Jain [Director (DARE)] visited Rome from 17 to 18 May 2006 for participation in meeting of the GFAR, in Rome, for finalization of GFAR Conference.
- Mrs Sushama Nath [Former Additional Secretary (DARE)/ Secretary, ICAR] visited Yemen from 23 to 24 June 2006 for participation in the Steering Committee Meeting of GFAR.
- Dr A.K. Singh (Sr Scientist, IARI, New Delhi) visited Madrid from 12 to 14 June 2006 for attending the Global Initiative for Plant Breeding Capacity Building Meeting.
- Dr A.K. Singh (Project Director, Water Technology Centre, IARI, New Delhi) visited Vienna from 12 to 15 June 2006 for assignment on behalf of IAEA, Vienna.
- Dr A.K. Jain [ADG (ARIS), ICAR], visited Thailand from 3 to 4 July 2006 for participation in the APAARI-GFAR-FAO Inter-Regional Workshop.
- Dr Ramesh Chand (Director, NCAP, New Delhi) visited Bangkok from 28 to 19 August 2006 for participation in the Workshop on 'Regional Synthesis of Research Needs'.
- Dr S.V. Subbaiah (Head, Directorate of Rice Research, Hyderabad) visited Fiji on deputation under ITEC Programme for 1 year w.e.f. July 2006.
- Dr O. M. Bambawall (Principal Scientist, NCIPM, New Delhi) visited Syria from 16 to 21 August 2006 for participation in the Travelling Workshop on 'IPM'.
- Dr K.K. Sharma (Senior Scientist, IARI, New Delhi) visited Korea from 14 to 16 August 2006 for attending Regional Workshop.
- Dr Pitam Chandra [ADG (Agric Engg.), ICAR] visited Bangkok on 7 August 2006 for participation in the International Seminar on 'Enhancing Export Competitiveness of Fruits'.
- Dr T. Mohapatra (Principal Scientist, NRC on Plant Biotechnology, IARI, New Delhi) participated in the SAARC Workshop on 'Propagating Plants' from 8 to 9 August 2006.
- Dr R.J. Rabindra (Project Director) and Dr B.S. Bhummanavar (Principal Scientist, Project Directorate of Biological Control, Bangalore) participated in the International Workshop on 'Management and Biological Control' from 12 to 15 September 2006.
- Dr D.M. Kamra (Principal Scientist, IVRI, Izatnagar) participated in IAEA Workshop on 'Alternative Feed Resources and Livestock Production' from 12 to 15 September 2006.
- Dr Mohan Josheph (Director, CMFRI, Cochin) participated in the NACA Lead Centre Meeting from 27 to 28 November 2006.
- Dr K.P.R. Vittal (Director, CRIDA, Hyderabad) participated in the Workshop on 'Agricultural Water Management' from 18



PARTNERSHIP AND LINKAGES

to 22 September 2006.

- Dr V.K. Taneja [DDG (Animal Sciences), ICAR] participated in the International Assessment for Agricultural and Technology from 1 to 3 November 2006.
- Dr N, Sarangi (Director, CIFA, Bhubaneswar) visited Bangkok from 27 to 28 November 2006 for participation in the NACA Lead Centre Meeting.
- Dr Boby Ignatius (Scientist, CMFRI, Cochin) participated in the 4th Regional Group of Hatchery Training Course from

20 November to 6 December 2006.

- Dr M.M. Pandey (Director, CIAE, Bhopal) attended Technical Committee and Governing Council Meeting held from 20 to 24 November 2006.
- Dr K.M. Bujarbaruah (Director, ICAR Research Complex for NEH Region, Barapani) participated in the Workshop on Pig System in Asia from 23 to 24 November 2006.
- Dr P. Ravichandran (Principial Scientist, CIBA, Chennai) participated in the NACA/ACIAR meeting on 'BMP's'.



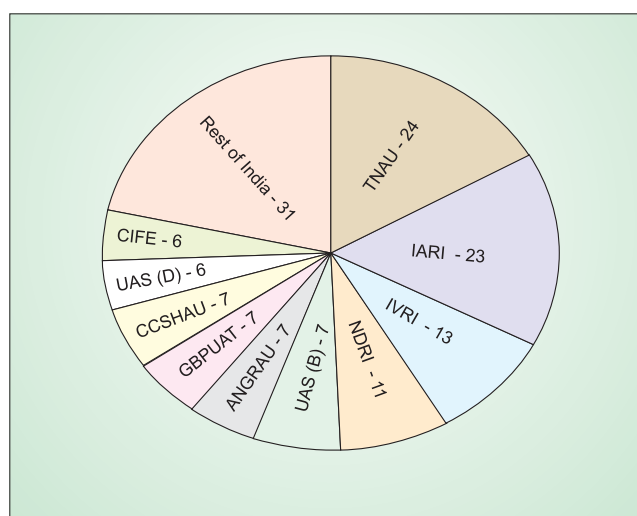
7. Agricultural Scientists' Recruitment Board

The Agricultural Scientists' Recruitment Board (ASRB), an independent recruitment agency under DARE/ICAR, had undertaken a number of reforms to make assessment and recruitment more transparent and efficient. The impetus given to reform process during 2005–2006, was maintained during the current year as well. The highlights of the various activities undertaken during 2006–2007 are briefly described.

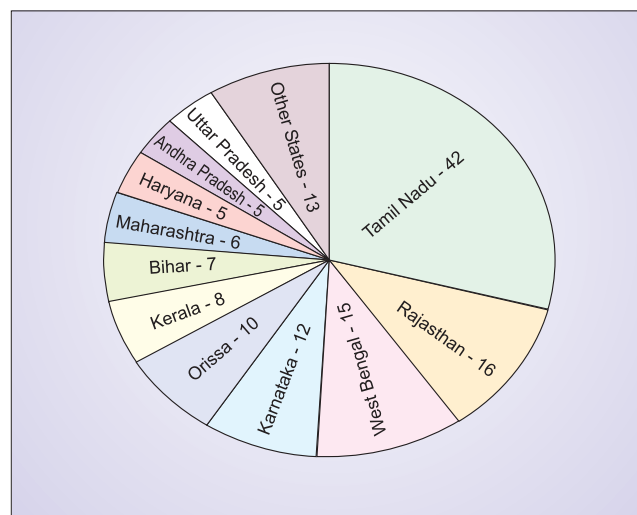
ARS/NET Examination 2005

The Agricultural Research Service (ARS)/National Eligibility Test (NET) examination was held in February 2006 at 32 centres spread throughout the country. Of the 12,524 candidates appeared in the examination, 1,760 cleared NET and ratio being 1 : 7. There were 599 candidates who were called for interview in ARS. Though the advertised vacancies were 160, none qualified in certain disciplines, and thus only 145 vacancies could be filled. The critical analysis of the ARS results indicated:

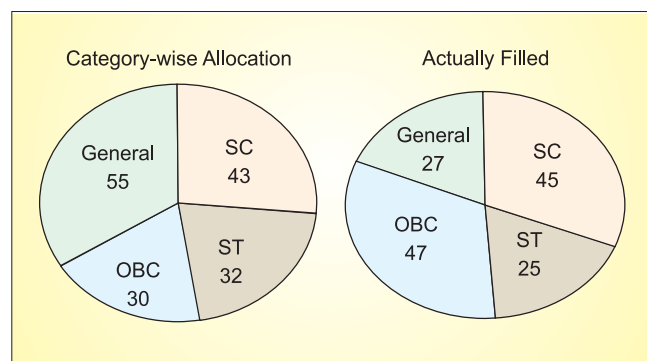
- The candidates belonging to OBC category outperformed the general category, and they claimed 17 seats in general category.
- The candidates belonging to SC category also performed fairly well and could claim 2 seats in general category.
- The top 10 state agricultural universities (SAUs)/deemed-to-be universities contributed 79% of the successful ARS candidates.
- The state-wise distribution was also skewed, as 50% ARS scientists were from only 3 states, viz. Tamil Nadu,



Performance of top ten SAU's/ICAR deemed-to-be universities



State-wise distribution of performance in ARS-2005



Category-wise performance of different groups in ARS examination 2005

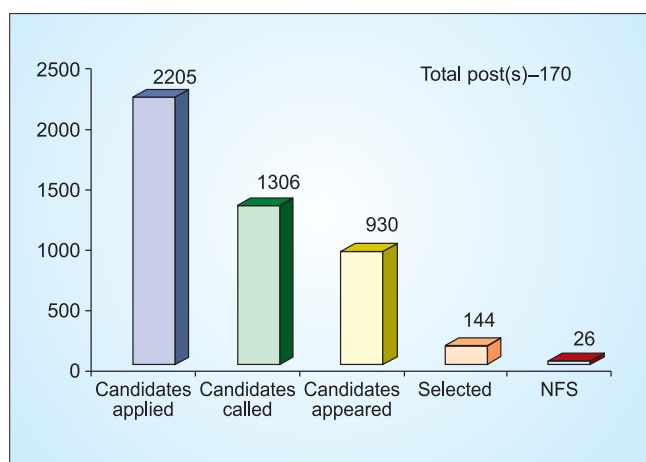
Karnataka and Rajasthan. The tally of Rajasthan was high owing to its contribution to ST category.

- This calls for in-depth analysis of the factors leading to skewed distribution and planning for remedial measures. Therefore in many states steps are called for upgrading the academic standards.



Direct Recruitment to Scientific Positions through Interview

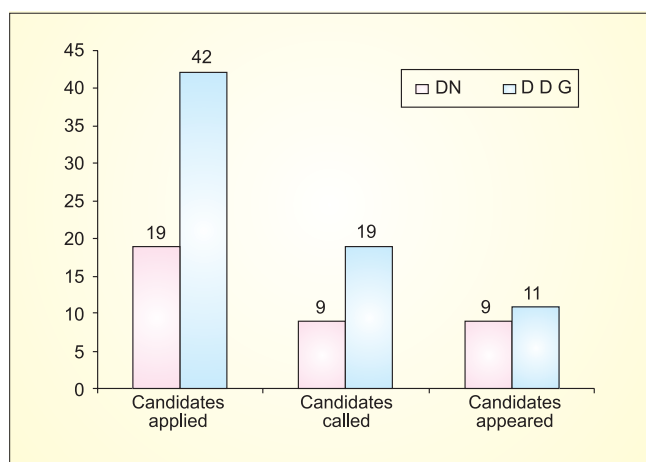
The Board has completed recruitment process in respect of 170 posts during the current year. Of these, 40 posts fall in research and management category (RMP), 25 in middle level management (Heads, Project Co-ordinators, Zonal Co-ordinators etc.) and the remaining in Senior and Principal Scientist category. The Board could make positive recommendations in 144 cases, whereas in rest of the cases, no suitable candidates were available.



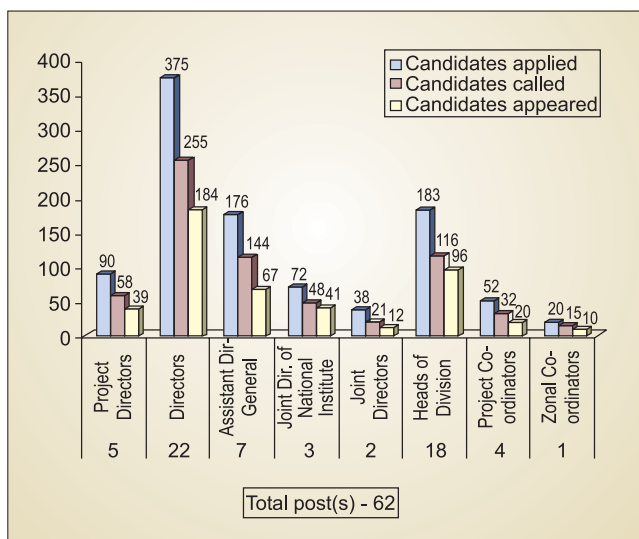
Details of 170 direct selection posts

In all, the Board screened more than 2,200 applications and called about 1,306 candidates for interview. A total of 930 candidates actually attended the interview.

Thus on an average, there were 5.5 candidates for each position. But the inter-category distribution of available candidates was

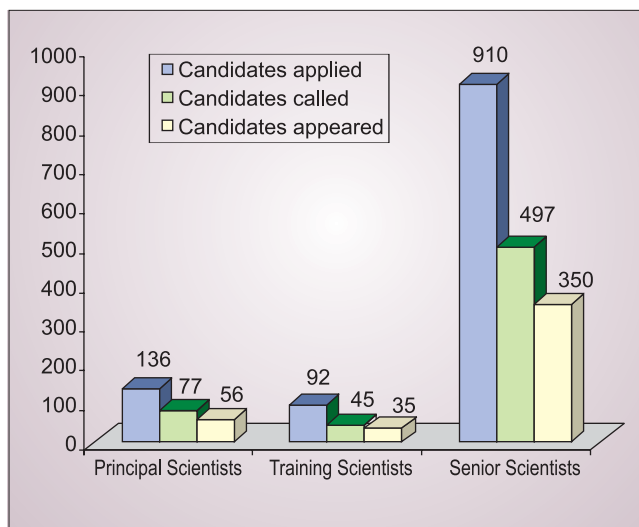


Recruitment detail of Directors of National Institutes (DN) and Deputy Directors General (DDG)



Recruitment detail of Project Directors, Directors, Assistant Directors General, Joint Directors of National Institutes, Heads of Division, Project Co-ordinators and Zonal Co-ordinators

highly skewed. The availability of the candidates for Senior Scientists posts was very low and about 50% of selections were based on 1–3 eligible candidates.



Recruitment detail of Pr. Scientists, Training Organizers and Sr Scientists

Recruitment of Administrative Officers

The open competitive examination for recruitment of 12 Administrative officers was held in 2004, for which 3,489 candidates appeared in the test. The first 60 qualifying applicants were called, but only 44 attended the interview. The category-wise distribution of candidates was SC 13, ST 4, General 27, whereas the distribution of post in each category was SC 3, ST 1 and General 8. The Board



observed that the quality of the candidates for these positions was very good across all categories. It indicates that better qualified persons are opting for ICAR administrative service.

Recruitment of Section Officers

Limited departmental competitive examination for section officers at the ICAR headquarters was held during August 2006. Twentyeight candidates took the examination for 15 posts.

Reforms

Revision of Guidelines for Promotion through Career Advancement Scheme

The ASRB has developed new guidelines for assessing Senior Scientist for promotion to Principal Scientist. The primary objective of these guidelines is to ensure transparency and assess the scientists for the job assigned to them. Accordingly, separate proforma have been prepared for scientists engaged in research,

teaching and research, research and extension, at ICAR Hq. and the NAARM. In the new guidelines, the weightage for personal discussion has been increased from 10 to 20%, while that of confidential report reduced from 30 to 20%.

Comprehension of ARS/NET Disciplines

The need for comprehending and rationalizing the existing 69 scientific disciplines of ARS/NET had been felt since long. A high level committee deliberated on this issue and recommended 37 compact broad disciplines. Accordingly, the syllabus has been recast. The new scheme will come into force with effect from 2007.

Development of Manual for Operating Right To Information (RTI) Act–2005

A comprehensive manual containing guidelines entertaining and disposing cases received under RTI, has been developed. The document would be useful in quick and correct disposal of information being sought.



8. Publications and Information

Nothing succeeds without information. That is why the research conducted by Indian Council of Agricultural Research in the fields of agriculture, animal sciences, fisheries and allied subjects through a network of its Institutes, National Research Centres/Project Directorates/All India Co-ordinated Research Projects, and its results are disseminated to farmers, students, research scholars, scientists, extension workers etc. through the publications brought out by the Directorate of Information and Publications of Agriculture (DIPA).

The DIPA brings out various research journals, periodicals, textbooks, technical books, monographs, technical bulletins, newsletters and brochures in a popular style and lucid manner in English and Hindi languages. Besides, it also provides latest information on title of the publication, authors name, abstracts appeared in the journals, periodicals, books etc. on ICAR website www.icar.org.in.

The DIPA also co-ordinates with the Heads of the Subject Matter Divisions in compilation of the manuscripts of the *DARE/ICAR Annual Report*, preparation of brochures, viz. *ICAR – At a Glance*, *Highlights of the AP Cess Fund*, preparation of textbooks under AHRD programme of Education Division, National Agricultural Innovative Project, ATIC bodies of the ICAR institutes etc.

DIPA's electronic connectivity provided one more channel for mass communication with a large number of ICAR Institutes, National Research Centres, State Agricultural Universities, Central

Agricultural University, All India Co-ordinated Research Projects spread all over the country. In this endeavour, the DIPA has developed compact disc on on-going projects of ICAR Institutes.

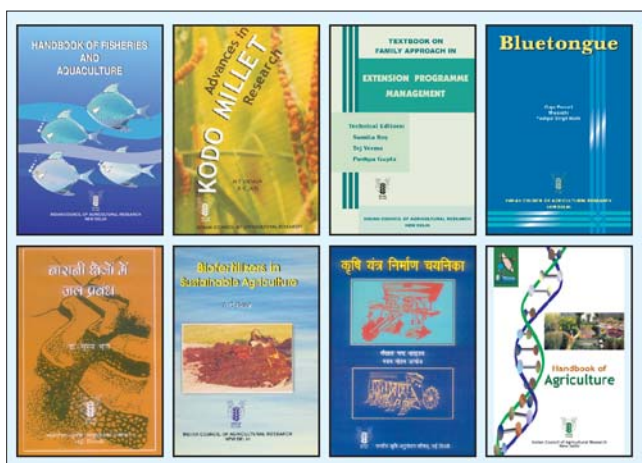
With a view to reach farmers, students, research workers etc. the DIPA participates in *Kisan Melas* and Book Fairs organized by Institutes, National and International agencies. This gives an opportunity to the visitors to get first hand information on the major breakthrough in agriculture, animal sciences and allied subjects.

English Editorial Unit

During 2006–07 the unit brought out 48 publications in English. Some of the important publications were first addition of *Handbook of Fisheries and Aquaculture*, *Biofertilizers for Sustainable Agriculture*, *Bluetongue*, *Advances in Kodo millet Research*. Besides *DARE/ICAR Annual Report 2006–07*, *ICAR - At a Glance* and a number of miscellaneous publications, viz. *Annual Plan*, *Report on NAIP*, *Highlights of AP Cess Fund*, *International Training Programme* etc. The English Editorial Unit also brought out speeches of Minister of Agriculture, Secretary (DARE) and DG (ICAR), Additional Secretary (DARE) and Secretary (ICAR) as a time-bound work.

The Directorate of Information and Publications of Agriculture brought out two monthly research journals, viz. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*. These journals have been indexed internationally (AGRIS, *Science Citation Index*, *Current Contents*). All the issues of the journals were brought out on time. The *Indian Farming*, a semi-technical monthly periodical brought out special issue on the occasion of International Rice Congress in October 2006 with a complete new look, and 1 issue dedicated to Central Institute of Freshwater Aquaculture, Bhubaneswar in February 2007, and all the issues were on time. The *Indian Horticulture*, a bi-monthly popular magazine brought out 2 accent issues, one in May–June 2006 on Indian Institute of Vegetable Research, Varanasi and other in November–December 2006 on Central Tuber Crops Research Institute, Thiruvananthapuram. Besides two quarterly periodicals *ICAR News* and *ICAR Reporter* were also brought out on time. The *ICAR News*, a newsletter covered the activities of ICAR (headquarters) and ICAR Research Institutes/Centres/SAUs etc. It





disseminated information relating to promising technologies, new crop varieties developed at the ICAR Institutes/Centres/SAUs etc. The *ICAR Reporter*, covered reports of all the important events that took place at the ICAR (headquarters) and within the ICAR systems. It covered meetings, workshops, National and International Seminars, Conferences etc. Under the International Linkages, the Memoranda of Understandings/Work Plans signed between the ICAR and International bodies were also covered

Hindi Editorial Unit

Hindi Editorial Unit has a mandate of disseminating agricultural research information to farmers, extension workers, students and scientists through a variety of publications. Hindi Editorial Unit is fulfilling its mandates by publishing regular periodicals, books, reports etc. in Hindi. These publications are widely appreciated by the peers and users for their quality and useful contents.

During 2006–07 Hindi Editorial Unit brought out more than a dozen publications which include books, monographs and reports in addition to its regular periodicals, viz. *Kheti* (monthly), *Phal-Phool* (bi-monthly) and *Krisbi Chayanika* (quarterly). Hindi Editorial Unit is also shouldering the responsibility of publication of Hindi version of speeches of Minister of Agriculture, State Minister of Agriculture, DG, ICAR and other dignitaries as and when required. Hindi version of documents related to AGM and GB are also prepared in the Unit. Besides, Hindi versions of answers to parliament questions are also prepared in the unit, particularly when the questions are of technical nature.

Kheti and *Phal Phool* are popular magazines, which cater to the needs of farmers and students. *Kheti* publishes articles related to agriculture and allied vocations such as animal husbandry, beekeeping, agricultural engineering, forestry, etc. while *Phal Phool* publishes articles pertaining to fruits, vegetables, spices and

medicinal plants. In the light of recent developments in the national vis-à-vis global agricultural scenario, various new topics are being covered in the periodicals such as IPR and its implications in the Indian farming, protection of farmers rights, cultivation of transgenic, organic farming, value-addition and use of renewable sources of energy in agriculture.

Krisbi Chayanika, an informative agriculture digest, publishes information on the latest achievements/researches carried out in India and abroad in its columns. Latest agricultural information available on various websites of international agricultural organizations and the information for the cultivation of medicinal and aromatic plants are also included in its regular columns. During the current year, efforts were made to make *Krisbi Chayanika* more users-friendly, for example photo feature was introduced as a regular column in the periodical.

During the year *Kheti* brought out four special/accents Nos. on topics of current interest, viz. Environment and Agriculture (June 2006), World Food Day (October 2006), Agricultural Implements (November 2006) and Emerging Technologies in Agriculture (January 2007). A new column, *Khet-Khliban : Samasya aur Samadhan* was introduced for the benefit of the farmers in question-answer format.

The popular horticulture bi-monthly *Phal-Phool* brought out accent issues on the theme of Commercial flowers, Insect management, Vegetable cultivation and Hi-tech. horticulture.

In addition to *DARE/ICAR Annual Report (2006–07)* the Hindi Editorial Unit brought out some important publications such as *Krisbi Yantra Nirman Chayanika*, *Shail Udhaniki* and continued its role as disseminator of ICAR Technologies through Hindi medium. Besides publications programme, Hindi Editorial Unit lended language support to various subject matter divisions, ASRB and ICAR headquarters

Production Unit

The Production Unit plays a key role in administrative planning, management and execution of the publication programme in DIPA. It is primarily responsible for management of all the aspects of printing and publishing books and journals, including time-bound publications for the headquarters of the Council. The major activities of Production Unit focus on the management of printing of Council's publications/journals, maintaining close liaison with Editorial, Art and Business Units. The Unit examines the technical aspects of paper quality and processes it for procurement. It is responsible for proper utilization of printing paper and for certification of its consumption. All the monthly journals (3 in English and 1 in Hindi) were printed well in time maintaining the desired print quality. The Council's prestigious quarterly newsletter *ICAR News* and *ICAR Reporter* were



printed well in time using the state-of-art print technology to achieve the desired print quality, catering to the needs of national and international readership, Besides, 48 publications in English and 15 in Hindi were printed maintaining the high class print standard and holding the schedule in time.

The Unit is also assigned the responsibility of printing important annual publications of the Council such as speeches of the Union Agriculture Minister and DG, ICAR for AGM of ICAR Society, *DARE/ICAR Annual Report* in English and Hindi, Agenda Notes, ICAR Budget Book etc. The time-bound publications/certificates/citations/invitation cards meant for the ICAR Award Ceremony and Hindi *Puruskar Vitaran* were also printed with desired quality within a short time. A special issue of *Indian Farming* on the occasion of International Rice Congress was brought out with new style of cover page, layout design and type font for textual matter.

During the period, some of the selected important publications brought out in English were *Handbook of Fisheries and Aquaculture*, *Biofertilizers for Sustainable Agriculture*, *Bluetongue* and *Advances in Kodo Millet Research*. Some Hindi Publications were *Rajbhasha Alok*, *Barani Chhetron Main Jal Prabandh*, *Vegyanik Vidhi Se Ganne Ki Kheti*, *Lokoktiyon Main Bhartiya Krishi Aur Pariwar*, *Krisbi Yantra Nirman Chayanika* and poster for *Hindi Chetna* week etc.

Assistance was provided to NAIP in production of various publications brought out by them during the year. Education Division was also assisted in the production of various course curricula and Information bulletins for admission of UG and PG Courses. For Hindi Section of the Council, various certificates and citations were designed and produced in Hindi. India Map depicting various zones for distribution of ICAR Awards was developed in the Unit. Agricultural Scientists Recruitment Board Logo was also developed which was released by the DG, ICAR on the Foundation Day of ASRB. The production unit also looks after the electronic production processes of DIPA.

Under revenue generating scheme for DIPA, Production Unit has produced publication of State Agricultural Universities maintaining desired quality standard. The Unit is consistently adopting and implementing the modern printing techniques. In this process, the Unit has adopted CtP (Computer to Plate) technology for printing of the *ICAR Annual Report*, *ICAR News*, *ICAR Reporter*. The staff of the Unit was also trained for enhancing their professional capabilities. The Unit has provided training to the students of Polytechnic in the area of Advanced Production Techniques.

Art and Photography Unit

This Unit prepared cover designs, illustrations and line-drawings for textbooks, research journals, newsletters and other

miscellaneous publications.

Photo Unit of DIPA covered all the important activities of the Council, viz. Press Conference of Minister of Agriculture, Minister of State for Agriculture, Secretary (DARE) and DG (ICAR); supply of photographs for press releases and supply of colour transparencies, photographs to various publications brought out in English and Hindi. Photographs were also provided for cover of books, magazines and brochures brought out by the Council. Besides, this Unit also covered visits of foreign dignitaries, signing of Memoranda of Understanding, Protocols, Workshops, Seminars, Convocations, Training Courses etc. The Photo Unit provides slides and other visual support to Secretary (DARE) and DG (ICAR), DDGs and other Scientists of the Council to disseminate information in national and international seminars, meetings etc.

Business Unit

During the period under report, The Business Unit earned revenue of Rs 5.5 million (approx.) including revolving fund scheme (up to January 2007) by way of sale of publications and advertisements. ICAR publications were marketed through government emporia, ATIC bookshops at various SAUs, Institutes, book agents and distributors across the country.

The Unit is responsible for distributing important publications like *DARE/ICAR Annual Report*, *ICAR Budget Book*, *ICAR Reporter*, *ICAR News* and *Telephone Directory* to all the officers of ICAR Institutes, Project Directors, Co-ordinators, Vice-Chancellors, SAUs, NGOs, Scientists, Extension Workers, MPs and other important dignitaries regularly.

With a view to multiply sale of ICAR publications, new marketing strategies were adopted while putting up a book display-cum-sales counter at *Kisan Melas* and organizing Book Exhibition at various SAUs, Institutes and other organizations in different parts of the country. This Unit participated in 11 such events including India International Trade Fair during 14–27 November 2006, Western Region Agricultural Fair-cum-Exhibition at NRC Soybean, Indore during 15–17 February 2007 and IARI *Kisan Mela* during 24–26 February 2007. The Business Unit has taken various other initiatives to promote the publications and periodicals, and advertisements were released in various newspapers and magazines including *A Survey of Indian Agriculture 2006*. The Unit also published the advertisements of ICAR periodicals on Meghdoot Postcard printed by Department of Post and Telegraph to spread the vital information amongst the rural clientele.

Agricultural Research Information Centre and DIPA Library

Agricultural Research Information Centre is the central source of research information of the Council. During 2006–07, it



collected and processed information on Research Projects of ICAR Institutes (RPFs), All India Co-ordinated Research Projects (AICRPs), National Agricultural Research Database. Selective Dissemination of Information (SDI) and Document Delivery Services were provided to about 120 scientists, research scholars and students. The Unit has co-ordinated the activities of the development of National Agricultural Research Database of all the ICAR Institutes and SAUs working as data input centre for this database. This database covered the bibliographical details of all research information published in India in agriculture and its allied sciences. To cover maximum agricultural information generated at different ICAR Institutes NARD/AGRIS database, two training programmes on input preparation and development of NARD were conducted at ARIC in July 2006. DIPA has also procured information on 2,200 inputs and added this information to the National Agricultural Research Database (NARD). The two issues of Abstract Journal, viz. *The Indian Journal of Agricultural Sciences Abstracts* and *The Indian Journal of Animal Sciences Abstracts* were published from this database. Besides, this Unit has brought out *ARIS News* (half-yearly) and Directory of Conferences, Seminars, Symposia, Workshops in Agriculture and Allied Sciences

(half-yearly) for the users of ICAR and SAU system. ARIC has compiled *ICAR Telephone Directory 2007*, and same information is made available at ICAR website: www.icar.org.in. This Unit has indexed 2,200 bibliographic inputs from Indian Agricultural Periodicals and submitted to Food and Agriculture Organization for inclusion in AGRIS database.

ARIC maintained ad-hoc research scheme, AICRP, RPF database. Web page of DIPA was updated with the free text search facilities for books, journals, ad-hoc schemes. Online publication of *ICAR News* (quarterly) and *ICAR Reporter* (quarterly), *ARIS News* (half-yearly) and Directory of Conferences, Seminars, Symposia, Workshops in Agriculture and Allied Sciences (half-yearly), *DARE/ICAR Annual Report*, were also made available at ICAR website www.icar.org.in. This Unit is maintaining the Local Area Network (LAN) of Krishi Anusandhan Bhavan (KAB-I) and assisting internet/e-mail services to all the users of KAB-I.

DIPA Library

The DIPA library received about 361 books, periodicals, *Annual Reports* of the ICAR Institutes and State Agricultural Universities and provided references to the scientists, students and the DIPA staff.

Appendices

(A) DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

APPENDIX I

**THE GOVERNMENT OF INDIA (ALLOCATION OF BUSINESS) RULES
THE SECOND SCHEDULE
(RULE 3)**

- (A) Distribution of Subjects in the Department (Vibhag),
Ministry of Agriculture (Krishi Mantralaya)**
- (B) Department of Agricultural Research and Education
(Krishi Anusandhan aur Shiksha Vibhag)**

Part I

The following subjects which fall within List I of the Seventh Schedule of the Constitution of India.

1. International co-operation in the field of agricultural research and education including relations with foreign and international agricultural research and educational institutions and organizations, including participation in international conferences, associations and other bodies dealing with agricultural research and education and follow-up of decisions at such international conferences, etc.
2. Fundamental, applied and operational research and higher education including co-ordination of such research and higher education in agriculture including agroforestry, animal husbandry, dairying and fisheries, including agricultural statistics, economics and marketing.
3. Co-ordination and determination of standards in institutions for higher education or research and scientific and technical institutions insofar as it relates to food and agriculture including animal husbandry, dairying and fisheries.
4. Cesses for financing to the Indian Council of Agricultural Research, and the commodity research programmes other than those relating to tea, coffee and rubber.
5. Sugarcane research.

Part II

For Union Territories the subjects mentioned in Part I above so far as they exist in regard to these territories and in addition the following subject which falls within List II of the Seventh Schedule of the Constitution of India.

6. Agricultural Education and Research.

Part III

General and consequential:

7. All matters relating to foreign aid received from foreign countries and International Organizations insofar 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	2
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	1
B	Assistant Director (Official Language)	7,500 – 12,000	1
B	Private Secretary	6,500 – 10,500	1
B	Section Officer	6,500 – 10,500	4
B	Assistant	6,500 – 10,500	4
B	Personal Assistant	6,500 – 10,500	2
C	Junior Hindi Translator	5,500 – 9,000	1
C	UDC-cum-Cashier	4,000 – 6,000	1
C	UDC	4,000 – 6,000	2
C	Steno Grade 'D'	4,000 – 6,000	7
C	UDC-Hindi Typist	4,000 – 6,000	1
C	Staff Car Driver	4,000 – 6,000	1
C	LDC	3,050 – 4,590	3
D	Daftry	2,610 – 4,000	1
D	Peon	2,550 – 3,200	5
Total			49

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 Ram Avtar	Deputy Secretary
6.	Mr M S Nayar	Under-Secretary
7.	Mr Rakesh Sharma	Under-Secretary
8.	Mr Roopak Chaudhuri	Under-Secretary
9.	Ms Vandana Sharma	Under-Secretary
10.	Ms Sunita Dasgupta	Under-Secretary
11.	Mr Madan Lal	Under-Secretary
12.	Mr D K Chhatwal	Under-Secretary
13.	Ms Geeta Nair	Principal Private Secretary

APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2005–2006 are Rs 1,942.00 crores and Rs 1900.00 crores respectively and BE for 2006–2007 (Plan and Non-Plan) is Rs 2,160 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 2005–2006 and BE for 2006–2007 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'	–	145	–	145	–	145
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	–	355	–	355	–	375
(030032) -Other Programmes	*4550	–	90	–	*4550	–
(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 45 crore for National Fund for basic and strategic research in agriculture

Table 2 Details of Financial Outlay

Demand No. 2. Department of Agricultural Research and Education

(Rupees in crores)

	Major Head	2005–2006 Budget			2005–2006 Revised			2006–2007 Budget		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
A. Budget Allocation, net of recoveries										
Revenue		1150.00	792.00	942.00	1070.00	830.00	1900.00	1350.00	810.00	2160.00
Capital		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1150.00	792.00	1942.00	1070.00	830.00	1900.00	1350.00	810.00	2160.00
1. Secretariat - Economic Service Agricultural Research and Education Payments to ICAR	3451	0.00	1.45	1.45	0.00	1.45	1.45	0.00	1.55	1.55
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	189.00	190.00	379.00	231.50	198.65	430.15	312.00	194.60	506.60
2.2.02 Horticulture	2415	79.00	69.50	148.50	71.00	71.75	142.75	69.00	71.20	140.20
2.2.03 Agricultural Extension	2415	230.00	0.75	230.75	232.50	0.80	233.30	245.00	0.80	245.80
2.2.04 Agricultural Education	2415	177.00	5.20	182.20	192.60	5.65	198.25	196.00	5.25	201.25
2.2.05 Economics, Statistics and Management	2415	4.50	12.50	17.00	4.50	12.80	17.30	4.00	12.60	16.60
2.2.06 Agricultural Engg.	2415	30.00	23.50	53.50	28.50	24.10	52.60	40.00	23.90	63.90
2.2.07 ICAR Hq Admn. including ASRB and DIPA	2415	3.82	190.00	193.82	12.10	204.00	216.10	30.00	194.25	224.25
2.2.08 National Agril. Technology Project	2415	60.00	0.00	60.00	11.22	0.00	11.22	92.00	0.00	92.00
2.2.09 Indo-French Proj. on Seabass Breedings and Culture	2415	1.18	0.00	1.18	1.18	0.00	1.18	0.50	0.00	0.50
Total other Programme of Crop Husbandry		774.50	491.45	1265.95	785.10	517.75	1302.85	988.50	502.60	1491.10
Total Crop Husbandry		774.50	531.45	1305.95	785.10	557.75	1342.85	988.50	542.60	1531.10
3. Soil and Water Conservation										
3.1 Soil and Water Conservation Institutes	2415	4.50	11.20	15.70	4.50	11.33	15.83	3.60	11.63	15.23
3.2 Other NRM Instts. including Agroforestry Research	2415	76.50	69.00	145.50	76.50	70.92	147.42	73.40	70.02	143.42
Total- Soil & Water Conservation		81.00	80.20	161.20	81.00	82.25	163.25	77.00	81.65	158.65
4. Animal Husbandry	2415	95.00	118.80	213.00	60.00	124.95	184.95	75.00	121.90	196.90
5. Fisheries	2415	39.00	57.00	96.00	36.00	59.70	95.70	29.00	58.20	87.20

(Contd . . .)

(Contd . . .)

	Major Head	2005-2006 Budget			2005-2006 Revised			2006-2007 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	115.00	0.00	115.00	107.00	0.00	107.00	135.00	0.00	135.00
Total-Payments to ICAR		1104.50	786.65	1891.15	1069.10	824.65	1893.75	1304.50	804.35	2108.85
7. Contribution to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institutes	2415	45.50	3.90	49.40	0.90	3.90	4.80	45.50	4.10	49.60
8. Total-Agricultural Research and Education	2415	1150.00	790.00	1940.55	1070.00	828.55	1898.55	1350.00	808.45	2158.45
Grand Total		1150.00	792.00	1942.00	1070.00	830.00	1900.00	1350.00	810.00	2160.00
	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	1035.00	0.00	1035.00	963.00	0.00	963.00	1215.00	0.00	1215.00
2. North-eastern Areas	22552	115.00	0.00	115.00	107.00	0.00	107.00	135.00	0.00	135.00
Total		1150.00	0.00	1150.00	1070.00	0.00	1070.00	1350.00	0.00	1350.00
D. Major Head-wise Total	2415	1035.00	790.55	1825.55	963.00	828.55	1791.55	1251.00	808.45	2023.45
	3451	0.00	1.45	1.45	0.00	1.45	1.45	0.00	1.55	1.55
	2552	115.10	0.00	115.10	107.00	0.00	107.00	135.00	0.00	135.00
	4552	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total		1150.00	792.00	1942.00	1070.00	830.00	1900.00	1350.00	810.00	2160.00

(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 110 001
- (iii) *Union Ministers holding charge of Finance, Planning, Science and Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/Department concerned)*
3. Mr P Chidambaram
Minister of Finance, Government of India
North Block, New Delhi 110 001
4. Mr M V Rajasekharan
Minister of State for Planning
Yojana Bhawan, Government of India
New Delhi 110 001
5. Mr Kapil Sibal
Minister of Science & Technology, and
Human Resource Development
Government of India, Shastri Bhawan
New Delhi 110 001
6. Mr Arjun Singh
Minister for Human Resources
Government of India
New Delhi 110 001
7. Mr Kamal Nath
Minister of Commerce, Government of India
Udyog Bhawan, New Delhi 110 001
- (iv) *Other Ministers in the Union Ministry of Agriculture*
8. Mr Kanti Lal Bhuria
Minister of State for Agriculture
Government of India, Krishi Bhavan,
New Delhi 110 001
9. Mr Taslimuddin
Minister for Animal Husbandry, Dairying and Fisheries
Krishi Bhawan, New Delhi 110 001
- (v) *Ministers in the States/Incharge of Agriculture/Animal Husbandry/Fisheries*

Andhra Pradesh

10. Mr N Raghuvveera Reddy
Minister of Agriculture
Government of Andhra Pradesh
Hyderabad
(Andhra Pradesh) 500 022

11. Mr Fareeduddin Mohammed
Minister of Fisheries
Government of Andhra Pradesh
Hyderabad (Andhra Pradesh) 500 022
12. Mr Suryarao Gollapalli
Minister for Animal Husbandry and Dairy Development
Government of Andhra Pradesh
Hyderabad (Andhra Pradesh) 500 022

Arunachal Pradesh

13. Mr Tsering Gyurme
Minister for Agriculture
Government of Arunachal Pradesh
Itanagar (Arunachal Pradesh) 791 111
14. Mr Chowna Mein
Minister of Fisheries
Government of Arunachal Pradesh
Itanagar (Arunachal Pradesh) 791 111

Assam

15. Ms Pramila Rani
Minister for Agriculture and Horticulture, 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 Narendra Singh
Minister for Agriculture
Government of Bihar
Patna (Bihar) 800 015
20. Mr Sushil Kumar Modi
Minister for Animal Husbandry and Fisheries
Government of Bihar
Patna (Bihar) 800 015

Chhatisgarh

21. Mr Nanki Ram Kanwar
Minister for Agriculture, Animal Husbandry & Fisheries
Government of Chhatisgarh
Raipur (Chhatisgarh)

Delhi

22. Mr Raj Kumar Chauhan
Minister for Agriculture Development and Food,
Animal Husbandry & Fisheries
National Capital Territory of Delhi, Delhi

Goa

23. Mr Francisco 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 Arjun Munda
Minister of Animal Husbandry, Horticulture and Fisheries
Government of Jharkhand, Ranchi (Jharkhand) 834 002

Karnataka

33. Mr Nagaraja Shetty
Minister of Fisheries and Horticulture
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001
34. Dv V S Acharya
Minister for Animal Husbandry
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001

35. Mr Bandeppa Kashempur
Minister for Agriculture
Government of Karnataka, Vidhan Soudha
Bangalore (Karnataka) 560 001

Kerala

36. Mr Mullakkara Ratnakaran
Minister for Agriculture & Coir including Animal
Husbandry and Horticulture
Government of Kerala
Thriuvananthapuram (Kerala) 695 001
37. Mr S Sharma
Minister of Fisheries
Government of Kerala
Thiruvananthapuram (Kerala) 695 001

Madhya Pradesh

38. Mr Choudhary Chanderbhan Singh
Minister for Agriculture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
39. Mr Moti Kashyap
Minister for Fisheries
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
40. Mr Ramakant Tiwari
Minister for Animal Husbandry
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
41. Minister for Horticulture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 432 006

Maharashtra

42. Mr Balasaheb Thorat
Minister for Agriculture
Government of Maharashtra
Mumbai (Maharashtra) 400 032
43. Mr Anees Ahmad
Minister for Fisheries, Animal Husbandry and Dairy
Development
Government of Maharashtra
Mumbai (Maharashtra) 400 032
44. Mr Vinay Kore
Minister for Horticulture and Non-conventional Energy
Government of Maharashtra
Mumbai (Maharashtra) 400 032

Manipur

45. Mr P H Parijat Singh
Minister of Agriculture
Government of Manipur
Imphal (Manipur) 795 001
46. Ms Leima Devi
Minister for Animal Husbandry and Veterinary
Government of Manipur
Imphal (Manipur) 795 001
47. Dr N Mangi Singh
Minister for Fisheries
Government of Manipur
Imphal (Manipur) 795 001
48. Mr Francis Ngajokpa
Minister for Horticulture
Government of Manipur
Imphal (Manipur) 795 001

Meghalaya

49. Mr Manirul Islam Sarkar
Minister for Agriculture and Horticulture
Government of Meghalaya
Meghalaya Secretariat
Shillong (Meghalaya) 793 001
50. Dr Shitlang Pale
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 Rammawi
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 Lalhlengliana
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
Bhubaneswar (Orissa) 751 001
59. Ms Golak Bihari Naik
Minister for Animal Resources Development, Fisheries, Textiles
and Handlooms
Government of Orissa
Bhubaneswar (Orissa) 751 001

Pondicherry

60. Mr V Vaithilingam
Minister for Agriculture, Horticulture, Animal Husbandry
Government of Pondicherry
Pondicherry 605 001
61. Mr MOHF Shajahan
Minister of Fisheries, Horticulture and Animal Husbandry
Government of Pondicherry
Pondicherry 605 001

Punjab

62. Capt. Amarinder Singh
Chief Minister and holding charge of Agriculture
Government of Punjab
Chandigarh (Punjab) 160 001
63. Mr Jagmohan Singh Kang
Minister of Animal Husbandry, Fisheries
and Dairy Development
Government of Punjab
Chandigarh (Punjab) 160 001
64. Mr Jasjit Singh Randhawa
Minister of Horticulture
Government of Punjab
Chandigarh (Punjab) 160 001

Rajasthan

65. Mr Prabhu Lal Saini
Minister of State for Agriculture, Animal Husbandry and
Horticulture
Government of Rajasthan
Jaipur (Rajasthan) 302 005

Sikkim

66. Mr Somnath Poudyal
Minister for Agriculture and Horticulture
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 101
67. Ms Kalawati Subba
Minister for Animal Husbandry, Livestock and Fisheries
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 001

Tamil Nadu

68. Mr 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

Uttaranchal

73. Mr Mahinder Singh Mahra
Minister for Agriculture
Government of Uttaranchal
Dehradun (Uttaranchal)
74. Mr Govind Singh Kunjwal
Minister for Horticulture
Government of Uttaranchal
Dehradun (Uttaranchal)

75. Minister for Fisheries Government of Uttaranchal Dehradun (Uttaranchal)		87. Mr Mahdevrao Shivankar Member of Parliament (LS), Amgaon, Distt. Gundia 441 902 Maharashtra, and B-603, MS Flats, BKS Marg, New Delhi 110 001.	Till the expiry of term in the Lok Sabha
Uttar Pradesh			
76. Mr Ashok Bajpai Minister for Agriculture Government of Uttar Pradesh Lucknow (Uttar Pradesh) 226 001		88. Mr K Manvendra Singh, Member of Parliament (LS) Amargarh House, Dampier Nagar, Mathura, Uttar Pradesh and 20, Willingdon Crescent, New Delhi 110 001.	-do-
77. Dr Virendra Singh Minister for Animal Husbandry Government of Uttar Pradesh Lucknow (Uttar Pradesh) 226 001		89. Mr Kishan Singh Sangwan Member of Parliament (LS) H. No. 563, Ward No. 4, Tehsil Road, Gohana, Sonapat 131 001 Haryanan and 18, Dr Rajendra Prasad Road, New Delhi 110 001.	-do
78. Mr Raj Kishore Singh Minister for Horticulture Government of Uttar Pradesh Lucknow (Uttar Pradesh) 226 001		90. Mr V K Thummar Member of Parliament (LS) Amrut Complex, Station Road, Amreli 365 601 Gujarat and 7, H C Mathur Lane, New Delhi 110 001	-do-
79. Mr Shyam Narayan Minister of Fisheries Government of Uttar Pradesh Lucknow (Uttar Pradesh) 226 001		(viii) Director-General, ICAR	
West Bengal			
80. Mr Naren De Minister for Agriculture Government of West Bengal Writers' Building Kolkata (West Bengal) 700 001		91. Dr Mangala Rai Director-General, ICAR Krishi Bhavan, New Delhi 110 001	
81. Mr Anisur Rahman Minister for Animal Resources Development Government of West Bengal Kolkata, (West Bengal) 700 001		(ix) All Secretaries in the Ministry of Agriculture Mr P K Mishra Secretary (Agriculture and Co-operation) Ministry of Agriculture, Department of Agriculture, Krishi Bhavan, New Delhi 110 001	
82. Mr Kironmoy Nanda Minister for Fisheries & Aquatic Resources and Fishing Harbours Government of West Bengal Kolkata (West Bengal) 700 001		93. Ms Charusheela Sohoni Secretary (Animal Husbandry and Dairying) Krishi Bhavan, New Delhi 110 001	
83. Mr Mohanta Chatterjee Minister for Horticulture and Food Processing Government of West Bengal Writers Building Kolkata (West Bengal) 700 001		(x) Secretary, Planning Commission Mr R R Shah Secretary, Planning Commission Yojana Bhavan, New Delhi 110 001	
(vi) Member of Planning Commission, Incharge of Agriculture		(xi) Secretary, Department of Biotechnology Mr M K Bhan Secretary Department of Biotechnology CGO Complex, New Delhi 110 003	
84. Mr Abhijit Sen Member (Agriculture), Planning Commission Yojana Bhavan New Delhi		(xii) Director-General, Council of Scientific and Industrial Research, Anusandhan Bhawan, New Delhi 110 001	
(vii) Six members of Parliament (Four elected by Lok Sabha and two elected by Rajya Sabha)		96. Director General Council of Science and Industrial Research Anusandhan Bhawan, New Delhi 110 001	
85. Shri Harish Rawat Member of Parliament (RS) Village Mohanari P.O. Chaunalia Tehsil Bhikaisan Distt. Almora, Uttaranchal and 12-A, Canning Lane New Delhi 110 001	25.11.2008	(xiii) Chairman, University Grants Commission 97. Dr S K Thorat Chairman, University Grants Commission Bahadur Shah Zafar Marg, New Delhi	
86. Mr Sharad Anantrao Joshi Member of Parliament (RS) Angar Mala, Village Ambethan, Taluk khed, Distt Pune and 40 Meena Bagh, New Delhi 110 001	04.07.2010	(xiv) Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)	
		98. 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)*
99. 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*
100. Vacant
101. Dr S S Baghel 18.07.2008
Vice-Chancellor
Assam Agricultural University
Jorhat, Assam 785 013
102. Vacant
103. 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*
104. Dr N B Singh Ex-officio
Agricultural Commissioner
Department of Agriculture and Co-operation
Krishi Bhavan,
New Delhi 110 001
105. Dr M L Choudhary
Horticultural Commissioner, Department of
Agriculture,
Krishi Bhavan, New Delhi 110 001
106. Dr S K Bandyopadhyay
Animal Husbandry
Commissioner
Department of Agriculture, Krishi Bhawan,
New Delhi
107. Mr M K R Nair Ex-officio
Fisheries Development Commissioner
Department of Agriculture, Krishi Bhavan
New Delhi 110 001
108. 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*
- 109–122. Vacant
- Representative of the ICMR**
123. Dr Vasantha Muthuswamy 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*
- 124–126. Vacant
- (xx) *One farmer from each region mentioned in Rule 60(a) and four representatives of rural interest nominated by the President*
- 127–133. Vacant
134. Mr Loloark Singh 18.02.2007
Village Dhaurhara
Post Khulwa
Tehsil Sadar
Distt. Mirzapur (Uttar Pradesh)
- Representatives of Rural Interest**
- 135–138. Vacant
- (xxi) *Four Directors of the ICAR Research Institutes, nominated by the President*
- 139–142. Vacant
- (xxii) *Secretary, Indian Council of Agricultural Research*
143. Mr A K Upadhyay
Member-Secretary
Indian Council of Agricultural Research
Krishi Bhawan,
New Delhi 110 001

APPENDIX 2

GOVERNING BODY

Chairman

1. Dr Mangala Rai
Director-General
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001

Ex-officio Members

Member-Finance

2. Mr 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 110 001

Chairman, University Grants Commission

5. Dr S K Thorat
Chairman
University Grants Commission
Bahadur Shah Zafar Marg, New Delhi

Secretary, Animal Husbandry and Dairying

6. Ms Charusheela Sohoni
Secretary
Department of Animal Husbandry and Dairying
Krishi Bhavan, New Delhi 110 001

Secretary, Department of Biotechnology

7. M K Bhan
Secretary
Department of Biotechnology
CGO Complex, New Delhi 110 003

Director General Council of Scientific and Industrial Research

8. 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. Vacant

Scientists

10. Vacant
11. Vacant
12. Vacant

Three Vice-Chancellors (nominated by President)

13. Dr R B Deshmukh
Vice-Chancellor
Mahatama Phule Krishi Vidyapeeth
Ahmednagar
Rahuri (Maharashtra) 413 722
18.07.2008
14. Dr S S Baghel
Vice-Chancellor
Assam Agricultural University
Jorhat 785 013
Assam
18.07.2008
15. Vacant

Three Members of Parliament (Two from Lok Sabha and one from Rajya Sabha) nominated by the President

16. Mr Mahdevrao Shivankar
Member of Parliament (Lok Sabha)
Amgaon, Gundia 441 902 and
B 603, MS Flats, B K S Marg, New Delhi 110 001
16.08.2009
17. Mr Manvendra Singh
Member of Parliament (Lok Sabha)
Angarmala House, Dambiev Nagar, Mathura and
20, Willigdon Crescent
New Delhi 110 001
16.08.2009
18. Mr Sharad Anantrao Joshi
Member of Parliament (Rajya Sabha)
Angarmala, Vill. Ambethom, Taluk Khed, Distt. Pune and
40, Meena Bagh, New Delhi 110 001
19.06.2009

Three Farmers/Representatives of rural areas nominated by President

19. Vacant
20. Vacant
21. Vacant

Three Directors of Research Institutes of the Council nominated by the President

22. Vacant
23. Vacant
24. Vacant

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

STANDING FINANCE COMMITTEE

**Chairman,
Director-General**

1. Dr Mangala Rai
Director-General
Indian Council of Agricultural Research,
Krishi Bhavan, New Delhi

**Ex-officio Members
Member-Finance**

2. Ms Rita Menon
Additional Secretary to the
Govt. of India
Ministry of Finance
Department of Expenditure, New Delhi
- Ex-officio

**Secretary,
Agriculture**

3. Mr P K Mishra
Secretary (Agriculture & Coop.)
Govt. of India
Ministry of Agriculture
Department of Agriculture
Krishi Bhawan, New Delhi
- Ex-officio

Seven members of the Governing Body of the ICAR Society (viz. one Management Expert, two Scientists, one Vice-Chancellor, one Director, one Farmer & one Member of Parliament elected by the Governing Body in its 192nd (15.7.2003) and 193rd (24.12.2003) to the Standing Finance Committee for a fresh period of one year

SCIENTISTS

4. Vacant

5. Vacant

DIRECTOR

6. Vacant

FARMER

7. Vacant

MEMBER OF PARLIAMENT

8. Vacant

MANAGEMENT EXPERT

9. Vacant

VICE-CHANCELLOR

10. Vacant

SPECIAL INVITEES

11. Vacant

12. Mr Shailender Aggarwal
Director (Agri) Room No. 276
Dept. of Commerce
Ministry of Commerce & Industry
Udyog Bhavan, New Delhi 110 001

13. Dr J P Mishra
Asstt. Director-General (TC)
ICAR, Krishi Bhavan, New Delhi 110 001

MEMBER-SECRETARY

14. Ms A K Upadhyay
Additional Secretary (DARE) & Secretary
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001

APPENDIX 4

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. Dr Mangala Rai

Director-General, ICAR and
Secretary to the Government of India
Department of Agricultural Research and Education

2. 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 J S Samra (Natural Resource Management)
3. Dr S Ayyappan (Fisheries and Additional charge Animal Sciences)
4. Dr Nawab Ali (Agricultural Engineering)
5. Dr S P Tiwari (Educational and Additional charge Crop Sciences)
6. Dr H P Singh (Horticulture)

Assistant Directors-General

Crop Sciences

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 (H&VC)
2. Dr K V Ramana (Plantation Crops)

Natural Resource Management

1. Dr P D Sharma (Soils)
2. Dr A K Gogoi (Agronomy)

Engineering

1. Dr P Chandra (Process Engineering)
2. Dr S K Tandon (Engineering)

Animal Sciences

1. Dr Lal Krishna (Animal Health)
2. Dr T J Rasool (AP&B)
3. Dr O P Dhanda (ANP)

Fisheries

1. Dr A D Diwan (Marine Fisheries)
2. Dr V V Sugunan (Inland Fisheries)

Education

1. Dr G C Tiwari (EPD)
2. Dr H S Nainawatee (EQR)
3. Dr B S Bisht (HRD I)

Extension

1. Dr Rajinder Parshad (Agril. Extn.)
2. Dr Ram Chand (KVK)

Others

1. Dr J P Mishra (ESM & Co-ordinator)
2. Dr K S Khokhar (PIM)
3. Dr S Mauria (IPR & Policy)

Principal Scientists

Crop Science

1. Dr A K Sharma (Food Crops)
2. Dr C P Singh (Seeds)
3. Dr Sudhir Kochhar (PB)
4. Dr (Ms) P Kaur (Plant Protection)
5. Dr S Kochhar (Intellectual Property Rights)

Horticulture

1. Dr U C Srivastava
2. Dr D P Singh

Natural Resource Management

1. Dr D K Paul (IWM)
2. Dr O P Sharma (AF)

Education

1. Dr G D Diwakar (Accreditation)

Fisheries

1. Dr Anil Aggarwal (Marine Fisheries)
2. Dr V R Chitranshi (Fisheries)

ARIS Unit

1. Dr A K Jain
2. Dr D K Aggarwal

Extension

1. Dr G Appa Rao
2. Dr A M Narula
3. Dr (Ms) Tej Verma

Engineering

1. Dr S K Tandon

Others

1. Dr A K Bawa (DG Section)
2. Dr V S Upadhyaya
3. Dr D B S Sehra (ES&M)
4. Dr R K Mittal (Tech. Cdn.)

National Agricultural Technology Project

1. Dr Mruthunjaya, National Director
2. Dr J P Mittal, National Coordinator
3. Dr K P Agarwal, 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 Sodhi Singh
4. Mr J Ravi
5. Mr B N Rao

Others

1. Mr B N P Pathak, Legal Advisor

Agricultural Scientists' Recruitment Board

1. Dr C D Mayee, Chairman
2. Dr N K Tyagi, Member
3. Mr Sanjay Kant, Secretary
4. Mr Vikram Singh, Controller of Examination

**Directorate of Information and Publications of
Agriculture (DIPA)**

1. Mr Kuldeep Sharma, Incharge
2. Mr V K Bharti, Chief Production Officer
3. Mr S K Joshi, Business Manager
4. Mr Han Raj, Information System Officer
5. Dr R P Sharma, Editor (English) and Unit Incharge
6. Mr B C Mazumder, Incharge (Art Unit)

APPENDIX 5

ICAR INSTITUTES AND THEIR DIRECTORS

National Institutes

1. Dr 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

Agricultural Sciences

5. Dr R C Srivastava
Central Agricultural Research Institute
Andaman and Nicobar Group of Islands
P B 181 Port Blair
(Andamans & Nicobar Islands) 744 101
6. Dr K P R Vittal
Central Arid Zone Research Institute
Jodhpur (Rajasthan) 342 003
7. Dr M M Pandey
Central Institute of Agricultural Engineering
Berasia Road, Nabi Bagh,
Bhopal (Madhya Pradesh) 462 038
8. Dr T A More
Central Institute of Arid Horticulture
Bikaner (Rajasthan) 334 006
9. Dr B M Khadi
Central Institute for Cotton Research
ICAR Housing Complex, Central Bazar Road
Bajaj Nagar, Nagpur (Maharashtra) 440 010
10. Dr R T Patil
Central Institute of Post-Harvest Engineering and
Technology, Ludhiana (Punjab) 141 004
11. Dr S Sreenivasan
Central Institute for Research on Cotton Technology
PB 16640, Adenwala Road, Matunga
Mumbai (Maharashtra) 400 019
12. Dr B M C Reddy
Central Institute for Sub-tropical Horticulture
Rehmankhhera, PO Kakori
Lucknow (Uttar Pradesh) 227 107
13. Dr A A Sofi
Central Institute of Temperate Horticulture
Old Air Field
Rangreth (Jammu and Kashmir) 190 007
14. Dr G V Thomas
Central Plantation Crops Research Institute
Kasaragod (Kerala) 671 124
15. Dr S K Pandey
Central Potato Research Institute
Shimla (Himachal Pradesh) 171 001
16. Dr Y S Ramakrishna
Central Research Institute for Dryland Agriculture
Santoshnagar, P O Saidabad
Hyderabad (Andhra Pradesh) 500 059
17. Dr H S Sen
Central Research Institute for Jute and Allied Fibres
Barrackpore, Distt 24 Paraganas
(West Bengal) 700 120
18. Dr M P Pandey
Central Rice Research Institute
Cuttack (Orissa) 753 006
19. Dr Gurbachan Singh
Central Soil Salinity Research Institute
Zarifa Farm, Kachwa Road, Karnal (Haryana) 132 001
20. Dr V N Sharda
Central Soil and Water Conservation Research and
Training Institute, 218 Kaulagarh Road
Dehradun (Uttaranchal) 248 195
21. Dr V Krishnamurthy
Central Tobacco Research Institute
Rajahmundry (Andhra Pradesh) 533 105
22. Dr S Edison
Central Tuber Crops Research Institute, PB 3502
Sreekariyam, Thiruvananthapuram (Kerala) 695 017
23. Dr V S Korikanthimath
ICAR Research Complex for Goa,
Ela, Old Goa (Goa) 403 402
24. Dr A K Sikka
ICAR Research Complex for Eastern Region
Walmi Complex, Phulwari Sharif
Patna (Bihar) 801 505
25. Dr K M Bujarbaruah
ICAR Research Complex for North-Eastern Hills Region
Umroi Road, Barapani (Meghalaya) 793 103
26. Dr S D Sharma
Indian Agricultural Statistics Research Institute
Library Avenue, Pusa Campus, New Delhi 110 012
27. Dr K A Singh
Indian Grassland and Fodder Research Institute
Pahuj Dam, Gwalior-Jhansi Road
Jhansi (Uttar Pradesh) 284 003
28. Dr S D Shikhamany
Indian Institute of Horticultural Research
P.O. Hassaraghatta Lake
Bangalore (Karnataka) 560 089
29. Dr Masood Ali
Indian Institute of Pulses Research
Kanpur (Uttar Pradesh) 208 024
30. Dr A Subba Rao
Indian Institute of Soil Science
Nabi Bagh, Bhopal (Madhya Pradesh) 462 038
31. Dr V A Parthasarathy
Indian Institute of Spices Research
P B 1701, P O Marikunnu
Kozhikode (Kerala) 673 012

32. Dr R L Yadav
Indian Institute of Sugarcane Research
P O Dilkusha, Lucknow (Uttar Pradesh) 226 002
33. Dr Bangali Baboo
Indian Lac Research Institute
Namkum, Ranchi (Jharkhand) 834 010
34. Dr Mathura Rai
Indian Institute of Vegetable Research
P.B. 01, P.O. Jakhini
Shahanshapur, Varanasi (Uttar Pradesh) 221 305
35. Dr S K Bhattacharya
National Institute of Research on Jute and
Allied Fibre Technology
12 Reagent Park, Calcutta (West Bengal) 700 040
36. Dr N Vijayan Nair
Sugarcane Breeding Institute
Coimbatore (Tamil Nadu) 641 007
37. Dr H S Gupta
Vivekananda Parvatiya Krishi Anusandhan Sansthan
Almora (Uttar Pradesh) 263 601

Animal Sciences and Fisheries

38. Dr Rajvir Singh
Central Avian Research Institute
Izatnagar (Uttar Pradesh) 243 122
39. Dr K K Vass
Central Inland Fisheries Research Institute
Barrackpore (West Bengal) 700 120
40. Dr A G Ponniah
Central Institute of Brackishwater Aquaculture
75 Santhome High Road
R A Puram, Chennai (Tamil Nadu) 600 028

41. Dr K Devadasan
Central Institute of Fisheries Technology
Willingdon Island, P O Matsyapuri
Cochin (Kerala) 682 029
42. Dr N Sarangi
Central Institute of Freshwater Aquaculture
Kausalyaganga, Bhubaneshwar (Orissa) 751 002
43. Dr B S Punia
Central Institute for Research on Buffaloes
Sirs Road, Hisar (Haryana) 125 001
44. Dr N P Singh
Central Institute for Research on Goats
Makhdoom, Mathura, (Uttar Pradesh) 281 122
45. Dr M J Modayil
Central Marine Fisheries Research Institute
P B 1603, Tatapuram, Kochi (Kerala) 682 018
46. Dr V K Singh
Central Sheep and Wool Research Institute
Avikanagar, District Tonk
Via Jaipur (Rajasthan) 304 501
47. Dr K T Sampath
National Institute of Animal Nutrition and Physiology
Adugodi, Bangalore (Karnataka) 560 030

Other

48. Dr S M Ilyas
National Academy of Agricultural Research and
Management, Rajendranagar
(Andhra Pradesh) 500 030

APPENDIX 6

NATIONAL BUREAUX AND THEIR DIRECTORS

Agricultural Sciences

1. Dr S K Sharma
National Bureau of Plant Genetic Resources
FCI Building, Pusa, New Delhi 110 012
2. Dr A K Maji
National Bureau of Soil Survey and Land Use Planning
P B 426, Shankar Nagar, Amravati Road
Nagpur (Maharashtra) 440 010

Animal Sciences

3. Director
National Bureau of Animal Genetic Resources
PB 129, Karnal (Haryana) 132 001

4. Dr W S Lakra
National Bureau of Fish Genetic Resources
Radhaswami Bhavan, 351/28,
Dariya Pur, Talkatora Road
PO Dilkusha
Lucknow (Uttar Pradesh) 226 002
5. Prof D K Arora
National Bureau of Agriculturally Important Micro-organisms
PB No. 6, Kusmaur
Mau Nath Bhanjan
Uttar Pradesh 275 101

APPENDIX 7

PROJECT DIRECTORATES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr M S Gill
Directorate of Cropping Systems Research
Modipuram,
Meerut (Uttar Pradesh) 250 110
2. Dr D M Hegde
Directorate of Oilseeds Research
Hyderabad (Andhra Pradesh) 500 030
3. Dr B C Viraktamath
Directorate of Rice Research
Hyderabad (Andhra Pradesh) 500 030
4. Dr B Mishra
Directorate of Wheat Research
P B 158, Kunjpura Road,
Karnal (Haryana) 132 001
5. Dr R J Rabindra
Project Directorate of Biological Control
Bellary Road, P.B. 2491, HA Farm Post, Hebbal
Bangalore (Karnataka) 560 024
6. Dr Sain Dass
Project Directorate of Maize Research
Cummings Laboratory
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
7. Dr S D Kulkarni
Project Directorate on Soybean
Processing and Utilization
CIAE Complex, T T Nagar,
Bhopal (Madhya Pradesh) 462 018

Animal Sciences

8. Dr A B Mondal
Project Director
Directorate of Seed Research
Kusmaur, Mau Nath Bhanjan (Uttar Pradesh) 275 101
9. Dr A K Mishra
Project Directorate on Cattle
Grass Farm Road, PB 17
Meerut (Uttar Pradesh) 250 001
10. Dr R P Sharma
Project Directorate on Poultry
Rajendranagar
Hyderabad (Andhra Pradesh) 500 030
11. Dr K Prabhudas (Acting)
Project Directorate on Animal Disease Monitoring
and Surveillance
Hebbal, Bangalore (Karnataka) 560 024
12. Dr B Pattnaik
Project Directorate on Foot and Mouth Diseases
IVRI Campus, Mukteshwar
Kumaon (Uttaranchal) 263 138

APPENDIX 8

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

Agricultural Sciences

1. Dr S K Dhyani
National Research Centre for Agroforestry
IGFRI Campus, Pahuj Dam, Gwalior-Jhansi Road
Jhansi (Uttar Pradesh) 284 003
2. Dr 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
5. Dr P G Adsule
National Research Centre for Grapes
PB No. 3, Manjri Farm Post
Pune (Maharashtra) 412 307
6. Dr M S Basu
National Research Centre for Groundnut
Ivnagar Road, Timbawadi
PB 5, Junagadh (Gujarat) 362 001
7. Prof. Amerika Singh
National Research Centre for
Integrated Pest Management
Lal Bahadur Shastri Building
IARI, Hillside Road, Pusa
New Delhi 110 012
8. Dr K K Kumar
National Research Centre for Litchi, Manchi House
Muzaffarpur (Bihar) 842 002
9. Dr Janardan Jee (Acting)
National Research Centre for Makhana
Patna (Bihar) 801 506
10. Dr Satyabrata Maiti
National Research Centre for Medicinal and
Aromatic Plants
Boriavi Seed Farm, Boriavi
Anand (Gujarat) 387 310
11. Dr R P Tewari
National Research Centre for Mushroom
Chambaghat, Solan (Himachal Pradesh) 173 213
12. Dr M Kochu Babu
National Research Centre for Oilpalm
Pedavegi (Andhra Pradesh) 534 450
13. Dr K E Lawande
National Research Centre for Onion and Garlic
Rajguru Nagar, Pune, (Maharashtra) 410 505
14. Dr R C Upadhyaya
National Research Centre for Orchids
Pakyang (Sikkim) 737 106
15. Dr R K Katiyar
National Research Centre for Plant Biotechnology
Indian Agricultural Research Institute, Pusa,
New Delhi 110 012
16. Dr Arvind Kumar
National Research Centre for Rapeseed and Mustard
P B 41, Bharatpur (Rajasthan) 321 303
17. Dr B B Vashishtha
National Research Centre for Seed Spices
Tabiji, Ajmer (Rajasthan) 305 206
18. Dr N Seetharama
National Research Centre for Sorghum
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
19. Dr G S Chauhan
National Research Centre for Soybean
Bhawerkua Farm, Khandwa Road,
Indore (Madhya Pradesh) 452 017
20. Dr Ashwani Kumar
National Research Centre of Water Technology for
Eastern Region,
Chandrasekharapur, Bhubaneswar (Orissa) 751 023
21. Dr J G Varshney
National Research Centre for Weed Science
Maharajpur, Adhartal, Jabalpur (Madhya Pradesh) 482 004
22. Dr S K Sharma
National Research Centre on DNA Finger Printing
NBPGR, Pusa Campus
New Delhi 110 012
23. Dr P Kumar
National Research Centre on Pomegranate
C/o Centre on Rabi Sorghum
NH 9 Bye Pass
Shelgi, Solapur (Maharashtra) 413 007

Animal Sciences and Fisheries

24. Dr K M L Pathak
National Research Centre on Camel
Jorbeer, PB 07, Bikaner (Rajasthan) 334 001
25. Dr P C Mahanta
National Research Centre for Coldwater Fisheries
Saurabh Cottage, Thandi Sarak
Naintal (Uttaranchal) 263 136
26. Dr S K Dwivedi
National Research Centre for Equines
Sirsa Road, Hisar (Haryana) 125 001
27. Dr T R K Murthy
National Research Centre on Meat and
Meat Products
CRIDA Campus, Santosnagar
Hyderabad (Andhra Pradesh) 500 059
28. Dr Chandan Rajkhowa
National Research Centre for Mithun
ICAR Research Complex
Jharnapani, Medziphema (Nagaland) 797 106
29. Dr Anuprata Das
National Research Centre for Pigs
Panjabari Road, 6th Mile
Guwahati (Assam) 785 037
30. Dr Mohan Bhattacharya
National Research Centre on Yak
West Kemeng, Dirang (Arunachal Pradesh) 790 101

General

31. Dr P K Joshi
National Centre for Agricultural Economics and
Policy Research
Library Avenue, Pusa, New Delhi 110 012
32. Dr (Ms) Hema Pandey
National Research Centre for Women in Agriculture
1199, Jagamara
Bhubaneswar (Orissa) 751 030

APPENDIX 9

A. ALL-INDIA CO-ORDINATED RESEARCH PROJECTS AND PROJECT CO-ORDINATORS

Crop Sciences

1. Dr S P Mishra
Project Co-ordinator (Chickpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
2. Project Co-ordinator (Cotton)
CICR Research Station, PO Lawley Road, Coimbatore
(Tamil Nadu) 641 003
3. Dr S A Faruqi
Project Co-ordinator (Forage Crops)
Indian Grassland and Fodder Research Institute
PO Pahuj Dam, Jhansi-Gwalior Road
Jhansi (Uttar Pradesh) 284 003
4. Dr R K Lakra
Project Co-ordinator (Honeybees)
Division of Entomology
CCS Haryana Agricultural University
Hisar (Haryana) 125 004
5. Dr R L Srivastava
Project Co-ordinator (Linseed)
CSA University of Agriculture and Technology
Kanpur (Uttar Pradesh) 208 002
6. Dr K T Krishne Gowda
Project Co-ordinator (Small Millets)
University of Agricultural Sciences
GKVK Campus, Bangalore (Karnataka) 560 065
7. Dr B B Singh
Project Co-ordinator (MULLARP)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
8. Dr R K Jain
Project Co-ordinator (Nematodes)
Division of Nematology
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
9. Dr I S Khairwal
Project Co-ordinator (Pearl Millet)
Agricultural Research Station, RAU, Mandore
Jodhpur (Rajasthan) 342 304
10. Dr N D Majumdar
Project Co-ordinator (Pigeonpea)
Indian Institute of Pulses Research
Kalyanpur, Kanpur (Uttar Pradesh) 208 024
11. Dr S S Duhoon
Project Co-ordinator (Sesame and Niger)
JNKVV, Jabalpur (Madhya Pradesh) 482 004
12. Dr O K Sinha
Project Co-ordinator (Sugarcane)
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002

Horticulture

13. Project Co-ordinator (Floriculture)
Division of Floriculture and Landscaping
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
14. Dr S Arulraj
Project Co-ordinator (Palms)
Central Plantation Crops Research Institute
Kasaragod (Kerala) 671 124
15. Dr P S Naik
Project Co-ordinator (Potato)
Central Potato Research Institute
Shimla (Himachal Pradesh) 171 001
16. Dr Om Prakash
Project Co-ordinator (Subtropical Fruits)
Central Institute for Subtropical Horticulture
Rahmankhera, Lucknow (Uttar Pradesh) 227 107
17. Dr M Anandraj
Project Co-ordinator (Spices)
Indian Institute of Spices Research
PB 170, Marikunnu, Calicut (Kerala) 673 012
18. Dr M S Palaniswami
Project Co-ordinator (Tuber Crops), Regional Station
of the Central Tuber Crops Research Institute
Thiruvananthapuram (Kerala) 695 017

Natural Resource Management

19. Project Co-ordinator (Dryland Agriculture)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 059
20. Dr Muneshwar Singh
Project Co-ordinator (Long-term Fertilizer Experiments)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
21. Dr M V Singh
Project Co-ordinator (Micronutrients and
Secondary Nutrients and Pollutant Elements in Soils and Plants)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
22. Dr Y Muralidharudu
Project Co-ordinator (Soil Test and Crop Response)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
23. Dr P S Minhas
Project Co-ordinator (Management of Salt-affected
Soils and Saline Water in Agriculture)
Central Soil Salinity Research Institute
Karnal (Haryana) 132 001

24. Dr G G S N Rao
Project Co-ordinator (Agricultural Meteorology)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 059

Engineering and Technology

25. Dr M M Pandey
Project Co-ordinator (Farm Implements and Machinery)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
26. Dr L P Gite
Project Co-ordinator (Human Engineering and Safety in Agriculture)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
27. Dr S K Nanda
Project Co-ordinator (Post-Harvest Technology)
Central Institute of Post-Harvest Technology
Ludhiana (Punjab) 141 004
28. Dr M Shyam
Project Co-ordinator (Renewable Sources of Energy for and Agriculture and Agro-based Industries)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
29. Dr S K Rautaray
Project Co-ordinator (Utilization of Animal Energy)
Central Institute of Agricultural Engineering
(Madhya Pradesh) 462 038
30. Project Co-ordinator (Application of Plastic in Agriculture)
Central Institute of Post-harvest Technology
Ludhiana (Punjab) 141 004

B. Other All-India Co-ordinated Research Projects (AICRPs)

Crop Sciences

31. Arid Legumes
CAZRI, Beehwal, Jodhpur (Rajasthan) 342 003
32. Project Co-ordinator Wheat and Barley
PDWR, Karnal (Haryana) 132 001
33. Groundnut
National Research Centre on Groundnut
Ivanagar Road, PB 5
Junagadh (Gujarat) 362 001
34. Jute and Allied fibres
Central Research Institute for Jute and Allied Fibres
Barrackpore (West Bengal) 700 120
35. Maize
Directorate of Maize Research
IARI Campus, Pusa
New Delhi 110012
36. Component of National Seed Project—Crops
Division of Seed Science and Technology
IARI, Pusa, New Delhi 110 012
37. Network on Pesticide Residues
Division of Agricultural Chemicals, LBS Building
Indian Agricultural Research Institute, Pusa
New Delhi 110 012
38. National Research Centre for Rapeseed-Mustard
Sewar Farm, Distt Bharatpur (Rajasthan) 321 303
39. Biological Control
Project Directorate of Biological Control
Hebbal, Bangalore (Karnataka) 560 024

40. Sorghum
National Research Centre for Sorghum
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
41. Soybean
National Research Centre for Soybean
Khandwa Road, Indore (Madhya Pradesh) 452 017
42. (Sunflower, safflower, centor)
Directorate of Oilseeds Research
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
43. Under-utilized and Under-exploited Crops
NBPGR, Pusa, New Delhi 110 012
44. Rice
Directorate of Rice Research
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030

Horticulture

45. Arid Fruits
Central Institute of Arid Horticulture
Bikaner (Rajasthan) 334 006
46. Cashew
National Research Centre for Cashew
Puttur (Karnataka) 574 202
47. Mushrooms
National Centre for Mushroom Research and Training
Chambaghat, Solan (Himachal Pradesh) 173 213
48. Tropical Fruits
Indian Institute of Horticultural Research
Hessarghatta Lake Post
Bangalore (Karnataka) 560 089
49. Vegetable
Indian Institute of Vegetable Research
Varanasi (Uttar Pradesh) 221 005

Natural Resource Management

50. Agroforestry
National Research Centre on Agroforestry
Jhansi (Uttar Pradesh) 284 003
51. Biological Nitrogen Fixation—Network on Biofertilizer
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
52. Cropping Systems Research
Project Directorate of Cropping Systems Research, Modipuram
Meerut (Uttar Pradesh) 250 110
53. Water Management Research
Khurda, Bhubaneswar (Orissa) 751 023
54. Weed Control
National Research Centre for Weed Science
Adhartal, Jabalpur (Madhya Pradesh) 482 004
55. Optimization of Ground Water Utilization
Khurda, Bhubaneswar (Orissa) 751 023
56. Processing, Handling and Storage of
Jaggery and Khandsari
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002
57. Goat Improvement
Central Institute for Research on Goats, Makhdoom
Mathura (Uttar Pradesh) 281 122
58. Pig
Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122

59. Improvement of Feed Resources and Nutrient Utilization for raising Animal Production
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001

60. Cattle Research
Project Directorate on cattle
Grass Farm Road, PB17
Meerut (Uttar Pradesh) 250 001

61. Poultry breeding
Project Directorate on Poultry
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030

Education

62. Home Science
Division of Education
ICAR, Krishi Anusandhan Bhavan II
Pusa, New Delhi 110 012

APPENDIX 10

AGRICULTURAL UNIVERSITIES AND THEIR VICE-CHANCELLORS

1. Dr S Raghuvardhan Reddy
Acharya N G Ranga Agricultural University
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
2. Dr M C Varshneya
Anand Agricultural University
Anand (Gujarat) 388 110
3. Dr S S Baghel
Assam Agricultural University, Jorhat
(Assam) 785 013
4. Dr Deepak Kumar Bagchi
Bidhan Chandra Krishi Vishwa Vidyalaya
Mohanpur, Nadia (West Bengal) 741 252
5. Dr N N Singh
Birsa Agricultural University
Ranchi (Jharkhand) 834 006
6. Dr 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 S A Nimbalkar
Dr Panjabrao Deshmukh Krishi Vidyapeeth
Akola (Maharashtra) 444 104
9. Dr Jagmon Singh
Dr Yashwant Singh Parmar University of
Horticulture and Forestry
Nauni, Distt Solan (Himachal Pradesh) 173 230
10. Dr P L Gautam
Govind Ballabh Pant University of Agriculture
and Technology
Pantnagar (Uttaranchal) 263 145
11. Dr R N Sreenivas Gowda
Karnataka Veterinary, Animal and Fisheries Sciences University
Bidar (Karnataka) 585 401
12. Dr D S Rathore
Ch Sarwan Kumar Krishi Vishwavidyalaya
Palampur (Himachal Pradesh) 176 062
13. Dr C R Hazra
Indira Gandhi Krishi Vishwavidyalaya
Raipur (Chhatisgarh) 492 012
14. Dr D P Singh
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur (Madhya Pradesh) 482 004
15. Dr B K Kikani
Junagarh Agricultural University
Junagarh (Gujarat) 362 001
16. Dr E K Manjhi
Kerala Agricultural University
Vellanikara, Distt Trichur (Kerala) 680 656
17. Dr Vijay B Mehta
Dr Balaesahib Sawant Konkan Krishi Vidyapeeth
Dapoli (Maharashtra) 415 712
18. Dr R B Deshmukh
Mahatma Phule Krishi Vidyapeeth
Rahuri (Maharashtra) 413 722
19. Dr S S Kadam
Marathwada Agricultural University
Parbhani (Maharashtra) 431 402
20. Dr S L Mehta
Maharana Pratap University of Agriculture and
Technology
Udaipur (Rajasthan) 313 001
21. Dr S M Ilyas
Narendra Dev University of Agriculture
and Technology,
Faizabad (Uttar Pradesh) 224 229
22. Dr R P S Ahlawat
Navsari Agricultural University
Navsari (Gujarat) 396 450
23. Dr B Senapati
Orissa University of Agriculture and Technology
Bhubaneswar (Orissa) 751 003
24. Dr K S Aulakh
Punjab Agricultural University
Ludhiana (Punjab) 141 004
25. Dr Parmatma Singh
Rajasthan Agricultural University
Bikaner (Rajasthan) 334 002
26. Dr H P Singh
Rajendra Agricultural University
Samastipur, Pusa (Bihar) 848 125
27. Dr R C Maheshwari
Sardar Krishi Nagar Dantiwada Agricultural University
Dantiwada (Gujarat) 385 506
28. Dr M P Yadav
Sardar Ballabh Bhai Patel University of Agriculture
and Technology
Modipuram, Meerut (Uttar Pradesh) 250 110
29. Dr Anwar Alam
Sher-E-Kashmir University of Agricultural Sciences
and Technology
Srinagar (Jammu and Kashmir) 191 121
30. Dr Nagendra Sharma
Sher-e-Kashmir University of Agricultural
Sciences and Technology
45-B, Gandhinagar, PB 37
Jammu (Jammu and Kashmir) 180 012
31. Dr Manmohan Singh
Sri Venkateswara Veterinary University
Tirupati (Andhra Pradesh)
32. Dr C Ramasamy
Tamil Nadu Agricultural University
Coimbatore (Tamil Nadu) 641 003
33. Dr N Balaraman
Tamil Nadu Veterinary and Animal Sciences
University, Chennai (Tamil Nadu) 600 051
34. Dr M N Sheelavantar
University of Agricultural Sciences, GKVK
Bangalore (Karnataka) 560 065

35. Dr J H Kulkarni
University of Agricultural Sciences
Dharwad (Karnataka) 580 005
36. Dr A K Bandyopadhyay
West Bengal University of Animal and
Fishery Sciences, 68KB Sarani
Kolkata (West Bengal) 700 037
37. Dr A T Sherikar
Maharashtra Animal Sciences and Fisheries University
Nagpur (Maharashtra) 440 006
38. Dr M L Madan
Deen Dayal Upadhyaya Veterinary and Animal Science University
Mathura (Uttar Pradesh) 281 001
39. Dr M K Majumdar
Uttar Banga Krishi Vishwavidyalaya
Pundibari, Cooch
Bihar (West Bengal) 736 165
40. Dr V K Taneja
Guru Angad Dev Veterinary and Animal Sciences University,
PAU Campus, Ludhiana, Punjab 141 004

Central Agricultural Universities

1. Dr S N Puri
Central Agricultural University
Imphal (Manipur) 795 004

Central Universities

1. Dr Naseem Ahmad
Aligarh Muslim University
Aligarh (Uttar Pradesh) 202 002

2. Dr Panjab Singh
Banaras Hindu University
Varanasi (Uttar Pradesh) 221 005
3. Professor S K Basu
Upacharya, Visva Bharati
Sriniketan (West Bengal) 731 236
4. Prof G D Sharma
School of Agricultural Sciences and Rural Development
Nagaland University
Medziphema (Nagaland) 797 106

Deemed-to-be Universities

1. Dr 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 11

Total number of employees in the ICAR and its research institutes and number of Scheduled Castes, Scheduled Tribes and Other Backward Classes

Sl.no. Post	Total posts sanctioned	Total employees in position	Total scheduled castes among them	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	05	41
Principial Scientist	649	437	41	04	13
RMP Scientist	147	99	2	2	3
Total	6,328	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

APPENDIX 12

AWARDS

AWARD	AWARDEES
Sardar Patel Outstanding Institution Award (2005)	<i>ICAR Institutes</i> (i) Central Tuber Crops Research Institute, Thiruvananthapuram and (ii) Central Soil and Water Conservation Research and Training Institute, Dehradun (<i>Jointly</i>) <i>State Agricultural Universities</i> (i) GB Pant University of Agriculture and Technology, Pantnagar <i>NRC/Project Directorates</i> (i) NRC for Citrus, Nagpur
Jawaharlal Nehru Award for Outstanding Post-graduate Agricultural Research (2005)	<i>Crop Improvement</i> (i) Dr M G Vaishali, UAS, Bangalore (ii) Dr Mukesh Kumar Dhillon, CCSHAU, Hisar <i>Biotechnology</i> (i) Dr Abhijit Das, NRC on Plant Biotechnology, IARI, New Delhi Dr Sohini Dey, Madras Veterinary College, Chennai <i>Plant Protection</i> (i) Dr P Pretheep Kumar, TNAU, Coimbatore <i>Natural Resource Management</i> (i) Dr Baby Akula, Anand Agriculture University, Anand (ii) Dr Nila Rekha, Anna University, Chennai <i>Horticulture</i> (i) Dr A R Rasmi, CPCRI, Kasaragod <i>Engineering and Technology</i> (i) Dr Debabandya Mohapatra, IIT, Kharagpur (ii) Jagabandhu Panda, IIT, Kharagpur <i>Animal Sciences</i> (i) Dr Rajveer Singh Pawaiya, IVRI, Izatnagar (ii) Dr Amlan Kumar Patra, IVRI, Izatnagar (iii) Dr Mihir Sarkar, NDRI, Karnal <i>Fisheries</i> (i) Dr C P Suja, CMFRI, Tuticorin <i>Social Sciences</i> (i) Dr Shalendra, GBPUAT, Pantnagar (ii) Dr D Puthira Prathap, TNAU, Coimbatore
N.G. Ranga Farmer Award for Diversified Agriculture (2005)	(i) Dr M S Vanita Murlidhar, Vill. Kalitala, Pune, Maharashtra and (ii) Mr S K Rabi-ul-Haque, Vill. Kali Tala, Maharashtra (<i>Jointly</i>)
Panjabrao Deshmukh Women Agricultural Scientist Award (2005)	(i) Dr M Maheshwari, CRIDA, Hyderabad (ii) Dr Gita Kulshretha, IARI, New Delhi
Vasandrao Naik Award for Research Applications in Dryland Agriculture (2005)	(i) Dr K K Satpathi and Associates Dr Vinod Kavungal, Dr R K Singh, Mr J M S Tomar, ICAR, NEH Complex, Umiam
Chaudhary Devi Lal Outstanding AICRP Award (2005)	(i) AICRP on Potato, CPRI, Shimla (ii) AICRP on Cashew, DOR Hyderabad

AWARD	AWARDEES
Chaudhary Charan Singh Award for Excellence in Journalism in Agricultural Research & Development (2005)	(i) Mr R S Sharma, Agriculture and Rural Development, Doordarshan, New Delhi
Dr Rajendra Prasad Puruskar for Technical Books in Hindi in Agricultural and Allied Sciences (2003–2004)	<p><i>Crop Science</i></p> <p>(i) Dr Masood Ali, Dr Sajeew Gupta, Dr Naimuddin, Dr Diwakar Upadhyaya, IIPR, Kanpur</p> <p><i>Soil and Agronomy</i></p> <p>(i) Dr Shambhou Dutta Dhiman, IARI, R-43, Pallavpuram-II, Modipuram (Meerut)</p> <p><i>Horticulture</i></p> <p>(i) Dr Ram Roshan Sharma, Kendriya Katai Uprant Abhiyantriki evm Prodhogiki Sansthan, CIPHET, Abohar (Punjab)</p> <p>(ii) Shri Anil Kumar Gupta, ATIC, IARI, New Delhi</p> <p><i>Engineering</i></p> <p>(i) Mr Kailash Chand Bhardwaj, CIAE, Bhopal</p> <p><i>Animal Health</i></p> <p>(i) Mr Krishna Murari Singh 'Kisan', Innovative Farmer Vill. Barma, PO Kaithma, Via Sirari, Distt Sheikhpura (Bihar)</p>
ICAR Awards for Outstanding Multi-Disciplinary Team Research in Agriculture and Allied Sciences for the Biennium (2003–2004)	<p><i>Crop Improvement</i></p> <p>(i) Dr Keshav Raj Kranthi, Team Leader, CICR, Nagpur Dr C D Mayee, Dr B M Kahdi, Dr A M Nirula, Dr Sheo Raj, Dr A Dhawan, Dr A Barik, Dr D Monga</p> <p>(ii) Dr Nallanthigal Shobha Rani, Team Leader, DOR, Hyderabad Dr S V Subbaiah, Dr K Muralidharan, Dr I C Pasalu, Dr S P Singh, Dr G S V Prasad, Dr A S Rama Prasad, Mr Kondal Rao</p> <p><i>Natural Resource Management</i></p> <p>(i) Dr Ravender Singh, Team Leader, WTC for Eastern Region, Bhubaneswar Dr D K Kundu, Dr A K Thakur, Dr Rajeeb K Mohanty, Dr Souvik Ghosh, Mr K Kannan</p> <p><i>Engineering and Technology</i></p> <p>(i) Dr Kadavakat Madhavan, Team Leader, CPCRI, Kasaragod Dr J D B Sowriappan, Dr Tapeswar Vidhan Singh, Dr A C Mathew</p> <p><i>Horticultural Science</i></p> <p>(i) Dr Mathura Rai, Team Leader, IIVR, Varanasi Dr B Singh, Dr M Singh, Dr K K Pandey, Dr S Satpathy, Dr Sanjeev Kumar, Dr Neeraj Singh, Dr Sudhakar Pandey</p> <p><i>Fisheries</i></p> <p>(i) Dr Satya Dev Gupta, Team Leader, CIFA, Bhubaneswar, Dr Padamanav Routray, Dr Priyabrat Swain, Dr Niranjana Sarangi, Mr Dhananjay Kumar Verma, Dr Kishore Chandra Pani</p> <p><i>Animal Production and Health</i></p> <p>(i) Dr V K Singh, Team Leader, CSWRI Avikanagar, Amrit Lal Arora, Anil Kumar Mishra, Syed Mohammed Khursheed Naqvi, Anil Joshi, Dharendra Singh, Chander Prakash Swarnker, Satish Kumar</p>

AWARD	AWARDEES
Fakhruddin Ali Ahmed Award for Outstanding Agricultural Research for Tribal Areas for the Biennium (2004–2005)	<p>(ii) Dr Ramashrya Prasad Sharma, Team Leader, Project Directorate on Poultry, Hyderabad Dr Ramesh Hazary, Dr Savaram Venkata Rama Rao, Dr Sita Ram Sharma</p> <p><i>Social Science</i></p> <p>(i) Dr A S Mishra, Team Leader, CS&WCR&TI, Dehradun Dr V N Sharda, Mr S C Mohan, Mr D S Tomar, Dr B L Dhyani, Dr S K Verma</p> <p><i>Agricultural Sciences</i></p> <p>(i) Dr B P Bhatt and Dr K M Bujarbaruah ICAR Research Complex for NEH Region, Umiam, Meghalaya</p>
Bharat Ratna Dr C Subramaniam Award for Outstanding Teachers for the Biennium (2004–2005)	<p><i>Animal Sciences</i></p> <p>(i) Dr K P Ramesha and Mihir Sarkar, NRC on Yak, Arunachal Pradesh</p> <p><i>Crop Sciences</i></p> <p>(i) Dr Ramesh Chandra Gautam, IARI, New Delhi (ii) Dr (Mrs) D Alice, TNAU, Coimbatore</p> <p><i>Natural Resource Management</i></p> <p>(i) Dr Balraj S Parmar, IARI, New Delhi</p> <p><i>Fisheries</i></p> <p>(i) Dr Asim Kumar Pal, CIFE, Mumbai</p> <p><i>Veterinary and Animal Sciences</i></p> <p>(i) Dr Mohammed Hafeez, Sri Venkateswara Veterinary University, Tirupati (ii) Dr Mapranath Raghavan Saseendranath College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala</p> <p><i>Social Sciences and Home Science</i></p> <p>(i) Dr (Mrs) Ritu Singhvi, MPUAT, Udaipur</p>
Jagjivan Ram Kisan Puraskar (2005)	<p><i>Crop Production</i></p> <p>(i) Shri Vishwasrao Dattatray Kachare "KASHTACHI BHAKAR", At Telangwadi, PO Shetphal, Taluka Mohal, District Solapur (Maharashtra) (ii) Mr Suresh Dattatray Waghdhare, At & PO Malinagar Taluka Malshiras, District Solapur (Maharashtra) (<i>Joint Award</i>)</p>
National KVK Award (2005)	<p><i>Livestock/Poultry/Fish Farming</i></p> <p>(i) Shri Sultan Singh, Vill. Butana, PO Nilokheri, District Karnal (Haryana)</p> <p>(i) K H Patil Krishi Vigyan Kendra, Halkoti, District Gadag (Karnataka) (ii) Krishi Vigyan Kendra, RAU, Abusar, Jhunjhun, Rajasthan (iii) Tulsi Krishi Vigyan Kendra, Ganivan, District Chitrakoot (Uttar Pradesh)</p>

APPENDIX 13

**MINISTRY OF AGRICULTURE
DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION**

Transaction Audit Observations

The Council has not received C&AG Report in the year 2006-07. Hence the information in this regard may be treated as nil.