1. Overview

Indian agriculture saw growth in all its dimensions during the year 2011-12 with a record production of foodgrains, fruits, vegetables, milk, meat, eggs and fish. The agriculture and allied sectors achieved a compound growth rate of 3.3% during the XI Five Year Plan which is higher than the 2.4 per cent registered in the X Five Year Plan. The year 2012 saw intense activity for the Indian National Agricultural Research and Education System (NARES), in terms of completion and consolidation of programmes of the XI Five Year Plan, introspection of the path we travelled and interactions for the way ahead. The year that went by posed challenges, with an erratic monsoon, drought-like situation in some parts of the country as also cyclones impacting agriculture. The technological backstopping by the ICAR institutes helped the farmers in their efforts to overcome the impact of these natural calamities. Some of the salient research achievements and new initiatives of DARE/ICAR during the year are as follows.

The ICAR has commenced establishment of Indian Institute of Agricultural Biotechnology, Ranchi and National Biotic Stress Management Institute, Raipur. The proposal for establishment of a Central Agricultural University for Bundelkhand Region was initiated. Five new Krishi Vigyan Kendras (KVKs), one each in the states of Andhra Pradesh, Odisha, Rajasthan, Karnataka and Maharashtra, were established.

Soil and water productivity

To account for and bring out the variability of land, soil and hydrology agro-ecological subunits in Kerala were delineated within an agro-ecological unit. The maps and reports highlight the potentials and problems of agro-eco unit of each district, that can be used as a base for planning agriculture and allied sectors in the state.

An innovative model of groundwater sharing aimed at enhancing water productivity in the Ranga Reddy district of Andhra Pradesh was evolved. This intervention not only avoided competitive digging of bore wells by the local farmers but also helped improving cropping intensity (150%) and water productivity (1.25-5.4 kg/ha-mm) besides ensuring judicious use of groundwater (achieving higher water productivity per unit groundwater by crop diversification). The NABARD and Department of Rural Development, Government of Andhra Pradesh are mainstreaming this application in the state.

Farming system

An integrated farming system (IFS) model for the resource poor farmers of western Uttar Pradesh was designed, which yielded a net return of ₹1 lakh from 0.70 ha of land (after fulfilling household food and nutritional security requirements). The system components included field crop, horticulture, apiary, dairying and vermicomposting units besides boundary planting of multipurpose trees. Recycling of crop residues and farm wastes accounted for a saving of 4,500 by offsetting the cost of chemical fertilizer application.

A new variety of rice, CSR 43, released for sodic soils of Uttar Pradesh, could withstand sodicity up to pH ~ 9.9 and showed yield potential of 3.5 to 4.0 tonnes/ha in sodic soils, and also saved irrigation water. The direct-seeded rice yielded at par with transplanted rice, saved 20-25% water, 40-50% diesel, 25-30% electricity and 25-30% labour. Rice transplanted with wheat-residue incorporation or transplanted after green-manuring was most remunerative, where irrigation water was not a constraint. An integration of fungal pathogens *Curvularia lunata* and *Alternaria alternata* with insect bioagent *Neochetina bruchi* effectively managed water hyacinth in and around Jabalpur, Madhya Pradesh.

Climate change

Under the National Initiative on Climate Resilient Agriculture (NICRA), technology demonstration was taken up in 100 vulnerable districts of the country. Increasing rainwater-harvesting capability along with crop production-supporting activities brought in new energy into NICRA villages. Land shaping and harvesting rainwater helped successfully reclaim lands affected by sea-water inundation due to Aila cyclone in South 24 Parganas, West Bengal.

Genetic resources

Forty explorations of crop plants were undertaken in 20 states and 2,676 accessions including 371 of wild species were collected. In the National Genebank, 6,550 germplasm accessions of orthodox seed species found place for long-term storage and 26 accessions of non-orthodox species were cryo-stored and 28 were added to *in vitro* culture.

In fruit crops, 55 mango accessions were morphologically characterized as per the International Descriptors. Grape germplasm was strengthened by adding seven new accessions, taking the total number

to 464. In pomegranate, 15 accessions were collected from Maharashtra and Odisha.

Black pepper accessions (236) were collected from Idukki, Sabari Hills and Goodrickal ranges in Kerala including two endangered species, *Piper barberi* and *P. hapnium*. Ninety-five core collections of cardamom germplasm were profiled using 25 ISSR and three microsatellite markers.

Complex genome of potato (*Solanum phureja*) was deciphered by a consortium of 26 international institutes including Central Potato Research Institute, Shimla.

Breed Registration Committee of the ICAR approved nine new populations, viz. Pulikulam cattle, Kosali cattle, Malnad Gidda, Kalahandi buffalo, Konkan Kanyal goat, Berari goat, Ghoongroo pig, Niang Megha pig, Spiti donkey, of indigenous farm animals as breeds. Presently, there are 144 registered indigenous livestock breeds, comprising 37 breeds of cattle, 13 of buffalo, 23 of goat, 39 of sheep, six of horses and ponies, and eight of camel, two of pig, one of donkey, and 15 of chicken.

Mahseer (*Tor tor*) inhabits mountaneous streams to fast-flowing rivers and was first time reported in the plains from Penganga river. A fish, *Pinniwallago bhagirathiensis* sp. nov. and a prawn *Macrobrachium hooghliense* sp. nov., were described and reported as new to science. *Hippocampus kuda*, an endangered fish species, was collected from Kakdwip area, being the first record of sea horse species from the riverine section of Hooghly estuary.

Crop improvement

Over 90 new varieties/hybrids of crops were released for different agro-climatic regions of the country. A six-row malt-barley variety DWRUB 64 was recommended for cultivation in the north-western plains zone (Punjab, Haryana, western Uttar Pradesh, Delhi and Rajasthan) in irrigated late-sown areas. Three new varieties of sugarcane, viz. Co 0403 for peninsular zone, and Co 0237 and Co 05011 for north-west zone of Punjab, Haryana, Rajasthan, Uttarakhand and Uttar Pradesh, were released.

Application of arbuscular mycorrhizal fungus, *Glomus mosseae* enhanced groundnut yield by 13%. Of the newly isolated groundnut rhizobia RH11, RH17 and RH20, inoculation with RH11 was found best in enhancing pod yield of TG 37A. Treatment of Him Alsi 2 linseed with *Bacillus subtilis* during retting resulted in fibre softness, fineness, higher yield and less retting time as compared to conventional retting process.

Multigene cassettes were developed for imparting tolerance against *Botrytis*, a major disease in castor. Soybean seed treatment with *Trichoderma viride* @ 6 g/kg seed was found most effective in increasing the seed germination (15.71%), reducing the seed rot causing pathogens (72.73%) and seedling blight (87.50%). Storage of wheat and paddy seeds in 40% CO_2 environment provided complete protection against *Rhizopertha dominica* up to nine months and against *Sitotroga cerealella* up to six months, respectively.

During the year, 9,838 tonnes of breeder seed, 13,228 tonnes of foundation seed, 20,541 tonnes of certified seed, 14,860 tonnes of truthfully labelled seed and 4,437 tonnes of planting materials were produced to meet the requirement of different States.

Two varieties of chilli, namely Kashi Sinduri for Karnataka, Tamil Nadu and Kerala and Kashi Gaurav for West Bengal and Asom, one hybrid of tomato Kashi Abhimaan for Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Uttar Pradesh and Bihar, were notified by the Central Varietal Release Committee. Three onion varieties, viz. Bhima Shubra for Maharashtra; Bhima Shweta for Delhi, Uttar Pradesh, Haryana, Bihar, Punjab, Madhya Pradesh, Chhattisgarh, Odisha, Maharashtra, Karnataka and Andhra Pradesh; and Bhima Shakti for Delhi, Uttar Pradesh, Haryana, Bihar, Punjab, Rajasthan, Gujarat,Madhya Pradesh, Chhattisgarh, Odisha, Maharashtra, Karnataka and Andhra Pradesh; one garlic variety Bhima Purple for Delhi, Uttar Pradesh, Haryana, Bihar, Punjab, Maharashtra, Karnataka and Andhra Pradesh were released. In pear, two high-yielding sweet and juicy Kashmiri Nakh selections, namely CITH-Nakh 1 and CITH-Nakh 2, were collected and maintained in field gene bank. In palms and nuts, three coconut varieties IND 045S, IND 048S and IND 058S, two arecanut varieties VTL 62-Shriwardhan selection and VTL7 Nalbari, and two selections of cocoa VTLC 1 and VTLC 57, were identified for commercial cultivation.

Livestock improvement

Ovum pick-up technique followed by *in-vitro* fertilization resulted in the birth of first cattle calf (named Holi) through this technique. This technology will be useful for harnessing valuable germplasm from infertile and aged dairy cattle. “Mohan” became the first mithun calf to be born through embryo transfer technology from a cryopreserved embryo. The technology of freezing goat semen for artificial insemination was standardized. Quality embryos were flushed from a superior Sirohi goat and transferred to non-descript goats, resulting in the birth of four kids. These findings demonstrated the potential of multiple ovulation embryo transfer technology (MOET) for fast multiplication of superior germplasm. A Barbari doe produced a record number of 13 kids in three kiddings (including two quintuplets) under field conditions. Introduction of superior genetic resources facilitated conservation of indigenous goats with considerable

enhancement in the income of goat keepers, ensuring better nutritional and livelihood security.

India joined the elite group of countries engaged in satellite tracking of yellow fin tuna (*Thunnusal bacares*), a migratory marine fish. These tags provide fisheries-independent measure of the straight-line distance traveled from the point of tagging. A new working module was developed to enhance the fish production in Dimbhe reservoir, Pune, Maharashtra through community co-management.

Crop management

In Odisha rice-potato-sesame cropping system showed the highest production efficiency and low-lying land utilization efficiency, while rice-maize-cowpea system was found the most economical one. Nitrogen applied just before irrigation resulted in higher wheat yield than its application after irrigation, and application of nitrogen in three splits was better than two splits. To maximize productivity in malt barley, row spacing of 18 cm with seed rate of 100 kg/ha was recommended in normal as well as late-sown conditions of the north-western plains zone.

In groundnut, irrigation at 6-day interval through drip and 15-day interval with check-basin method saved 15.4 and 26.0% water over 4-day interval through drip and 15-day interval under check-basin respectively. Maize-wheat-mungbean and pigeonpea-wheat systems showed a significant increase of 11 and 10% in organic carbon, respectively, and of 10 and 15% in soil microbial biomass carbon compared to maize-wheat system. Under moisture stress, *Mesorhizobium ciceri* strains, 13 and 30 enhanced yield of chickpea cultivar RSG 888 up to 27% and 20% respectively. A talc-based dry formulation of microbial consortium was developed for easy handling and use in farmers' fields and it could ret jute within 13-15 days with fibre strength of 27.8 to 29.9 g/tex.

Sugarcane bud-chip was developed and standardized for quick multiplication of quality seed-cane as well reducing quantity of seed-cane required per unit area. It ensures seed multiplication rate of 1:60 in comparison to 1:10 under the conventional method.

Nucleopolyhedrosis virus (NPV) was isolated for the first time from spotted pod-borer, *Maruca vitrata* in India under natural epizootic conditions in early pigeonpea. Eighteen chickpea lines screened against six races of *Fusarium oxysporum* f. sp. *ciceri* under artificially inoculated sick-tank conditions were found to possess multi-race resistance. Seven variants of *Fusarium udum* were identified and their distribution maps were prepared. The collections from Uttar Pradesh has all the seven variants, followed by Maharashtra, Karnataka (6 each), Madhya Pradesh, Bihar (5 each), Andhra Pradesh, Rajasthan (4 each), Haryana (3), Tamil Nadu, Jharkhand (2 each) and West Bengal (1). *Beauveria bassiana*, introduced as an endophyte in tossa jute (*Corchorus olitorius*), reduced the stem weevil infestation in white jute (*C. capsularis*).

An area-wise pest management in pigeonpea and chickpea was implemented through IPM awareness campaigns in conventional and electronic media and through the establishment of the National Pest Reporting and Alert System, covering more than 35,000 ha in five major pulse-growing states of Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh.

Intercropping of vegetables in eight year-old mango orchard proved beneficial, as it yielded 19.38 tonnes/ha brinjal and 2.88 tonnes/ha of mango; besides yields of bottle gourd (13.54 tonnes/ha), cauliflower (9.23 tonnes/ha) and cabbage (8.50 tonnes/ha), especially during pre-production phase and off-year in mango. This provided additional income to the mango farmers who were doing monocropping of mango previously.

Significantly higher yields of cowpea (11.45 tonnes/ha) and tomato (34.98 tonnes/ha) were achieved with zero tillage on permanent ridges and residue retention, compared to conventional tillage with flat planting and residue removal. Seed-pelleting techniques for onion, tomato and carrot were standardized. Pelleted onion, carrot and tomato seeds could be stored for three months under ambient conditions without reduction in seed germination and vigour. A dual purpose carrier-based microbial product, containing N-fixing, P- and Zn-solubilizing; and plant growth-promoting microbes, was developed and commercialized, where farmers need not apply two different products separately.

An organic farming package was developed for production of black pepper, ginger and turmeric by applying farmyard manure, vermicompost, ash, rockphosphate, *Azospirillum* sp. and phosphobacteria, and *Trichoderma* sp. and *Pseudomonas* sp. as biocontrol agents for disease control.

Decision support systems, namely Plausible Potato Growing Seasons Estimator (PPGSE) and Yield Estimator, developed for spatial and temporal diversification of potato cultivation, provide information on the growing seasons and their durations, climatic features of seasons and estimated yield potential for important locations in India.

Surveys on species composition of mites attacking Nagpur mandarin and bioagents revealed the presence of three species of phytophagous mites, namely *Eutetranychus orientalis, Brevalpus pheonicis* and *Polyphagotarsonemus latus*. The strains endo *Metarhizium anisopliae*-66 caused 76% banana stem weevil mortality and strain endo *Beauveria bassiana*-32 resulted in 54% corm weevil mortality. Two formulations of fungal pathogens, viz. *Metarrhizium*

anisopliae and *Beauveria bassiana*, showed efficacy at par with chemicals like Thiamethoxan and Acephate in effective management of grape thrips. PCR-based diagnosis was developed for quick detection and identification of phytoplasma infecting cucurbitaceous crops, viz. ash gourd, bitter gourd, bottle gourd and cucumber. Invasive mealy bug, *Phenacoccus solenopsis* is emerging as one of the major sucking pests in vegetable crops. The major biological control agents identified for this invasive pest were nymphal endoparasitoids *Aenasius bombawalei* and *Promuscidea unfasciati* and their cumulative parasitization was 22.35%.

Livestock management

The refined livestock feed resources database for cattle and buffaloes was launched. This provides information on large and small ruminant and poultry population and requirement vs availability of dry roughage balance, concentrates, dry roughages and greens in different states. A matrix of 712 feed resources, containing information on composition, mineral topography, rumen degradable and undegradable protein contents and amino acid profile, was developed.

The equation developed for estimating methane production, based on the nutrient composition of feed ingredients, revealed higher per cent methane of the fermented gas in concentrates than straw. Medicinal and aromatic plants such as *Clerodendrum inerme*, *Gymnema sylvestre* and *Sapindus laurifolia* showed the potential to suppress methanogenesis, which would help in development of new additives in ruminant feed formulations.

Artificial lighting in the poultry houses, using longer wavelength light (red spectrum-675 nm), improved the egg production in layers by about 8%. Naked neck broiler CARIBRO-Mritunjai showed better tolerance to heat stress.

India was declared rinderpest-free country. It is a major milestone towards ensuring enhanced livestock productivity, food security and livelihood of livestock owners. Diagnostics were developed for infectious bovine rhinotracheitis (IBR) virus, peste des petits ruminants (PPR) virus, bluetongue, coccidiosis etc.

Unique horn cancer-specific ligand sequences were identified for developing horn cancer-specific peptide nano-delivery vehicle. An analysis of cumulative disease data indicated — gradual decline in the occurrence of anthrax; 4.58% prevalence of PPRV antibody in cattle and buffaloes in different parts of Southern peninsular India; and highest mortality by trypanosomiasis. The complete genome of the Japanese encephalitis virus (JEV) strain JEV/eq/India/H225/2009(H225) was sequenced to decipher the genetic characteristics. The analysis indicated H225 to be a highly virulent strain and the study confirmed that it is associated with clinical cases in equines in India.

The m-KRISHI®-Fisheries mobile service was developed to disseminate potential fishing zone (PFZ) and wind advisories to fishers in local language. Satellite data on thermal and wind speed as well as algal movement were utilized to provide exact location of PFZ areas to reduce excessive fuel consumption in search of fish.

Mechanization and energy management

A two-row tractor-mounted inter-row site-specific herbicide applicator was developed in which laser sensor registers the presence of green weeds. This signal operates a solenoid actuated flow control valve which permits herbicide spray at the points where needed. A power weeder suited for cassava, developed by improvizing a commercial light weight mini roto-tiller, is light in weight (13 kg) and has a field capacity of 0.2 ha/day and weeding efficiency of about 90%.

A hydraulically operated three-wheel self-propelled platform system was developed for harvesting mango, oranges, oil palm, etc. capable of keeping the operator at various heights ranging from 1.8 to 6 m. A tractor-mounted pick positioner having a movable platform fitted on a tractor, with double acting hydraulic cylinder, was developed in which a person can be hoisted to a height of 9.6 m for harvesting fruits and pruning trees. One person could harvest about 120 kg aonla fruits/ hour.

Commercially available Chemperi model climber was modified to provide additional safety by locking the machine to the tree trunk. The attachment provides full safety to the climber during operation and also reduces the fear of height and risk of falling. Patent application has been filed for this device. A pilot scale non-electric pyrolysis unit of 2 kg capacity was developed for conversion of biomass into charcoal.

Post-harvest management and value-addition

A cost-effective and import substitute autoclavable system was evolved for microencapsulation of sensitive functional ingredients, i.e. bacteriocins, enzymes, nutraceuticals, probiotics and prebiotics, for food and feed applications. It can produce microcapsules of particle size of 100-1,000 µm.

Insulated and ventilated freight container suitable for transport of fruits and vegetables over long distance, was designed. The National Horticulture Board tested the design of container for transport of various fruits and vegetables through railways, and the train with these containers is named 'National Horticulture Train'. A fruit and vegetable grader of 2 tonnes/h capacity was developed for grading apple, guava, mango, sapota, citrus, tomato, onion, potato etc. with grading efficiency

of more than 92%. A coconut-fibre segregator was fabricated, with outturn of 50-60 kg/h, for grading coconut fibres into various grades. These graded fibres can be used selectively according to the product need or blended with other fibres for making value-added products. A polyhouse technique was developed for walnut, in which walnut plants were ready for transplanting in field after a year instead of four years.

A new eco-friendly hydrophobic finish for cotton fabrics was developed using zinc oxide nano particles, silicones and organic acid. The treatment was durable up to 20 hand washes with spray rating of 70, indicating good hydrophobic characteristic. The fabric also accorded protection from the harmful effects of ultra-violet rays (UPF rating 50) present in the light.

A sensitive test was developed for detection of detergents in milk, that can detect adulteration in less than five minutes. The low-calorie strawberry polyphenol fortified stirred dahi showed high antioxidant activity and total phenol content and was acceptable up to two weeks when stored at 7–8^{o}C. Dahi proved a good source of lactic acid bacteria in processing of fermented meat. Oat and milk based probiotic fermented product showed potential in rat trials to fight type-II diabetes. Super-chilling and vacuum packaging technology was developed for enhancing quality and shelf-life of buffalo meat steaks.

An edible oyster (*Crassostrea madrasensis*) peptide-based nutraceutical, OPex was developed that has potent antioxidant capabilities to protect cells from lipid peroxidation and deleterious membrane structure changes. Exploration of new sources of secondary metabolites from seaweeds led to the designing and development of green algal extract (GAe), a nutraceutical, to combat inflammatory diseases such as joint pain and arthritic conditions.

Agricultural Human Resource Development

The National Information System on Agricultural Education Network in India (NISAGENET) became operational which provides country/state/university/college level reporting on agricultural education in India (http://nisagenet.iasri.res.in). Under ICAR International Fellowships, which were started to develop competent human resource and showcasing the strengths of Indian ICAR-AUs system, 75 fellowships were given to the African nationals and 115 to students of Afghanistan for pursuing Masters' and Ph.D. programmes in Indian agricultural universities. ICAR International Fellowships were provided to seven Indian candidates for Ph.D. programmes in overseas universities.

Agricultural economics, marketing and statistics

Grain outlook model and oilseed model were developed for generating advance information on medium- and long-term projections on economic variables, viz. likely demand, production, trade and prices of important agricultural commodities. These models are capable of undertaking sensitivity analysis and simulations under alternative policy and technological scenarios. In future, it is targeted to integrate both grains and oilseeds models dynamically, so that each model takes inputs from the other model and gets converged simultaneously.

Pigeonpea microsatellite database (pipemicrodb) based on chromosome- as well as location-wise search of primers, is available at http://cabindb.iasri.res.in/pigeonpea/. This is the first database of pigeonpea marker in the world with 123387 STRs extracted in silico from pigeonpea genome. It will help in selection of desirable traits, such as high yield, resistance to a particular disease and other traits that will benefit the crop in a long run. These markers will be of immense use in marker assisted selection which would help to overcome approximately 50% loss in pigeonpea productivity due to biotic and abiotic stress in India as well as many parts of the world.

For precise comparison of treatment effects in presence of neighbour effects, neighbour balanced designs were developed. The efficiencies of these designs are quite high indicating that these are fairly robust against missing observations and ensure that no treatment is unduly disadvantaged by its neighbour(s).

Technology assessment, refinement and transfer

Five new Krishi Vigyan Kendras (KVKs), one each in Andhra Pradesh, Jammu and Kashmir, Odisha, Maharashtra and Karnataka, were established, raising the total to 631 KVKs across the country. In crops and livestock, 328 technological interventions were refined under different thematic areas in 395 locations. Besides, five women-specific income-generating technologies were also refined in eight locations. As many as 73,175 frontline demonstrations were undertaken on cereals, millets, oilseeds, pulses, and other important crops; 4,710 on improved tools and farm implements; 14,390 on livestock; and 5,991 on other enterprises including gender-specific technologies Under the National Initiative on Climate Resilient Agriculture (NICRA), 26,218 demonstrations were also carried out.

Over 65,000 training programmes were organized for capacity building in which nearly 18 lakh farmers, farm-women, rural youth and extension personnel participated. Over five lakh extension programmes/activities were organized to create awareness about improved technologies and to provide timely advisories to farmers. About 1.47 lakh short text messages were transmitted to 11.14 lakh farmers for timely actions through Kisan Mobile Advisory. Besides, Voice Mail Services to farmers was also attempted by a few KVKs.

Technological information was provided to 3.13 lakh farmers through print and electronic media and 2.60 lakh farmers were given technological products, viz. 88,077 q seed, 13.30 lakh seedlings/saplings, 3.41 lakh livestock, 3.79 lakh poultry birds and 1,172 q bio-products through the Agricultural Technology Information Centres.

Research for tribal and hill regions

New varieties, viz.Vivek Maize Hybrid 39, VL Lahsun 2, VL Mandua 347, VL Tamatar Hybrid 1, VL Shimla Mirch Hybrid 1, VL Cherry Tamatar 1, VL Shimla Mirch 3 and VL Tamatar 5, were notified/ released for various agro-climatic regions of the country. In place of traditional plough, VL Syahi Hal was developed for hilly areas, which is light in weight (<14 kg) and can be used for ploughing as well as leveling the fields. Colocasia-coriander-tomato and colocasia-onion-frenchbean cropping systems were found suitable in the North-Western Himalayas for higher energy-use efficiency and per unit energy productivity respectively.

Geo-referenced soil fertility mapping of macro- and micro-nutrients undertaken in 13 priority districts of Asom can be utilized for optimization of nutrient supply for better crop production and for regularizing supply of nutrients during crop season. A short-duration RCM 13 rice line, having low amylose content (11.70%), was found suitable as contingent variety for pre-*kharif* /early *kharif*/main *kharif* condition and different cropping systems in the Manipur region. Akhanphou, a popular local rice cultivar of Manipur, possessing high resistance to leaf blast under uniform blast nursery, was found to possess four major blast-resistant genes (Pita/Pita2, Pi40, Pi54 and Pi2). It also showed tolerance to low phosphorus conditions. Two candidate genes IPS1 and CAX2 were identified for improving aluminium toxicity tolerance in rice.

Indigenous leafy vegetables, *Mukia maderaspatana* and *Limnophila chinensis*, were identified and 64 species of medicinal and 19 of specialty flowers were collected from Island system and maintained in the gene garden at CARI, Port Blair. Deepika, an improved dual-purpose Nicobari fowl showed higher adult body weight and annual egg production with better survivability. Herbal products, namely Gromune (Tonic) and Morical feed supplement, were prepared from the fruits of *Morinda citrifolia*. Feeding of Gromune @ 15 ml/bird improved immunity and Morical @ 4% in feed supplement enhanced 24% egg production in Japanese quail.

The coral reefs in Andaman were monitored to study the coral recovery and reef fish diversity after the 2010 mass bleaching phenomena. All the sites showed significant increase (11%) in live coral cover. Abundance of *Chaetodontids* and *Pomacentrids* decreased with decrease in coral cover while that of *Acanthurids* and *Scarids* (predominantly algal grazers) increased.

IP portfolio management

Over 200 partnerships were developed by 39 research institutes with 120 public and private organizations, resulting in an earning of over Rs 640 lakh. Concerted efforts made by 30 research institutes led to filing of 96 patent applications during the year, raising the cumulative number to 716. Eight national patent applications were granted, besides two international applications — An Artificially Synthesized Peptide (in collaboration with DBT) and A Process for the Production of Organic Formulation of Bio-Pesticides *Pseudomonas florescens* — granted by United States Patent and Trademark Office (USPTO). Three copyrights were obtained for Monograph Hadamard Matrices, Monograph Q-designs and Expert System for Maize Crop (Maize AGRIdaksh).The cumulative total of varieties granted registration rose to 326. The technologies generated at the ICAR institutes are being transferred/commercialized through Memoranda of Understanding (MoU), licensing agreements, and consultancies/contract research/contract service to various stakeholders, and thus, about 165 such partnerships were developed by 20 research institutes with around 118 public and private organizations.

Awards and incentives

Under 16 different categories, awards were conferred to three Institutions, one All India Coordinated Research Project, nine Krishi Vigyan Kendras, nine farmers, one journalist, four teachers and 56 scientists including 5 women scientists.

Partnership and linkages

The Work Plans between ICAR and International Water Management Institute and International Rice Research Institute were signed during the year. Collaborative projects, viz. Global yield gap and water productivity between Independent Science and Partnership Council of the CGIAR, University of Nebraska, Lincoln and ICAR; New knowledge and innovation food design leading to sustainable development of the Agro-food sector and decreased poverty between Anand Agricultural University, Anand and SASNET Fermented Foods and Hildur Functional Foods Pvt. Ltd., to be funded by Swedish International Development Cooperation Agency, Lund, Sweden; Genetic analyses of Asia seabass populations in Indian peninsular waters using polymorphic DNA markers' between National Bureau of Fish Genetic Resources, Lucknow and Temasek Life Sciences Laboratory, Singapore; Precision farming for enhancing the

livelihood security of farmers between Tamil Nadu Agricultural University, Coimbatore and Nova Scotia Agricultural College, Canada; A global census of rumen microbial diversity between AgResearch, New Zealand and National Dairy Research Institute, Karnal; 'Genetic Engineering of stay green trait for development of drought tolerant wheat' between Indian Agricultural Research Institute, New Delhi and Institute of Experimental Botany, Academy of Science of the Czech Republic, Laboratory of Stress Physiology, Czech Republic were initiated.

Several major international events were organized during the year, Workshop on 'Climate Change, Adaptation and Mitigation in Agriculture in the ASEAN Region and India' at New Delhi during 23-24 August 2012; Meeting of Experts on Agro Products & Food Security of BRICS Countries (Brazil, Russia, India, China and South Africa)/2nd Meeting of Agriculture Experts Working Group at New Delhi during 27-28 August 2012; ICAR-APAARI expert Consultation on Trans-boundary Diseases 10-12 October 2012, and the 2nd ASEAN-India Ministerial Meeting on Agriculture and Forestry, ASEAN - India Agriculture Expo at New Delhi during 17–19 October 2012, and the ASEAN-India Farmers Exchange Programme (19-30 December 2012).

National Fund for Basic, Strategic and Frontier Application Research in Agriculture

Based on experience gained and learning from the execution of the Fund during the XI Plan, the Council has planned to enlarge the NFBSFARA substantially during the XII Plan. In the identified thrust areas for the XII Plan, a total of 29 projects were approved with a budget of Rs 71.69 crore. Some of the salient achievements include: optimized transformation protocol for pigeonpea using *Agrobacterium* strain EHA105 harbouring binary vector pBI121; stem cell culture using pig bone marrow mesenchymal stem cell lines; and design and fabricating indigenous lab-scale atmospheric pressure cold-plasma reactor with and without cooling system for environment friendly treatment of cotton-fabrics for effective dyeing and other qualities.

National Agricultural Innovation Project

The NAIP is supporting 185 sub-projects under four components, viz. ICAR as the Catalyzing Agent for Management of Change in the Indian NARS; Research on Production to Consumption Systems (PCS); Research on Sustainable Rural Livelihood Security (SRLS) and Basic and Strategic Research in the Frontier Areas of Agricultural Sciences (BSR) and has promoted inter institutional and inter organization collaboration. The main achievements were: development of Central Data Centre (CDC) and National Agricultural Bioinformatics Grid (NABG) for hosting different types of ICT applications; 24×7 Rice Knowledge Management Portal; Gender Work Participation Disparity Index (GWPDI); and Decision Support System for Agricultural Commodity Market Outlook based on online database repository called Commodity Market Outlook Statistics (CMOS).

A fuel-efficient propeller, capable of saving 19% fuel was developed. Its intervention in the sector having 1,100 vessels saved diesel worth around Rs 63-78 crore per annum. Foxtail-millet based food was found beneficial to diabetic, obese and heart patients. Under GEF-funded sub-projects, community gene banks were created for distribution of seed of local landraces to farmers that would help in conservation as well as enhancement of income to the beneficiary farmers. An innovative service 'm-Krishi-Fisheries', helped a village having 32 fishing boats to save 70,000 litres diesel/ month and avoided generation of 150,000 kg of CO_2. Allele mining for blast resistance genes *Piz (t), Pita* and *Pi54* was concluded in 268 heterogenous Indian rice landraces. A triple gene fusion construct was developed to build-up broad spectrum diagnostic tools for papaya ring spot virus (PRSV), cucumber mosaic virus (CMV) and groundnut bud necrosis virus (GBNV). Antimicrobial extracts/ fractions/pure molecules were identified from selected weeds against micro-organisms causing septic arthritis and urinary tract infection. Fungal isolates capable of synthesizing the ZnO nanoparticles and extracellular synthesis of Fe nanoparticles, were found. Starch nano-composite film was validated for good sealing-ability of pouches, a major criterion in food packaging.

Finance

The plan and non-plan allocations (RE) to DARE/ ICAR for 2011-12 were Rs 2,850 crore and Rs 2,157 crore respectively. An internal resource of Rs 137.89 crore (including interest and advances, income from revolving fund schemes, recovery of loans and advances and interest on short term deposits) was generated. The plan and non-plan allocations (BE) for 2012-13 are Rs 3,220 crore and Rs 2,172 crore respectively.

The 84th Foundation Day of ICAR Society was organized on 16th July 2012. The chief guest, Bharat Ratna Dr A.P.J. Abdul Kalam, former President of India, while addressing the august gathering suggested research missions for ICAR on efficient farm practices for small and marginal farmers, reviving waste lands and rejuvenating water bodies. He also highlighted the need for capacity building of small and marginal farmers through the intervention of KVKs and promotion of agro-processing through rural cooperatives. These valuable suggestions would guide us in formulation of

research programmes for the XII Plan.

The ICAR continually surged ahead in developing farmer-friendly technologies and assuring quality higher education. The Council, in consultation with all stakeholders, prepared the first ever Policy Framework for Research and Development in Agriculture and Allied Areas. It spells out the key role of the public sector in governance, funding, and execution of agricultural research and education. Human resource development, partnership within and outside the NARS, including private sector and farmers, and commercialization of technology are important dimensions of the R&D policy. This policy has also been recognized in the Science, Technology and Innovation Policy, 2013 unveiled during the 100th session of the Indian Science Congress at Kolkata, by the Hon'ble Prime Minister of India. The R&D policy articulated by the ICAR would be appropriately integrated with the national R&D system and S&T policy. Further, the Knowledge Meet of Directors, Vice Chancellors of State Agricultural Universities and other stakeholders initiated the formulation of Vision 2050 by all institutions.

I wish to place on record our gratitude to the Hon'ble Union Minister of Agriculture and Food Processing Industries and President of the ICAR Society and Hon'ble Union Ministers of State for Agriculture and Food Processing Industries, for their valuable guidance, support and encouragement in all endeavours of the DARE/ICAR. I wish to convey our thanks to various Ministries and Departments of the Government of India, State Agricultural Universities, National and International Organizations and other stakeholders, for their association in formulation and implementation of different programmes of the ICAR. I am confident that the efforts of the Council would enable technological empowerment of farmers to achieve higher levels of input efficiency and productivity to ensure sustainable agricultural growth.

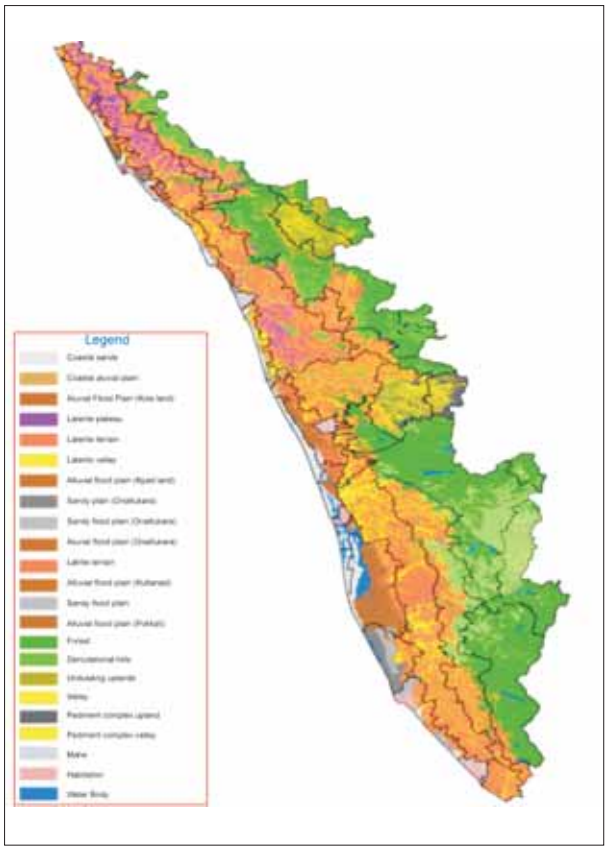
(S Ayyappan)
Secretary
Department of Agricultural Research and Education
and
Director General
Indian Council of Agricultural Research,
New Delhi

2. Soil and Water Productivity

Land degradation, groundwater imbalances, impaired soil health and contamination of food chain and environmental pollution are major problems today. Recent climate change impacts on agriculture further compounded the situation. Characterization, conservation and efficient utilization/management of the natural resources are essential to ensure food, nutritional and environmental security in the emerging context and work is progressing in that direction.

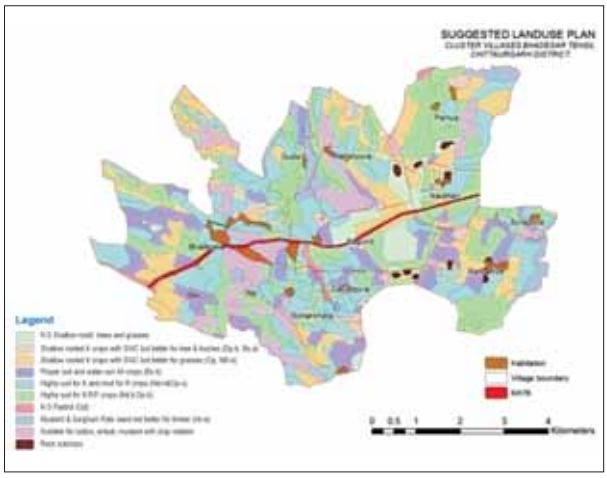
Soil resource inventory and management

Agro-ecological sub-units of Kerala mapped: To bring out the variability of land, soil and hydrology, agro-ecological subunits of Kerala were delineated. The maps highlight the potentials and problems of agro-eco units of each district, so that the same can be used as a base for planning agriculture and allied sectors.



Agro-ecological subunits of Kerala

Farm-level land use planning: A cadastral level (1:4000 scale) survey of 10 villages in Bhadesar tehsil of Chittaurgarh district of Rajasthan was undertaken along with remote sensing data (IRS-LISSS IU/P6) to suggest suitable crops in the region. Thematic maps for soil site characteristics, fertility and crop suitability maps

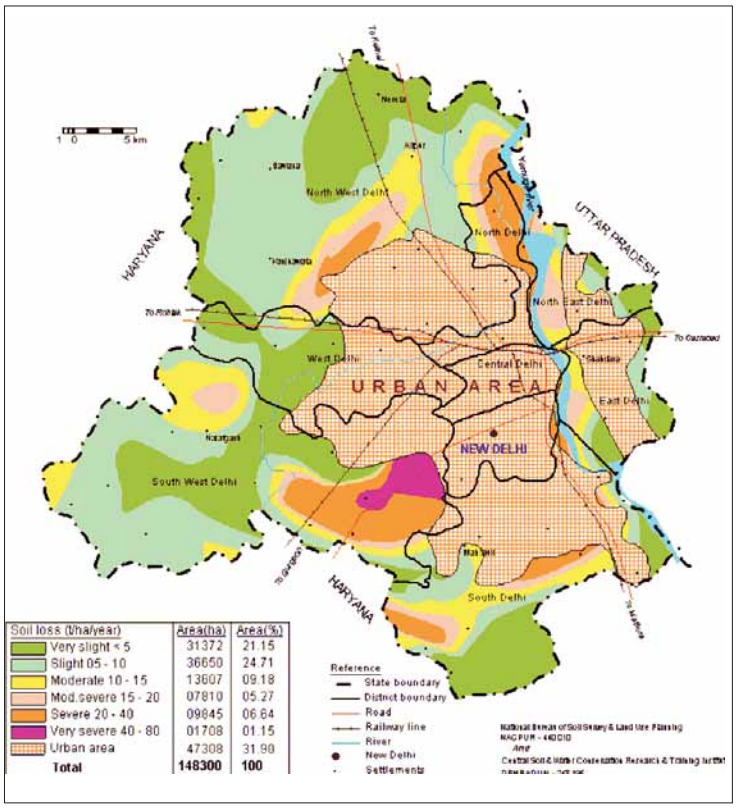


Suggested land use plan for cluster villages of Bhadesar tehsil

of the area were prepared to suggest alternative land use options.

Assessment of soil erosion in Delhi

GIS-based soil-erosion map of Delhi was generated using annual soil loss data. In Delhi, about 32% of the geographical area is within the limit of the New Delhi Municipal Committee (urban area), which was not assessed. Of the remaining non-urban area, 31% has very



Soil erosion map of Delhi

slight soil loss of < 5 tonnes/ha/year, and 36% area suffers from slight erosion in the range of 5–10 tonnes/ha/year. Only 19% of non-urban area has annual soil loss in the range of 15–45 tonnes/ha/year; these areas are concentrated in the pockets around Yamuna, Aravalli ridge-line in Tughlakabad, Mahipalpur and Mehrauli area, and contribute to more than one-half of total soil loss in Delhi state.

Integrated water management

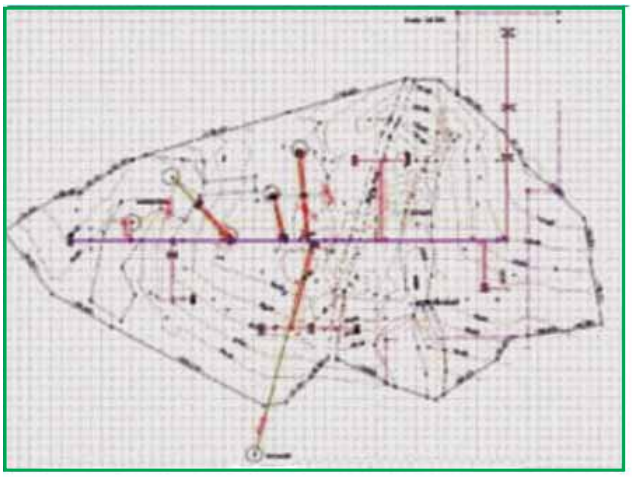
Enhancing water productivity through groundwater sharing: An innovative model of groundwater sharing was evolved in the Ranga Reddy district of Andhra Pradesh. An attempt was made for designing a pipeline network by pooling all bore wells in village Malkai Pet Thanda. This resulted in avoiding competitive digging by farmers, who do not own bore wells. Farmers were also encouraged to shift to irrigated dry crops in the village during *kharif* and *rabi*. About 18.21 ha under irrigated dry crops during *kharif* and 10.12 ha in *rabi* were brought under cultivation for the first time. The intervention helped in improving cropping intensity, water productivity and judicious use of groundwater. This successful model has attracted the attention of the NABARD and State Department of Rural Development, Andhra Pradesh are mainstreaming this practice.

Economic analysis of farm ponds for water harvesting: The extent and determinants of viability were examined using data from 100 ponds in Anantapur district (Andhra Pradesh). Based on the changes in cropping pattern and yield gains attributed to introduction of ponds, additional returns generated in the plots where ponds were located were computed. The results showed that 14 out of 100 ponds generated additional returns of about ₹3,000 and 10 ponds more than ₹15,000. Majority of the ponds generated returns varying between ₹3,000 and ₹6,000. Assuming these returns would occur every year for a period of 15 years, the economic viability in terms of Net Present Value and benefit : cost ratio was calculated. The benefit:cost ratio varied between 2 and 4 in majority of the ponds.

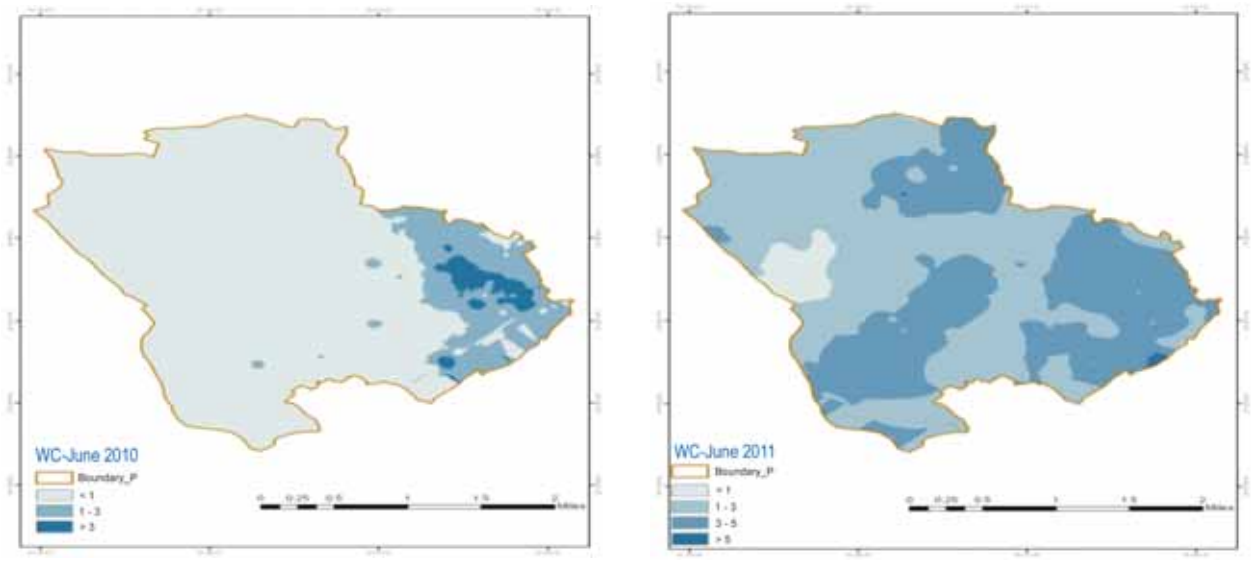
In order to examine the determinants of profitability, additional returns generated were regressed on independent variables, viz. size of the plot where the pond is located, size of the pond, change in cropping intensity (%), whether water is lifted to irrigate the crop, whether there is a bore well in the plot and number of fillings in the season. Four variables, size of plot, size of pond, change in cropping pattern and use of water for irrigation, showed significant positive effects on the profitability. Overall, it was found that larger plot size was more profitable.

Watershed management in drought-prone Bundelkhand region

Garhkundar-Dabar: Garhkundar-Dabar Watershed (Teekamgarh district) development project was initiated in October 2005 in a participatory mode. Soil- and water-conservation activities, crop diversification, agroforestry development and socioeconomic upliftment activities



Lay out of pipeline network (*top left*); pipeline network being laid (*left*) and *rabi* groundnut with sprinkler irrigation (*right*)



Depth of water column in open wells during June 2010 and June-2011

resulted in reduction of runoff and soil loss by 46% and 43%, respectively, compared to untreated (control) watershed. Peak discharge from treated watershed was delayed by 51 minutes, indicating more time for infiltration of rainfall. Cropping intensity increased to 161% and productivity of major crops increased from 20 to 60%. Increase in fodder availability, milk production and increase in buffalo population indicate overall watershed development. Flow of income increased by 250% and availability of fuel and fodder reduced drudgery of women and children.

Domagor-Pahuj: This watershed (1,373 ha) project was initiated in a participatory mode in Jhansi district in 2009. Soil- and water-conservation activities, agroforestry (plantation of 15,000 seedlings of multipurpose tree species) and other activities resulted in alround development. Using geographical information system, it

Watershed management in Domagor- Pahuj

Rainwater harvesting in Domagor –Pahuj watershed

was estimated that following the implementation of the project, depth of water column during June was in the range of 1–3 m in 55% area against 13% before implementation.

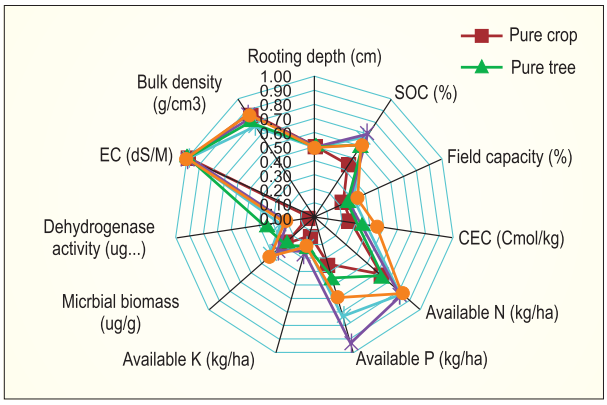
The results from the two experimental watersheds indicate that agroforestry with conservation measures provide drought-proofing with enhanced and sustained productivity and rural livelihoods.

Microbial bioremediation of wastewater with heavy metals: Wastewaters from industries contain high concentrations of heavy metals like Pb, Cd, Cr and Ni, which are toxic to living organisms even at low concentrations. To study the growth of efficient microbes on agro-waste materials for removal of heavy metals from aqueous solution, five fungi (*Trichoderma fasciculatum, Aspergillus niger, Aspergillus terreus, Trichoderma longibrachiatum, Aspergillus awamori*) and two bacteria (*Bacillus cereus* and *Bacillus* sp.) were grown on agro-waste materials. Fungal and bacterial growth was maximum on rice straw. The dead fungal biomass of *Aspergillus flavus* and *Aspergillus nidulans* packed in columns was able to remove substantial amounts of heavy metals such as Pb, Cd, Ni and Cr from aqueous solution. Six efficient fungal cultures, *Trichoderma fasciculatum, Aspergillus niger* var. *columnaris*, *Aspergillus niger*, *Aspergillus terreus* (MTCC9613), *Trichoderma longibrachiatum* and *Aspergillus flavus* developed for bioremediation have been deposited in the National Bureau of Agriculturally Important Microorganisms (NBAIM), Mau.

Integrated nutrient management

Maintaining soil organic carbon: Soil organic carbon (SOC) is a strong determinant of soil quality and agronomic productivity, especially in arid and semiarid tropics. The critical carbon (C) input required for maintaining SOC at the existing level was worked out for two agroecological settings using data from long-term experiments with chemical, organic and combined input use. The critical organic C input for maintaining SOC was 2.47 Mg/ha/year for Inceptisols under rice–lentil cropping system at Varanasi in the northern plain hot semi-arid ecosystem, and 1.12 Mg/ha/year for Alfisols under groundnut monocropping at Anantapur in the Deccan plateau hot arid ecosystem.

Soil-quality index for assessing soil health of agroforestry systems: To assess contribution of agroforestry in soil conservation, a soil-quality index (SQI) for assessing soil health of different agroforestry systems has been developed. For assessing soil quality, minimum data set of indicators comprising soil physical, chemical and biological properties was selected from



Radar plot of soil quality index and functional scores of soil health indicator for *Albizia procera* based agroforestry system

three agroforestry systems with *Albizia procera, Emblica officinalis* and *Hardwickia binata.*

Results from *A. procera*-based agroforestry system revealed that after 8 years of planting, maximum SQI was for the practice of zero pruning (0.566), closely followed by 50% pruning (0.552) and 70% pruning (0.548). Pure crop had minimum SQI (0.430). Radar diagram of functional scores indicated that soil biological activity was the most limiting indicator for all pruning treatments. Hence, canopy management through judicious pruning helps improving soil health.

Zinc delivery to plants through nano ZnO particles: A protocol was developed to coat seeds of maize, soybean, pigeonpea and okra with micron scale (<30 µm) and nano scale (<100 nm) ZnO powder @ 25 mg Zn/g of seed and @50 mg Zn/g of seed to supply the requisite Zn to plants. The germination test carried out with coated and uncoated seeds indicated better germination (93 to 100%) owing to ZnO coating compared to uncoated seeds (80%). Pot culture experiment conducted with coated seeds also revealed that the crop growth with ZnO coated seeds was similar to that observed with soluble Zn treatment applied as $ZnSO_4.7H_2O$ (2.5 ppm Zn). The advantage of seed coating with ZnO (both micron/nano scale) is that it does not exert any osmotic potential at the time of seed germination, thus, the total Zn requirement of the crop can be loaded on seeds.

Crop response to mixed biofertilizer formulations: In Vertisols of Maharashtra, chemical fertilizers to sweet sorghum up to 100% recommended dose of fertilizer (80:60:40 kg N, P_2O_5, K_2O/ha) along with dual inoculation of *Azospirillum* + *Gluconacetobacter* significantly increased green stalk (15.1%), millable cane (13.1%), grain (30.2%) and juice (30.2%) yields over the control. There was also significant improvement in juice quality (TSS, fermentable sugars) and nutrient uptake by crop.

Rhizobial (R33, R35) inoculation of soybean grown in Vertisols of Madhya Pradesh showed 17% increase in seed yield; PGPR strains (P3, P10, P25) increased it by 23%, and the combination of both by 28%. In chickpea, rhizobial strains (R40, R56, R58) revealed an average increase of 7.6% seed yield; PGPR strains (P3, P10, P25) by 9.7% and the combinations of both by 14.5%. In wheat, inoculation with three PGPR strains resulted in 26% higher seed yield.

Diversification of biofertilizers: The Plant Growth Promoting Rhizobacteria (PGPR) from cauliflower was identified by 16SrDNA analysis as *Bacillus pumilus.* Ten bacterial isolates associated with *Capsicum* in Himachal Pradesh were selected for PGP traits and antagonism against major fungal diseases—damping off (*Pythium* spp.), blight (*Phytophthora* spp.) and anthracnose fruit rot (*Colletotrichum* spp.). Field demonstrations involving application of *Bacillus pumilus* and 75% recommended doses of chemical fertilizer resulted in 30% increase in curd yield in cauliflower, besides saving 30 kg N and 20 kg P/ha.

Rose–A potential plant species for phytostabilization of chromium: A study was undertaken to examine response of rose to different levels (0, 25, 50, 100 and 200 mg/kg soil) of chromium and its possible use for remediation of soils contaminated with chromium. Rose grew well and tolerated up to 50 ppm. However, there was a reduction in the dry weight of roots and shoots. Cr decreased dry weight of roots by 18% at 25 ppm and 43% at 50 ppm. Partitioning of Cr revealed a higher concentration of Cr in roots (1985 µg/g on dry weight basis), followed by shoots (760 µg/g dry weight). Thus rose has a great potential to be used for phytostabilization of soils contaminated with moderate levels of Cr.

Rose, a potential plant species for phytostabilization of chromium

Utilization of inland saline waters: Shrimp farming technology developed for utilization of saline and sodic soil by Rohtak Centre of CIFE was validated. A production 1,280 kg/ha of *Penaeus monodon* with a net survival of 70% was obtained in 110 days culture duration at a stocking density of 10/m^2. In *Fenneropenaeus indicus,* cultured for the first time in such environment, an increase to an average size of 5 g/individual in two months was achieved. The technology can be easily applied for developing saline and sodic soils, thereby providing alternative means of livelihood and resource generation to affected farmers.

Water productivity enhancement through fish seed stocking: The water productivity of Mallaghatta reservoir in Karnataka was to 56 kg/ha/year with the stocking rate of 425 number of IMC/ha/year of catla : rohu : mrigal in the ratio of 4 : 3 : 3. During the reporting period the production of reservoir was 21.2 tonnes and the contribution of stocked species was 44.6% to the total catch. The average CPUE was 17.1 kg. ❑

3. Farming System

Integrated Farming System (IFS) approach considered to be the most appropriate in meeting the challenges of small-farm-agriculture and to fulfil the requirements of healthy and nutritious food, feed, fodder and other value-added commodities has been adopted. Location-specific IFS modules that not only increase system productivity, profitability and livelihood security of the farming community but also help in resource conservation and mitigating risk in agriculture and allied sectors to a large extent have been evolved.

Integrated farming systems (IFS) model for marginal farmers: An integrated farming system (IFS) model was started for marginal farmers of western Uttar Pradesh in *kharif* 2010. Of the 0.70 ha, 0.4 ha was allocated for production of cereals, pulses, oilseeds, green fodders to meet the demand of a farm family. Rest was allocated for providing nutritional security and livelihood improvement through supplementary/complementary enterprizes like horticulture (fruits/vegetables), apiary, mushroom cultivation, vermicomposting, boundary plantation along with provision for three milch animals. A net return of ₹ 100,000 was realized from 0.7 ha from the model. Recycling crop residues and farm wastes provided about 133 kg/year in terms of NPK and saved up to ₹ 4,500 on fertilizer application.

Ensuring livelihood food security and water productivity through farmers' participatory farming system approach: Promotion of kitchen gardening during monsoon in East Ganga Canal (EGC) and Agra Canal Command (ACC) resulted in vegetable production to the tune of 513 to 652 kg and 527 to 650 kg per family respectively saving up to ₹ 7,755 to 9,683 per family. Use of mineral mixture along with existing animal feed had a pronounced impact on milch animal health and enhanced milk production by 10 to 22% in Agra Canal Command and by 13 to 16% in East Ganga Canal Command area. The net annual gain due to such intervention was ₹ 9,720 to 20,088 and ₹ 5,832 to 18,144 per family per year, respectively. In a 0.2 ha fish sewage pond of Shahpur village (EGC), quality fish seedlings, mineral mixture, oilcake, rice bran and liming gave a total fish production of 2,538 kg worth ₹ 109,258.

Promotion of kitchen gardening in Ganga Canal Command

IFS model integrating fish and *singhara* with *makhana*: Integration of fish and *singhara* (*Trapa bispinosa*) with *makhana* (*Euryale ferox*) exhibited fish yield of 0.18 to 0.4 tonne/ha and *makhana* seed yield of 1.06 to 2.06 tonnes/ha and water chestnut yield of 3.08 to 8.8 tonnes/ha respectively. This resulted in net profit of ₹20,015/ha with an employment generation of 240 man-days/ha/year.

Integration of fish and *singhara* with *makhana*

Improved pointed gourd: Pointed gourd variety Swarna Suruchi, with the following characteristics, was released for commercial cultivation in Bihar and Jharkhand – Vine length 2.5 to 3 m; 70 to 80 nodes; smooth fruits, light green in colour with fruit length ranging from 8.5 to 9.0 cm with blunt ends on both sides; fruit weight 35 to 40 g; fruit breadth 3 to 3.5 cm; pulp : seed ratio 4 : 1; and yield/plant 4 to 4.5 kg.

Improved variety of pointed gourd

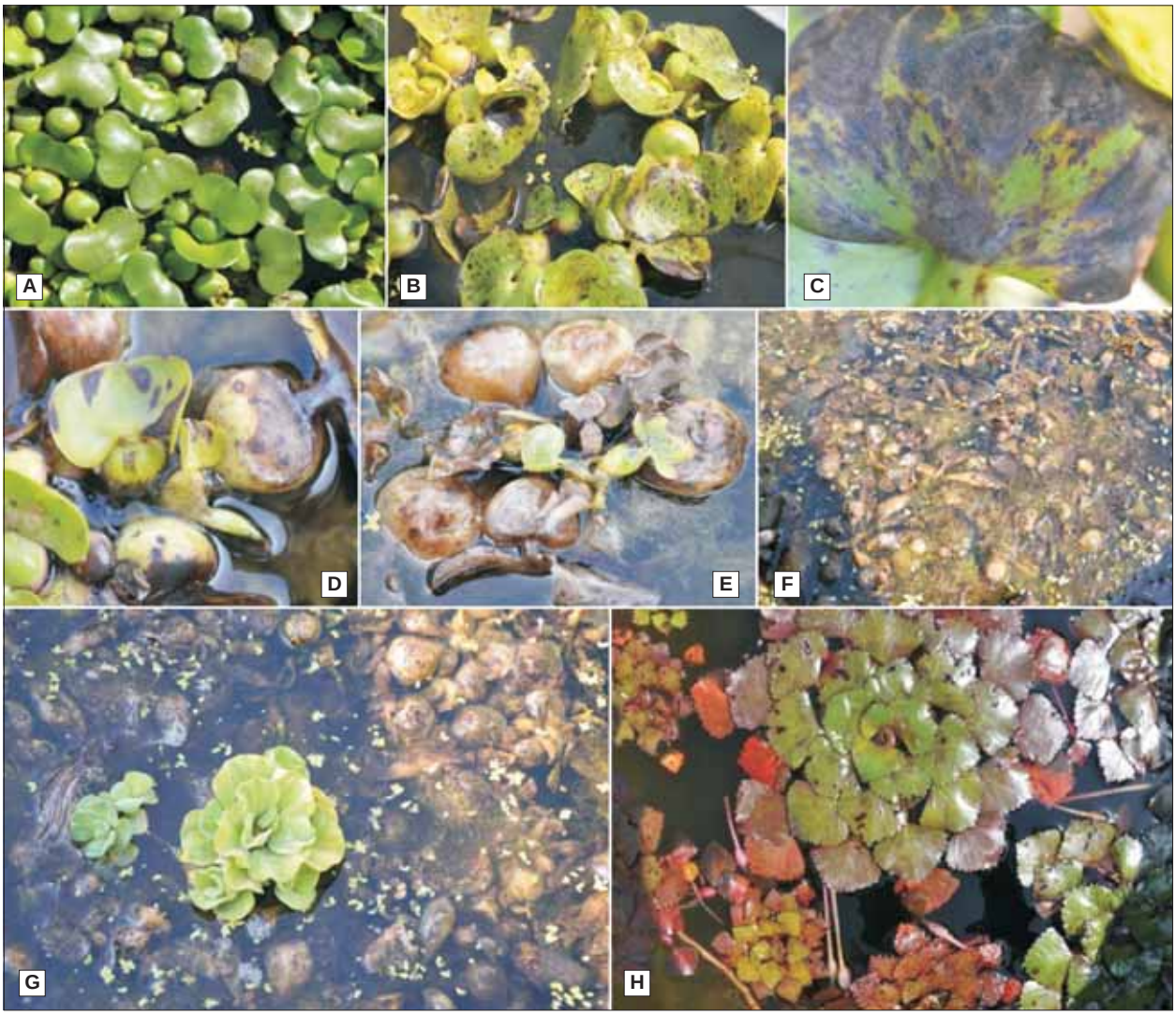
Improved *lasora* genotypes: Two elite genotypes, CAZRI-G 2021 and CAZRI-G 2025 of *lasora* or *gunda* (*Cordia dichotoma*), were selected from seedling

(A) CAZRI-G 2021; and (B) CAZRI-G 2025 are two elite genotypes of *Iasora* (*Cordia dichotoma)* and perform well in respect of fruit yield and pulp content

populations and further multiplied by budding, which performed consistently well in respect of fruit yield and pulp content. Yield potentials of 59.5 kg and 98.2 kg were recorded in CAZRI-G 2021 and CAZRI-G 2025 respectively.

Biological management of water hyacinth using antagonistic fungi and insect bioagent, *Neochetina bruchi*: Potential native antagonistic fungi, viz. *Fusarium* sp., *Curvularia lunata* and *Alternaria alternata,* were isolated from the naturally infested water hyacinth in and around Jabalpur and their pathogenicity confirmed by Koch's postulates. The fungi were applied 20 days after the inoculation of *Neochetina bruchi* weevils, a host-specific bioagent, responsible for creating injuries in the process of their feeding on the leaves of water hyacinth. The insect bioagent, facilitated and hastened the entry of the pathogen, compared to the weevil or fungi alone, causing severe disease in the second and third week after inoculation. This led to loss of floating ability and resulted in the submergence of water hyacinth. Host specificity test indicated that *A. alternata* and *A. eichhornia* did not infect other aquatic plants like *Pistia stratiotes* and *Eleocharis dulcis* (water chestnut) showing host specificity of the pathogen.

CSR 43: A new short-duration, salt-tolerant rice variety: A new variety of rice, CSR 43, was released for the sodic soils of Uttar Pradesh which can withstand sodicity up to pH ~ 9.9. This cultivar matures in 115 to 120 days, about 15 to 25 days earlier than the prevailing cultivars – Indrasan, Narendra 359 and Sambha Mahsoori – enabling to fit into the rice–wheat crop rotation with



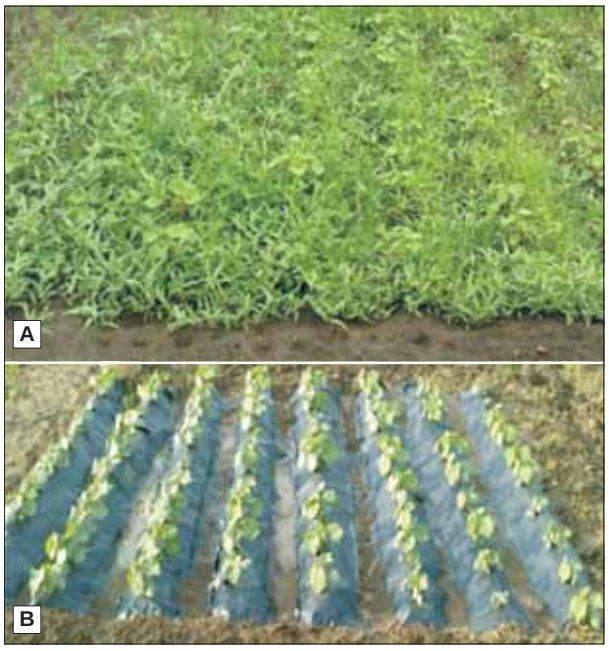
(A) Healthy water hyacinth; (B) Symptoms of *Neochetina bruchii* on water hyacinth; (C) Close-up of infection caused by weevil and fungal consortium; (D &E) Initial and advanced stages of symptoms of infection caused by the consortium of fungi and *N. bruchii*; (F) Complete submergence of diseased water hyacinth; (G & H) Both *A. alternata* and *A. eichhornia* were not pathogenic to other aquatic plants like *Pistia stratiotes* and *Eleocharis dulcis*

an yield potential of 3.5 to 4 tonnes/ha in sodic soils and saves two irrigations.

Resource-conservation technologies for rice-wheat cropping system: Experimentation for the past five years indicated that direct-seeded rice yielded at par with transplanted rice, but saved 20–25% water, 40–50% diesel, 25–30% electricity and 25–30% labour. Rice transplanted with wheat-residue incorporation and rice transplanted after green-manuring was most remunerative where irrigation water was not a constraint.

Weed management

***Kharif* okra-tomato cropping system:** In okra, major weed flora observed were: *Phyllanthus niruri, Echinochloa colona, Cyperus iria, Dinebra* sp., *Commelina benghalensis,* and *Physalis minima,* which caused yield losses of 15 to 55%. Use of black polythene mulch in okra recorded no weeds up to 60 days after sowing when integrated with farmyard manure (FYM 10 tonnes/ha) compared to control (145 no./m^2). This treatment recorded the highest pod yield of okra (15.07 tonnes/ha) compared to control (5.59 tonnes/ha). In case of tomato, major weeds consisting of *Medicago denticulata, Cichorium intybus, Physalis minima, Chenopodium album, Paspaladium* sp. and *Vicia sativa* caused 42 to 70% loss in fruit yield. Use of black polythene mulch along with FYM (10 tonnes/ha) resulted in lowest weed density at 60 days after sowing and highest tomato yield of 23.87 tonnes/ha, which was at a par with the treatment receiving 50% FYM + 50% NPK+ herbicide followed by one manual weeding 45 days after sowing (22.7 tonnes/ha) compared with the control (2.6 tonnes/ha).



(A) Unweeded okra; (B) crop using black polythene mulch + 10 tonnes/ha FYM

Fish

Farming of pompano—A marine fish in coastal ponds: The CMFRI successfully conducted maiden harvest of newly bred fish, silver pompano, *Trachinotus blochii* (American pomfret) at Antervedi Fish Farm, East Godavari, Andhra Pradesh. About 3,600 seed were stocked in one acre pond of a farmer, fed with indigenously formulated pellet feed costing about ₹125/kg. After 8 months of rearing with a survival of more than 95% and an FCR of 1 : 1.8, crop reached a size range of 450–550 g weight, an excellent table size for marketing. The fish tolerated wide salinity range from 5 to 35 ppt and can feed at all angles, which makes it a versatile and most aquaculture friendly species. By separating the nursery phase it is possible to have two harvests in one year. About 12,000 seeds can be stocked in 1 ha and about 5 tonnes of fish can be harvested for each crop. Silver pompano fetches a farm gate price of about ₹ 200/kg. In the domestic market, silver pompano has demand starting from 250 g size onwards. Hence, it is felt that pompano aquaculture can emerge as a major aquaculture enterprise in the coming years.

❑

4. Climate Change

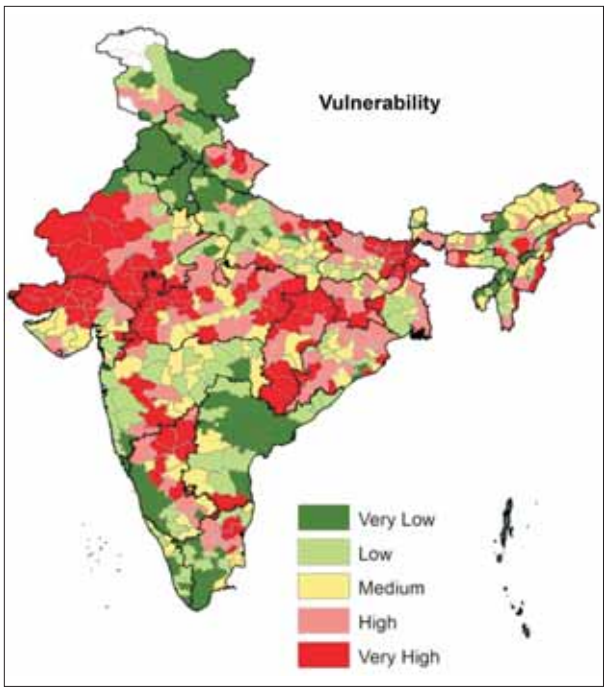
Climate change and variability pose serious challenges. There are evidences of negative impacts on yield of wheat, rice and other crops in certain parts of India due to increased temperature, water stress and reduction in number of rainy days. Research aimed at enhancing resilience of Indian agriculture to climate change and climate variability has been a major mandate of the ICAR.

Mapping vulnerability of agriculture

Vulnerability is a function of the character, magnitude, and the rate of climate variations to which a system is exposed, its sensitiveness and adaptive capacity. A database for 572 districts in India was developed with this perspective. To assess the degree of change in climate in the district in terms of change in drought occurrence, incidence of dry spells, change in annual rainfall, heat wave, cold wave, climate projections of the PRECIS model for A1B scenario for 2021-2050 were employed. The changes in different climatic parameters were computed relative to the baseline 1961-90 of the same model. Finally, the vulnerability index (VI) was computed :

VI = Sensitivity + Exposure – Adaptive Capacity

Based on the index, the districts were divided into five sensitivity categories. The districts with higher levels of vulnerability are located in the western and eastern regions and some parts in lower Indo-Gangetic Plain and Karnataka.



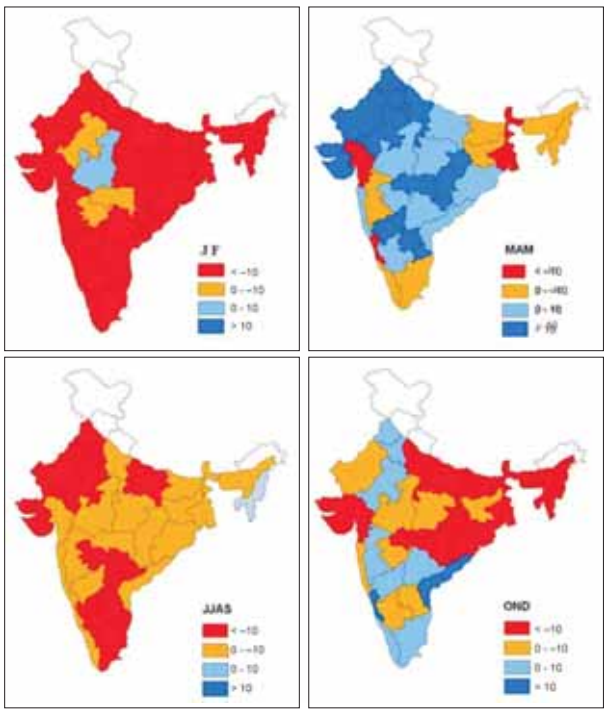
Districts mapped based on vulnerability to climate change and variability

El Nino and seasonal rainfall shifts over India

To study the changes in seasonal rainfall amounts over the country during El Nino, sub-divisional rainfall data collected from the Indian Institute of Tropical Meteorology, Pune (1901–2009), El Nino data from the National Oceanic Atmospheric Administration (NOAA), US website, and rainfall for summer (March to May), monsoon (June to September), post monsoon (October to December) and winter (January to February) during El Nino years were analyzed.

Results indicate that summer (except in coastal Karnataka, West Bengal and Gujarat, where less than 10% deviation was observed) and post-monsoon rainfall (except in Saurashtra and Kutchh, Gujarat region, entire Uttar Pradesh, Bihar, West Bengal, Odisha, Chhattisgarh and Vidharba where < 10% is observed) increased during El Nino events. Except western Madhya Pradesh, winter rainfall showed negative deviation (<10%).

Increased post-monsoon season rainfall was observed over Punjab, Haryana, eastern Rajasthan, North Coastal Karnataka, Madhya Maharashtra, coastal Andhra Pradesh, northern Telangana, Tamil Nadu and Kerala. This clearly indicates the seasonal rainfall shift during El Nino events.



Seasonal rainfall (% deviation) in different meteorological Sub-divisions during El Nino years

It calls for appropriate planning to implement suitable crop and natural resources management strategies to stabilize *kharif* and *rabi* crops.

Technology demonstration to help farmers cope with climate variability

Under the National Initiative on Climate Resilient Agriculture, technology demonstration was taken up in 100 vulnerable districts of the country. In each of the village clusters, a Village Climate Risk Management Committee (VCRMC) was formed, and also village-level weather station and custom-hiring centres were established to promote weather literacy and enable farmers in timely completion of farm operations during delayed monsoon.

Increasing rainwater harvesting capability along with crop production supporting activities such as introduction of improved cultivars, addressing micronutrient deficiency through site-specific nutrient management, supplemental irrigation, mulching, use of zero-till drill have brought in new energy into the NICRA villages. Mobilization of people to build a sand bag check-dam across a rivulet in Gumla, Jharkhand, has improved water-table in open wells and enabled farmers to secure the *rabi* crop. Land shaping and harvesting rainwater helped reclaim lands affected by sea water inundation due to *Aila* cyclone in South 24 Parganas, West Bengal. Custom hiring centres make available farm implements and equipment at normal hiring charges to the farmers and total amounts ranging from ₹ 10,000 to ₹ 100,000 have been collected as hire charges during a single season.

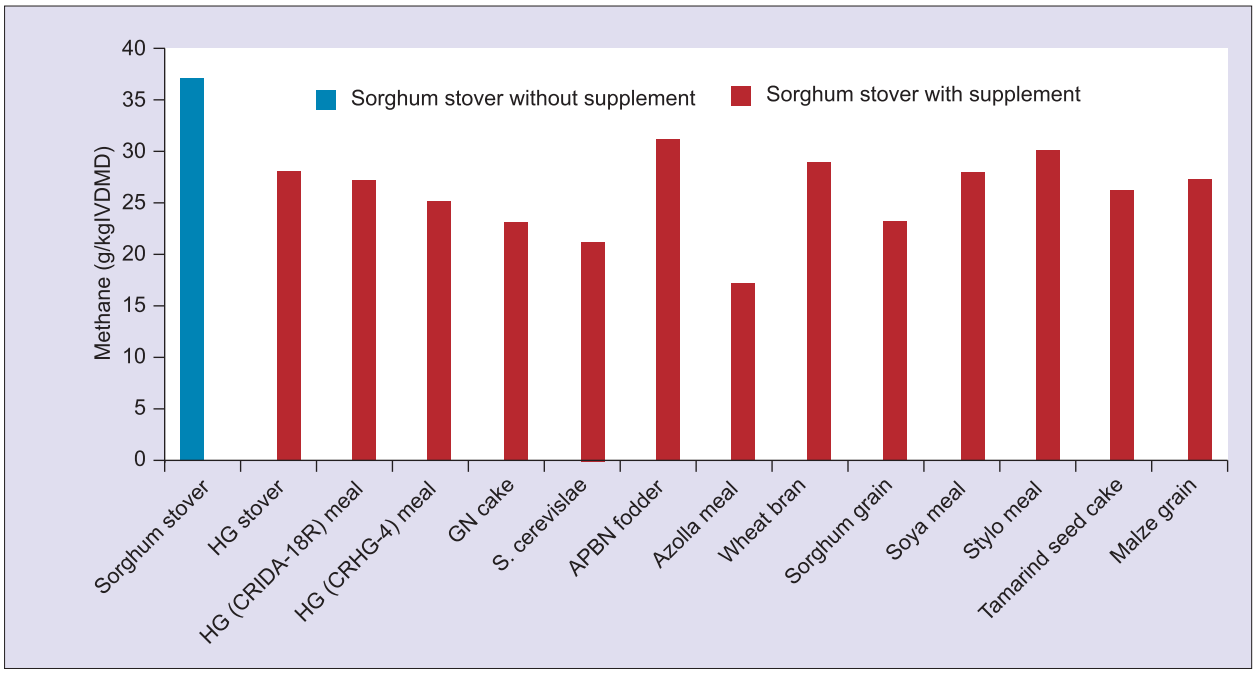
Reducing methane emission in livestock through feed manipulation

Microbial digestion in the rumen of cattle results in production of waste products such as carbon dioxide (CO_2) and methane (CH_4), and approximately 7% of dietary gross intake energy is lost to atmosphere as CH_4. *In vitro* gas production was employed to assess cumulative gas pool and the concentration of methane in cumulative gas from fermentation of coarse crop feed (sorghum stover) with different supplements. Gas volume was reduced significantly with supplementation and maximum reduction was observed with *Saccharomyces cerevisiae*, followed by groundnut cake. Tanniferous feed ingredients like stylo meal, sorghum grain, horsegram meal and tamarind seed cake also substantially reduced *in vitro* gas production. Similarly, methane concentration in the *in vitro* gas was less with supplementation compared to sole sorghum stover fermentation; 17 to 37 g/kg *in vitro* dry matter digestibility with maximum from sole sorghum stover and minimum with azolla supplementation. Further, *in vitro* degradability of dry matter and organic matter also enhanced with supplementation. These results indicate the significance of supplementation while feeding coarse crop residues in enhancing productivity and reducing GHG emissions.

Water resources development and management to adapt to climate change

To adapt to the climatic variability under irrigated command area, site-specific surface water harvesting and groundwater recharge structures were designed and evaluated in Odisha (Puri, Dhenkanal, Balasore, Nayagarh, Cuttack, Kendrapara), Tamil Nadu (Coimbatore), Rajasthan (Udaipur) and Gujarat (Junagarh).

A total volume of 12,842 m^3 (three ponds), 50,323 m^3 (nine ponds), 28,652 m^3 (six ponds), and 4,640 m^3 (one pond) was created at Nayagarh, Puri, Kendarpara and Cuttack, respectively, based on the available runoff at 67% probability, benefiting 155 farmers. Pond-based farming systems (crops, on-dyke horticulture, fisheries) were developed in the created water resources in three canal commands and one coastal area of Odisha to enhance water productivity and to overcome dry spells. Groundwater resources were created through 17 dug-wells in Dhenkanal and Cuttack districts of Odisha for



Methane production profiles from the fermentation of sorghum stover with or without supplementation

Creation of groundwater resource for irrigation during dry spell at Dhenkanal, Odisha

growing vegetable crops. Basic soil–water–plant relationships were assessed for different land ecologies.

Groundwater recharge structures were evaluated in Coimbatore (Tamil Nadu), Udaipur (Rajasthan) and Junagadh (Gujarat). The average groundwater recharge in Parambikulam–Aliyar Project basin at Coimbatore under hard rock condition varied from 2.29 to 11.06% rainfall with an average recharge of 5.22% during South West monsoon period. Average groundwater recharge varied from 4.34 to 28.62% with an average recharge of 12.5% due to North-east monsoon season.

Three types of recharge structures, viz. dry stone masonry pond, single wall cement masonry pond, single wall cement masonry pond, were designed and constructed in Girwa and Jhadol block of Udaipur district. The average recharge rate was found to be 7.63 cm/day. The additional quantity of water available in the well due to recharging was utilized for irrigating wheat in 1.2 ha.

Influence of climate on biochemical profile of host trees of lac insect

Key biochemical indicators of stress of host trees lac insect were studied at different periods at two locations to understand the impact of climate vis-à-vis lac insect survival. Proline content has shown significant reduction due to inoculation during active feeding stage of lac insect (February–March) in case of *ber* (*Ziziphus* sp.). Malone dialdehyde (MD) content, an indicator of oxidative stress, behaved differently with respect to host trees tested as well as locations. In case of *ber*, more oxidative stress was observed during the winter period. In case of *palas* (*Butea monosperma*), same pattern of increase/decrease in MD content was observed. Moreover, the inoculated *ber* showed significant difference with respect to locations (i.e. West Bengal showed maximum MD while Jharkhand showed the minimum). Proline content was significantly higher in lac-inoculated plants both in case of *ber* and *palas*.

Predictions on future temperature

Temperature predictions for 2020 and 2050 were computed and compared with the present levels to meet the likely impact of climate change on shrimp farming. As per the projections, the lowest minimum temperature is expected to be warmer by more than 2°C in 2020 and 2050 compared to the present and the average monthly maximum temperatures will increase by 0.65°C by 2020 and 1.84°C by 2050. The increase in temperatures will have an adverse effect on the water availability and water quality parameters thereby affecting shrimp growth. However the increase in temperature during winter would have a beneficial effect on pond productivity and shrimp growth with better food conversion rate and reduced white spot disease outbreaks.

❑

5. Genetic Resources

Crops

Plant genetic resources of cultivated, naturalized and wild crop species and genera are collected from the domestic locations as well as from the international sources. Their cataloguing, characterization and conservation are undertaken for crop improvement activities. Similar approach is taken up for agriculturally important microbial and insect species also.

Germplasm augmentation, conservation and use: In 20 states, 40 explorations were undertaken and 2,676 accessions were collected; of which 371 accessions were of wild species. In the National Herbarium of Cultivated Plants, 350 herbarium specimens were added. In the National Genebank, 6,550 germplasm accessions of the orthodox seed species were added for the long-term storage; 26 of non-orthodox species were cryo-stored and 28 were added in *in-vitro* culture. A total of 48,422 accessions were characterized and evaluated, and 6,271 accessions were supplied for research and crop improvement within the country.

Germplasm exchange comprised 41,210 accessions imported from 50 countries, including international trial material (35,150). Promising introductions were of rice: for thermogenic male sterility(EC 720903-4), tolerance to drought(EC 725224-5), tolerance to salinity and low-input lines (EC 733948-54), tolerance to heat (EC 733828-46), tolerance to salinity and resistance to brown planthopper and bacterial blight (EC 750230-57) from the IRRI, Philippines; high- yielding hybrid (EC 720905) from Indonesia; and drought- tolerant lines(EC 726475-54) from the USA; of wheat: nullisomic/tetrasomic/monosomic Chinese spring lines(EC 731579-636); cultivar Anton with low level of polyphenol oxidase (PPO) (EC 732856) and substitution/deletion/aneupoid lines(EC 736143-62) from the USA; and Vijay (BL 3063) (EC 721736) resistant to Ug 99 and terminal heat tolerant for normal/late sown conditions from Nepal; of mungbean: resistant to Mungbean Yellow Mosaic Virus(EC 718740-5) from the AVRDC, Taiwan; of tomato: high beta-carotene content lines (EC 721238-41) from Taiwan; of cucumber: recombinant lines (EC 738814-9038) from the Netherlands; of colocasia: leaf-blight tolerant lines (EC 719534-48) from Fiji; and of castor: low ricin-content line (EC 736481) from the USA.

One-hundred wild *Arachis* accessions belonging to six different sections—*Arachis* (54), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (7), *Procumbentes* (6) and *Rhizomatosae* (40) were maintained in the field gene bank, and 9,024 accessions were conserved in the medium-term cold storage module.

Germplasm registration: Seventy-one novel germplasm of cereals (11), grain-legumes (7), oilseeds (10), fibres and forages (7), vegetables (3), tubers (2), beverages (26), commercial crops (3) and agroforestry (2) were registered.

Rice germplasm accessions (124) collected from different districts of Odisha and West Bengal included 59 from drought-prone areas, 62 from saline areas, and three of *Oryza coarctata* Tateoka.

Eleven wheat genetic stocks, including one of durum (DDW 12) with novel traits, were registered with the NBPGR, New Delhi. These potential donor lines are included in the National Genetic Stock Nursery (NGSN) from time-to-time for use in wheat improvement and/or for genetic studies at the research centres.

Two maize hybrids registered are DMH1 (Matungha) and NAH 2049, and five composites are Aravali Makka 1, JM 8, Jawahar Makka 216, Jawahar Composite Makka 12 and Pratap Makka 5. Three hybrids and two varieties of pearl millet were registered in the PPV&FRA.

Wheat genetic stocks registered during 2011–12

Name	Developed by	Traits
DDW 12 (durum)	DWR, Karnal	High iron, zinc and manganese content; resistance to rusts and Karnal bunt
DBW 46	DWR, Karnal	Resistance to yellow and brown rusts and leaf blight
DBW 51	DWR, Karnal	High iron content, protein content; good *chapati*-making and with good biscuit spread factor; resistance to rusts and leaf blight
HTW 6, HTW 11	DWR, Karnal	Terminal heat tolerance
DWRL1	DWR, Karnal	Triple dwarf, resistance to rust (*Lr19*), high protein content
KBRL 76-3	PAU, Ludhiana	Karnal bunt resistance
WCF 12-7, WCF 12-19, WCF 12-61, WCF 12-208	IARI, New Delhi	Drought tolerance

A total of 300 accessions of six fodder species (cultivated/rangeland) were procured from the international agencies, USDA, ICARDA, ICRISAT, ILRI and national agencies, NBPGR and IIVR.Germplasm catalogue on 367 accessions (219 landraces and 148 exotic accessions) of fodder sorghum was published following DUS guidelines. A rare sexual obligate plant of *Cenchrus ciliaris* (IGFRI-CcSx-08/1) has been

registered as a novel genetic stock (INGR 11062) with the NBPGR.

Four novel genetic stocks of rapeseed-mustard, *moricandia*-based CMS line of *karan rai* (*Brassica carinata*) and MCA 1 (IC 0589777, IC 059009D3, INGR 11049), and three of Indian mustard (*Brassica juncea*) germplsam, BPR-349-9 for thermo-tolerance at the juvenile stage (IC 0589778; Regd. No. INGR 11048), DRMR WFM 1 (IC 059926; INGR12007) for white petals and RH 0116 (IC 0584669; INGR 11033) for tolerance to salinity (10ds/m) at juvenile stage were registered with the NBPGR, New Delhi. A yellow stem mutant of castor (INGR 11059) and a breeding line 96-508-2-90 (INGR 11060) with resistance to wilt, tolerance to aphid and moisture stress were also registered.

MCA 1–Flower with rudimentary anthers

White- flowered mustard

Four unique germplasm of urdbean, a mutant with protruded stigma IPU 99-167m (IC 0594172; INGR 12005), with sympodial bearing SPS 5 (IC 0594173 Regd. No.; INGR 12006) and two MYMV resistant, VBG09-012 and VBG04-008, and two of mungbean, extra early germplasm IPM 409-4 (IC0589310) and IPM 205-7 are registered at the NBPGR.

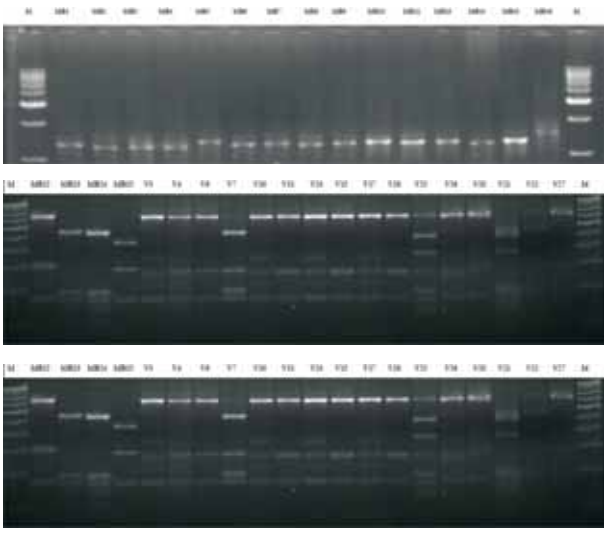
(A) Sympodial bearing urdbean; (B) Urdbean mutant with protruded stigma; (C) Extra early genotype of mungbean

Drought-tolerant culture of cotton CNH 30I (Regd No. INGR 11061; IC 0587405) is registered at the NBPGR. Two of the canes, suitable as feed stock in cogeneration and alcohol distillation industries, were identified and are registered with the NBPGR.

Agriculturally important micro-organisms

From salt-affected areas of eastern Uttar Pradesh, 55 isolates of *Bacillus* and 72 of predominant genera, which grew on more than 4 % NaCl concentration, were selected for diversity analysis. The molecular characterization on the basis of 16S and 16-23S rDNA PCR-RFLP analysis with three restriction endonucleases *Alu I, Hae III* and *Taq I* revealed greater diversity among the isolates.

Based on the 16S rDNA sequencing, *Bacillus* isolates identified were: *B. megaterium, B. subtilis, B. licheniformis, B. horikoshi, B. pumilus, Bacillus* sp., *B. cereus, B. simplex, B. flexus, B. arsenicus, B. thuriengiensis, Bacillus firmus, Lysinibacillus, B. marrisflavi* and of predominant genera were: *B. licheniformis, B. niabensis, b. aryabhattai, B. subtilis, B. thioparans, B. flexusm, B. marisflavi, B. endophyticus,*



Amplified 16-23S rDNA restriction analysis of 55 *Bacillus* isolates of eastern Uttar Pradesh with *AluI*, *Hae III*, *Taq I*

New sugarcane germplasm from north-east India

An exploration was conducted in Nagaland and in Manipur for sugarcane germplasm. Tall, medium-tall, short- and medium-short forms of *Saccharum spontaneum*, *Erianthus bengalensis, E. longisetosus, E. procerus, Sclerostachya* and *Phragmites* were found in Nagaland.

From Manipur, 67 germplasm were collected, including different forms of *S. spontaneum*, *S. officinarum* and *E. rufipilus*.

Saccharum spontaneum on a river bank in Nagaland

B, cereus, B. pumilus, Lycinibacillus xylanilyticus, Pseudomonas stutzeri, Staphylococcus, Enterobacter cloacae, Micrococcus sp., *Cellulosimicrobium funki, Ochrobacterium* sp., *Acinetobacter* sp. etc; 16S rRNA gene sequences of *Bacillus* were submitted to the NCBI and accession numbers assigned to them were from JN215486 to JN215522.

In Nimar region of Madhya Pradesh, occurrence of zinc-solubilizing *Bacillus cereus* isolates in soybean rhizosphere is a first report; four isolates solubilized three zinc compounds.

Agriculturally important insects and mites

New accessions: *Sticholotis magnostriata* Poorani (Coccinellidae) from Asom and *Microterys chaetococci* Hayat & Poorani (Encyrtidae) from Karnataka have been described. A distinctive species, akin to the Palaearctic region of the world, *Trichogramma bistrae*, was found to occur in Odisha.

Two new species of Platygastridae, *Odontacolus markadicus* Veenakumari and *Odontoscelio vikata* Veenakumari and Rajmohana, have been described from southern India. A checklist of Indian Microgastrinae was prepared with 21 genera and 231 species with information on distribution and biology. A total of 42 species of pseudococcids were identified, of which *Phenacoccus* Cockerell was predominant. Ten anthocorids including a new species of *Xylocoris* (*Proxylocoris*) sp. from maize and a new species of *Orius* sp. have been recorded. *Physopleurella armata* collected from coconut is a new record from India.Twenty-nine species of phytophagous mites and 19 species of predatory mites were collected from vegetable, fruit, cereal and ornamental crops from different locations in Punjab. Twenty new mites were recorded from fruit and vegetable crops of Himachal Pradesh. The new phytophagous mites are being studied for their possibility of becoming pests. The predatory mite fauna are characterized for their utility in biological control.

Horticulture

Fruit crops: Of the total 538 mango accessions, 55 were morphologically characterized as per the International Descriptors. Evaluation of these accessions indicated that mango variety, Safed Mulgoa, had maximum fruit weight (1,813 g), while Ramphalya and Ruswani recorded maximum TSS of 24.40° and 24.38° Brix respectively. Maximum pulp content of 88.95% was observed in Nymath. The chloroplast DNA (cpDNA) isolation protocol was standardized (100-150 ng/ml from 100 g of leaf). Eight cultivars were characterized for *trn*L and *trn*F genes (transfer RNA) and variations were ascribed to indels and SNPs. Sequence of mango hybrid, Arunika, revealed maximum similarity with the pollen parent, Vanraj, for *trn*F gene. Further, phylogenetic analysis of five chloroplast gene sequences revealed evolutionary pattern and varietal divergence.

Attempts were made to map the physical positions of certain chloroplast genes, viz. *trn*L, *trn*F, *pet*B-*pet*D and *atp-rbc*L, using partial chloroplast genome in mango for sequence alignment and then positioning of genes. The partial chloroplast genome consisted of a partial Large Single Copy (LSC) region, complete Invered Repeats (IR) regions and Small Single Copy (SSC) regions. This mapping study is an effort towards understanding the molecular phylogeny using cpDNA markers and would be a valuable tool for developing sequence-based markers for cultivar identification.

New species of natural enemies (*Left to right*: *top left - Sticholotis magnostriata*, *middle - Microterys chaetococci*, *right – Xylocoris* (*Proxylocoris*) sp.; *bottom left - Odontacolus markadicus*, *middle - Odontoscelio vikata*, *right – Orius* sp.)

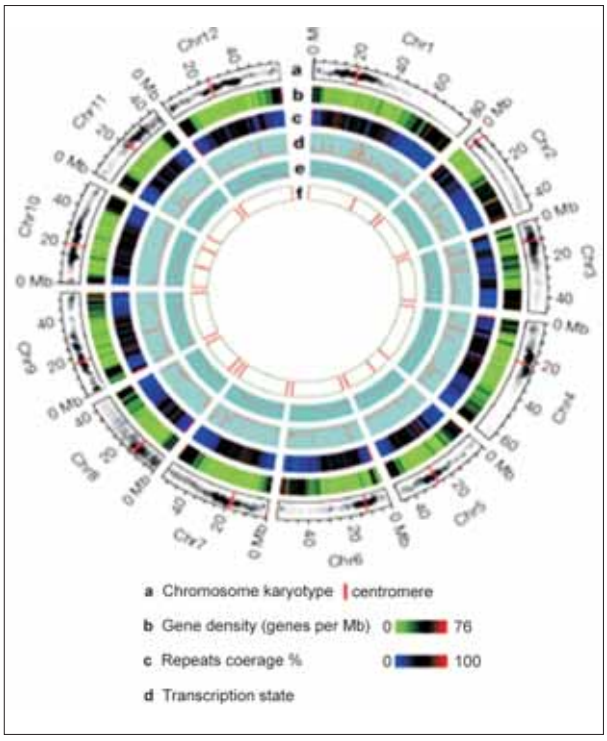
Citrus germplasm consisting of 614 accessions, including 23 rootstocks from exotic sources, 552 from indigenous sources and 39 scion cultivars was maintained. Twenty exotic accessions received from Brazil are being screened/tested for presence of pathogen. Banana accessions, Aittakola, Mizo Cavendish, Sabri, Behula (cooking type) and *M. acuminata* collected from Tripura, promising Cavendish clone with short duration from the secondary source in Odisha and *M.acuminata* ssp. *burmannica* from Anamalai Hills, Tamil Nadu and 88 exotic accessions from ITC, Belgium, were added to the field genebank. DNA fingerprinting profile was developed for 14 major commercial varieties. Further, expression profiling of Resistant Gene Analogus (RGAs) in nematode (*Pratylenchus coffeae*) infected samples indicated that C1, C5 and C6 transcripts might be related to root lesion nematode resistance in Karthobiumtham. Isolation and sequencing of full length genes of ATP synthase showed 98% homology to *M. acuminata* ATP synthase beta sub-unit and 97% homology to Maize and Rice ATP synthase. Seven new accessions were added to grape collection, totalling to 464. Microsatellite data of 317 accessions were analysed and several misnomers and duplicates were identified. Rootstock, B2/56, was identified as a clone of 110R. Cheema Sahebi was grouped to be a selection of Spin Sahebi and not Pandhari Sahebi as reported earlier.

Strawberry accessions collected from Sub-Himalayan region are promising

Fifteen pomegranate accessions were collected from Maharashtra and Odisha. The exotic accessions introduced from University of California, USDA, showed 86.0% survivability after one-and-a-half year of planting at Bhowali, where they are being maintained. Similarly, five litchi cultivars, collected from Spain have been established. Fifty-four clones of litchi from Vaishali and other districts were characterized and five were identified as promising. Among 11 longan germplasm evaluated, accession, Lgc-6, excelled in fruit yield (10.5 kg/plant). Two accessions of strawberry collected from Sub-Himalayan region (Rohtang Pass-Manali: altitude 3,978 m) were multiplied for further utilization.

Of the 28 ber varieties assessed, highest polyphenols were recorded in cv. Mehrun (140.93 mg/100 g), followed by ZG-3 (122.27 mg/100 g), and highest content of flavonoids and flavonols were observed in cv. ZG 3 (173 mg/100 g) and Aliganj (70.59 mg/100 g), respectively. The total antioxidant activity was the highest in cv. ZG 3 (6.3 MTE/100 g), followed by Thar Sevika (5.3 MTE/100 g), and Gola and Illaichi (5.2 MTE/100 g). The kachri lines were screened for incidence of diseases and fruit fly infestation. Based on maturity, fruit size, shape, yield potential and overall performance, kachri lines, AHK 119, AHK 200, AHK 411, AHK 564 and AHK 572, were promising.

Vegetable crops: Six potato hybrids, J/2-14, MS/6-819 and MS/6-1947, PS/5-73, PS/5-75 and PS/6-88, for table purpose and 2 (MP/04-578, French fry and MP/04-816, chips) for processing were introduced in AICRP for multilocation testing. The accessions, J 93-98, MS/82-638 and MS/82-398, were identified for efficient nitrogen uptake than Kufri Gaurav based on nitrogen requirement for getting equivalent yield. Complex genome of potato (*Solanum phureja*) was deciphered by a consortium of 26 international institutes including CPRI, Shimla. A hybrid approach including Sanger and next generation sequencing were adapted for sequencing of 727 Mb constituting 86% of the complete potato genome.



Potato genome for future

Palms and nuts: The field gene bank at Kidu in Karnataka has the largest number of accessions of coconut (269 indigenous and 132 exotic), arecanut (141 indigenous and 23 exotic) and cocoa (36 indigenous and 255 exotic). Four coconut ecotypes, viz. Puvar, Edawa Oblong, Edawa Round and Kappil, with good quality fibre, were identified from Thiruvananthapuram district of Kerala. Horned coconuts were collected for conservation from Andamans to study the segregation pattern and evolution in coconut. Cluster analysis based on palm and fruit characters showed Devermute and Mavinkuruva coconut ecotypes (from Honavar, Karnataka) as distinct populations and quite different from West Coast Tall (WCT) populations. Coconut

Horned coconuts in National Gene Bank

accessions, viz. IND085S, IND001S, IND013S, IND086S, IND026S, IND027S, IND038S, IND054S, IND01S, IND015S and IND071S, were identified for high copra yield. Among arecanut accessions, VTL 28I, VTL 29I and VTL 12, exhibited high yield potential of 3.86, 3.98 and 3.70 kg dry kernel/palm/year, respectively. Evaluation of cocoa collections showed high yield potential in VTLC 65 (128.8 pods/tree/ year) and VTLC 85 (102.7 pods/tree/year).

Forty-five new accessions of cashew germplasm characterized using RAPD, ISSR and SSR markers revealed less diversity. Further, 19 germplasm accessions were characterized as per the IPGRI (Bioversity International) Descriptors, bringing the total number of accessions evaluated to 452, out of 527 maintained in field. The evaluation indicated highest cumulative nut yield in BLA 39/4 (66.48 kg/tree) at Bapatla (Andhra Pradesh). More than 60 out of 94 accessions yielded bold nuts (7.0–16 g) with high shelling capacity (28–36%) at Bhubaneswar (Odisha), while HC 6 showed dwarfing feature at Vridhachalam (Tamil Nadu).

Ornamental crops: One hundred and seventy-two orchid accessions were collected, especially from north-eastern Himalayan regions. The characterization of collected orchid germplasm revealed two novel variants of *Pleione humilis*, and alba varieties of *Coelogyne nitida*, *Coelogyne punctulata* and *Dendrobium amoeneum* which were not reported so far. The explorations resulted in addition of four new records, *Calanthe mannii* Hook f., *Calanthe yucksomnensis* Lucksom, *Calanthe pachystylis* and *Cymbidium cyperifolium* Lindl. The two significant observations, are *ex situ* germination in *Calanthe yucksomnensis* and vivipary in *Coelogyne nitida.* The efforts are to isolate mycorrhizal fungi and use them for improvement in seed germination and hardening of tissue cultured plants. True vivipary, an alternative reproductive strategy, was also noticed which had so far not been observed in members of family Orchidaceae.

Medicinal crops: Explorations undertaken in different parts of the country revealed that of the total 121 accessions, 43 were of *Desmodium gangeticum*, 44 of *Asparagus adscendens*, and 34 of *Asparagus recemosus* and *Gymnema sylvestre*. In *Gymnema sylvestre*, two high leaf-yielding lines, DGS 22 and DGS 6, were identified. Another line, DGS 2, has been identified to possess high (>3%) gymnemic acid content as well a high root-yielding *Asparagus adscendens*, DAA 2. Two morphotypes, pure white (DAA 1) and purple white flower (DAA 38), were identified in *Asparagus adscendens*. In *D. gangeticum*, different morphotypes, viz. prostrate dwarf plant (DDG 6) and tall erect plants (DDG 15), narrow long leaves (DDG 29) and broad large leaves (DDG 8), white flowers (DDG 18) and pink flowers (DDG 8) types of plants, were identified. A total of 140 *ashwagandha* germplasm accessions were maintained and characterized. For dry root yield, DWS 132 and DWS 135 performed significantly better than the control, JA 20 and JA 134.

Spices: A total of 236 accessions of black pepper were collected from Idukki, Sabari hills and Goodrickal ranges in Kerala. Endangered species such as *Piper barberi* and *P. hapnium* were collected from Sabari Hills. Ninety-five core collections of cardamom germplasm were profiled using 25 ISSR and 3 microsatellite markers.

Piper hapnium (male), an endangered wild species collected from Sabari Hills

Tuber crops: One hundred fifty-three accessions of cassava, 15 of sweet potato and 57 of aroids were collected. Further, a land race, *Aniyoor*, has been identified as potassium uptake-efficient cassava genotype suitable for table consumption.

Livestock

Breed registration

Breed Registration Committee of the ICAR approved nine new populations of indigenous farm animals as breeds. Now there are 144 registered indigenous livestock breeds—37 of cattle, 13 of buffalo, 23 of goat, 39 of sheep, 6 of horse and pony, 8 of camel, 2 of pig, 1 of donkey, and 15 of chicken. Details of new breeds are as follows:

Pulikulam cattle (INDIA_CATTLE_1800_PULIKULAM_03035)—are maintained in large migratory herds in Madurai and adjoining districts of Tamil Nadu, and are used in Jallikattu (bull riding) games.

Kosali cattle (INDIA_CATTLE_2600_KOSALI_03036)—is a small size, draught cattle breed of Chhattisgarh. The bullocks are employed for removal of weeds from paddy field.

Malnad Gidda (INDIA_CATTLE_0800_MALNADGIDDA_03037)—are small cattle from Western Ghat region of Karnataka. Breed is reared for milk and light draught work.

Kalahandi buffalo (INDIA_BUFFALO_1500_KALAHANDI_01013)—is a dual purpose breed, used for milk and draught purpose in Kalahandi and Rayagada districts of Odisha. Animals are of medium size with long and half circled horns.

Konkan Kanyal goat (INDIA_GOAT_1100_KONKAN KANYAL_06022)—is a meat type breed adapted to high rainfall and hot and humid climate of Konkan region. Animals have typical white bands on black face and black ear with white margin.

Berari goat (INDIA_GOAT_1100_BERARI_06023)—is reared mainly for meat purpose in Vidarbha region of Maharashtra. As a unique feature, animals have light to dark strips on lateral sides from horn base to nostrils.

Ghoongroo pig (INDIA_PIG_2100_GHOONGROO_09001)—is found in Darjeeling and Doar area of West Bengal. The animals are black and have upwardly curved snout and large heart shaped ears.

Niang Megha pig (INDIA_PIG_1300_NIANGMEGHA_09002)—is found in Meghalaya. The animals have small erect ears extended vertically.

Spiti donkey (INDIA_DONKEY_0600_SPITI_05001)—is found in Lahaul and Spiti regions of Himachal Pradesh. The animals are utilized for transportation at high altitude (around 3,500 m above msl) with low level of environmental oxygen. These animals can survive well in scarcity of feed and fodder during harsh winter when the area is completely snow bound.

Phenotypic characterization and conservation of farm animal genetic resources

Nari cattle: Nari cattle are found in Sirohi district and Bali tehsil of Pali district in Rajasthan. The breed is reared by Raika/ Rebari communities. Nari cattle are very hardy and sustain well in the hilly terrain. The herd size varies from 20 to 100 animals. They travel 150–200 km during migration even to neighboring Gujarat state. The coat colour is mainly white. The horns are long and spirally curved outwards or forward. The age at first calving is 3.5 to 5 years. The per day milk yield varies from 3 to 8 kg.

Nari cattle on an average gives 3 to 8 kg milk/day

Tripura cattle: These cattle are found in West and South districts of the Tripura. Animals are compact and of small size with brown, reddish, black and grey, and white coat; small hump, dewlap and horns; small ears which are horizontal in orientation. The average age at first calving, daily milk yield, lactation length, dry period, service period, herd life and number of calving during life time are 44 months, 1.36±0.06 kg, 145 days, 272 days, 231 days, 427 days, 12–15 years and 8–10 calving, respectively.

Tripura cattle are well built and compact

Purnea cattle: These cattle are distributed mainly in the Purnea, Araria, Katihar and Kishanganj districts of Bihar. The coat is light to deep red and greyish white; head profile is straight in females and slightly bulged in males; and horns are short, crescent shaped and pointed forward. The age at sexual maturity in males is 2.5 to 3 years. Age at first calving ranges between 3 and 4 years. Average daily milk yield of cows varies between 0.5 and 2 kg.

Ghumsuri goats: These are medium in size and reared for meat in Ghumsuri of Khandamal district of Odisha. The coat is black or light brown to black brown. The adult body weights of females and males are 19.88 and 20.86 kg respectively. The flock size varies from 5 to 25. Female animals attain sexual maturity at 12–18 months of age.

Ghumsuri goats are reared mainly for meat in Ghumsuri of Khandamal district of Odisha

Local non-descript donkeys: Comparative biometric analysis revealed that donkeys of Poitu breed were significantly taller than the indigenous donkeys of Himachal Pradesh and Gujarat. Donkeys from Spiti area of Himachal Pradesh were the smallest. However canon, face length and width as well as hoof length and width were similar in both the indigenous donkey populations. Coat colour and biometric indices generated will serve as baseline information for defining and identifying donkey populations as different breeds.

Mithun: Cytogenetic analysis was carried out on all mithuns available in the Institute farm, and data were compiled and presented in the form of a digital album.

Molecular genetic characterization

***FecB* mutation in Edka sheep:** In Edka sheep 37% of the Edka animals were *FecB*+ heterozygous carriers, whereas remaining 63% animals were *FecB* non-carriers. Edka is the third prolific sheep in India after Garole and Kuzi/Kendrapada. Genotyping of FecG locus in five sheep breeds Garole, Kuzi, Shahabadi, Balangir and Bonpala showed presence of only one genotype i.e. FecGHH, suggesting fixing of *FecG* gene in these breeds.

Indigenous pigs: Indigenous pig breeds, viz. Ghoongroo and Niang Megha were characterized using 22 ISAG/FAO recommended microsatellite markers, all of which were found to be polymorphic. The Nei's genetic identity and other estimates indicated varied genetic distance among different populations. The study on genetic relationship among the other breeds found in the adjoining areas, revealed lower genetic distance between Niang Megha and Naga Local (Suho) pigs than Ghoongroo pigs.

Polymorphism in toll-like receptor (*TLR*) genes: Buffalo *TLR4* gene was analysed by sequencing of 24 different riverine and swamp animals. Total 28 polymorphic nucleotide sites were identified in buffalo *TLR4*. Polymorphic nucleotide sites were also identified in 3'UTR of TLR2 and buffalo TLR7 promoter region. Genotyping protocols, developed for the SNPs in TLR4-3463C > T, 3'UTR of buffalo TLR2 79C > T and -322G > T SNP in TLR7 promoter within Oct1 binding site, revealed differences in the allele frequencies among riverine and swamp buffaloes. These SNPs could be the potential loci for association analysis with disease resistance traits. Characterization of goat *TLR2* gene showed presence of seven polymorphic nucleotides. Of the five SNPs in the coding region one SNP 1732A > G was non-synonymous changing amino acid 578Ala > Thr within LRRCT domain. Overall, goat *TLR2* gene was less polymorphic than cattle and buffalo.

***KIT* gene in Nukra horses:** *KIT* gene is responsible for development of the specific coat colour in horses. Till now, 17 variations leading to altered or truncated function of *KIT* gene, viz. W1-W17 have been identified and found associated with the dominant white coat colour across various horse breeds. Exon 7 region was amplified and sequenced in Nukra horse, in which GAAC deletion with respect to wild type was observed. The mutation was reported earlier as W10 variation in other horse breeds.

Leptin gene and its association with performance of mithun: The gene frequency for better meat quality was more in farm animals than that in animals from field. The result found after PCR-RFLP was quite encouraging, as some unique bands were noticed in animals belonging to a specific region. Initial analysis of data related to growth, nutritional performance and carcass quality traits for various strains of mithun, showed that the marbling and average fat thickness in mithun meat is moderately abundant, whereas the rib eye area is comparatively larger indicating the better meat quality of mithun.

Identification of *Internal control* genes (*ICG*) in cows: The study involved 4 periparturient Sahiwal cows (–21 days to 0 day to +21 days relative to parturition) and 10 known internal control genes (*ICG*) from different functional classes (GAPDH, ACTB, UXT, RPS15A, B2M, RPS23, HPRT1, EEF1A1, GTP, HMBS). All the genes showed acceptable expression stability as per recommended threshold values. Most of the 10 genes evaluated, showed consistent expression level in PMN at different time points of peripartum Sahiwal cows.

ACTB and B2M were the most abundant while HMBS was the least abundant transcripts in PMN of Sahiwal cows. The expression stability measure (M) of the 10 candidate ICG ranged from 0.236 (RPS9, RPS15A) to 0.636 (HPRT1). All candidate genes performed well displaying M values below the default limit of 1.5. The genes were ranked from the most stable (lowest M value) to the least stable genes (highest M value): RPS9, RPS15A>RPS23> ACTB> B2M > UXT> GAPDH> GTP> HMBS> HPRT1.

Transcriptomic response of buffalo mammary explants during heat stress: The changes in expression of inducible heat shock protein throughout the time course after heat shock indicated the responsiveness of mammary explant to heat stress in buffalo. In addition to HSP70, expression profiles of IL-6, TNF- α, BCL2, NF-kappaB, PRLR, BAX and c-Jun mRNA were also evaluated in heat stressed mammary explants to understand their responsiveness to heat challenge *in vitro*. Global expression analysis of 2 hr heat stressed mammary explant revealed 138 differentially expressed genes with ≥ 2-fold change (75 were up-regulated and 63 were down regulated). Gene ontology and pathway analysis revealed several pathways, including Interleukin signaling, chemokine and cytokine signaling, complement and coagulation cascades, antigen processing and presentation, MAPK signalling and JAK-STAT signaling pathway. The transcriptome data would help to understand the modulation of buffalo mammary expression signature in response to environmental heat load.

Transcriptome analysis of mammary epithelial cells (MEC): Agilent 44K bovine microarray data based on two- or more-fold change criteria revealed 89 differentially expressed genes in MEC of two species during early lactation stage. Majority genes were found upregulated in buffalo MEC, which was also revealed by gene set enrichment analysis. Number of biological pathways like ribosomal pathway, glycolysis, pentose phosphate synthesis, oxidative phosphorylation, fructose and mannose metabolism, proteosome; and signalling pathways like NOTCH, mTOR, insulin, MAPK, chemokine and JAK-STAT were identified through GSEA analysis. Ribosomal pathway was identified as the most significant pathway having maximum enrichment score. Microarray analysis suggested increased expression of genes associated with translation and metabolism activities in buffalo MEC during early lactation stages.

Molecular sex typing in pigs: A PCR based method for identification of sex from porcine DNA samples was designed for determination of sex in domestic pigs. This assay utilizes two sets of primers, one control and the other male specific multiplexed for sex typing. Repeatability of the assay was confirmed by testing different samples.

Candidate genes expression in muscle of broiler and layer chicken: Expression of troponin C and troponin slow type protein were upregulated in broiler day-old chicken, while only troponin slow type protein was upregulated in layer. At 6 weeks of age, expression of troponin C, troponin slow type protein and myoglobin gene were upregulated in both broiler and layer lines. In broiler line, calmodulin revealed about 200-fold greater expression than that in layer line. Myostatin, IGF-1 and GHR had higher expression in layer than broiler at day 1. In heart, calmodulin, troponin C, troponin slow type protein, myoglobin and cardiac related protein revealed upregulation of expression at day-old as well as 6 weeks of age in broilers while in layers, only myoglobin and cardiac related protein genes were upregulated both at day 1 and 6 weeks. In liver, activin, calmodulin, calreticulin, collagen, troponin C, troponin slow type protein, sarcolipin, myoglobin, cardiac related protein, myelin, myostatin, IGF1 and GHR genes were down regulated. At day 1, all genes showed higher expression in broiler than layer birds. At 6 weeks of age, troponin slow type protein, myoglobin and myelin had higher expression in layer than broiler chicken.

Fish

First record of extended distribution of *Tor tor*: Mahseer, *Tor tor,* a well known game and food fish that inhabits streams and fast flowing rivers along mountains was first time reported from Penganga river. River Penganga (N 19° 45.987, E 078° 43.058, Altitude 639 ft.) is a major tributary of River Godavari marking the boundary between the states of Maharashtra and Andhra Pradesh. The identification was supported by morpho-meristic and molecular investigations. The occurrence of various life stages of this species in river suggested that the species has adapted in wide range of distribution and established self-recruiting population in this river of Peninsular India.

New records of species of fish and prawn reported: A fish, *Pinniwallago bhagirathiensis* sp *nov.* and a prawn *Macrobrachium hooghliense* sp. *nov,* were described and reported as new to science by the CIFRI. The holotypes were deposited in the National Zoological Collections of the Zoological Survey of India, Kolkata with holotype IDs ZSI FF4488 and ZSI C5914/2 respectively.

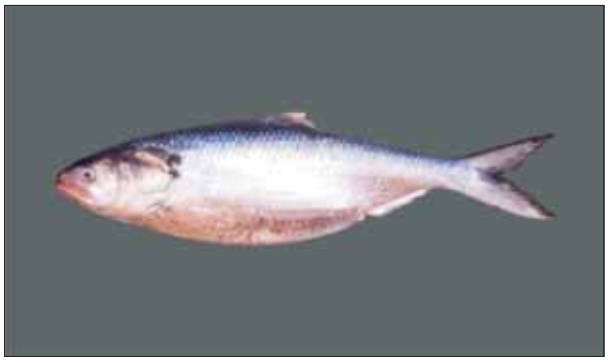
Prawn *Macrobrachium hooghliense sp. nov.* was described and reported as new to science

The sea horse species, *Hippocampus kuda*, an endangered fish species, listed in the Schedule-I of the Indian Wildlife (Protection) Act, 1972, was collected

The first record of sea horse species, *Hippocampus kuda*, an endangered fish, from the riverine section of Hooghly estuary

from Kakdwip area. This is the first record of sea horse species from the riverine section of Hooghly estuary.

The CIFRI recorded a female hilsa *(Tenualosa ilisha*) of 614 mm in length and 4,250 g from commercial catch of Tapti estuary at Surat. As on record, the specimen was the biggest from the Indian waters.



Giant hilsa (*Tenualosa ilisha*) from Tapti estuary — the biggest specimen from the Indian waters

Genetic characterization

Cell line as *in vitro* model: A cell line developed from eye tissue of *Puntis chelynoides* was used for genotoxicity and cytotoxicity assessment of heavy metal salts (cadmium, zinc) and nanoparticles. Toxicity potential of titanium oxide, zinc oxide, silver and gold nanoparticles was also evaluated. Heavy metal salts were cytotoxic as well as genotoxic to the studied cell line at various concentrations, cadmium salts being more toxic than zinc. Tested nanoparticles were found genotoxic to cell line but did not exhibit any significant cytotoxicity. Results strongly validated the efficacy of this cell line as an *in vitro* model for toxicity studies.

Macrophage cell line developed from *Catla catla*: A cell line designated as *Catla catla* macrophage (CCM) was developed. The cultured cells are avidly phagocytic as revealed by ingestion of yeast cells and fluorescent latex beads. The CCM cells showed increased production of reactive oxygen and nitrogen intermediates following stimulation with lipopolysaccharide and phorbol esters. The culture supernatant from CCM cells revealed lysozyme-like activity. The CCM cells had Fc receptors on their surface in fluorescent antibody test. Moreover, the cells were positive for alpha-naphthyl acetate esterase enzyme and took up acridine orange, indicating that CCM cells are of macrophage lineage. This cell line was successfully used for cytotoxicity assay, as revealed by uptake of neutral red. It can be a useful tool to study the role of macrophages in teleost immune response and development of markers for macrophages.

***De novo* whole transcriptome analysis of freshwater fish louse:** The transcriptome sequencing of *Argulus siamensis*, a major pest capable of causing huge economic losses in freshwater aquaculture sector,

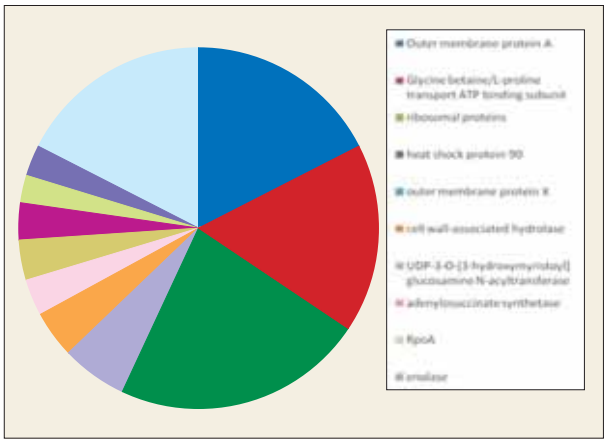
Development of Fish Genomic Resource Databases

Five fish genomic resource databases, namely Fish Barcode Information System (FBIS), Fish Karyome, Microsatellites Database of Indian Fishes (MIDIF), Ribosomal DNA/RNA, and Fish ESTs, were developed under the NAIP funded project entitled 'Establishment of National Agricultural Bioinformatics Grid in ICAR (NABG)' and are being updated periodically. Databases FBIS and Fish Karyome, are available online. FBIS contains 2,658 barcode records of 518 species. The web interface of FBIS was integrated with tools and applications for retrieving and viewing information about database statistics and taxonomy, including species identification as well as inter- and intra-sequence divergence estimation. The database can be accessed at URL: http://mail.nbfgr.res.in/fbis/. Fish Karyome database contains karyological information of 154 Indian fish species belonging to 42 families under 10 orders. It enables quick sharing of cytogenetic information on chromosome number, morphology, sex chromosomes and markers, like nucleolar organiser regions, constitutive heterochromatic regions etc. of the fish species, in addition to physical and phenotypic information. The database is accessible at URL: http://www.nbfgr.res.in/fishkaryome/. MIDIF presently contains 993 non-coding microsatellite sequences for 34 Indian fish species belonging to 11 families, including 531 records of *Labeo rohita*. The database is accessible at URL: http://mail.nbfgr.res.in/microsatellite.indices.php. Ribosomal DNA/RNA database presently contains 1,080 GenBank records for 219 Indian fish species. Fish EST database contains 2,662 GenBank records for *L. rohita* (1631 ESTs) and *Schizothorax richardsonii* (1,031 ESTs). It is anticipated that these databases would be useful as an appropriate source for characterization, cataloguing, conservation and management of Indian fish diversity.

was performed on Illumina HiSeq 2000. Of the 75,126,957 high quality reads generated, 46,352 transcript contigs were assembled with average length of 1,211 bp and N50 length of 2,302 bp. A total of 19,290 CDS including 184 novel CDS and 59,019 ORF were identified from the assembled contigs. Further, 28,035 transcripts were identified without CDS which include 2,931 novel contigs. Maximum percentage of *A. siamensis* CDS, showed significant similarity with *Lepeophtheirus salmonis*, the salmon louse. From the assembled contigs, 1,171 SSRs were identified. The transcriptome data generated will facilitate future functional studies on the genome of the parasite which will subsequently be applied for vaccine development and other control strategies.

Ceruloplasmin, a potential indirect marker: Ceruloplasmin, an acute phase protein, was found to be activated by the host immune system during stress conditions. The expression of ceruloplasmin gene was detected at 9 h post-fertilization onwards in rohu carp, *Labeo rohita* during ontogeny study. A strong level of expression was detected at 24 h (38-fold) and 15 days (34-fold) post-fertilization in real time PCR. The ceruloplasmin transcripts were evident in liver, spleen, stomach, and heart but undetectable in gill, brain, eye, skin, muscle, intestine, anterior and posterior kidney tissues of healthy juvenile rohu. The level of ceruloplasmin was also compared in rohu selectively bred for higher growth and disease resistance to *A. hydrophila*. The estimated heritability was also quite high for this parameter. Thus, ceruloplsamin could be a useful marker trait for selection against *A. hydrophila* resistance in fish.

Salt responsive genes of *Mangrovibacter* spp: The genes responsible for salt tolerance in *Mangrovibacter* spp., a facultative anaerobic, nitrogen-fixing salt-tolerant bacterium usually associated with mangrove plants, were identified by using suppression subtractive hybridization (SSH). Clones (160) obtained from forward subtraction resulted in 37 uni-ESTs that comprised 25 contigs and 12 singletons. The outer



Salt responsive genes in *Mangrovibacter* spp. identified by suppressive subtractive hybridization and RT-qPCR

membrane protein A (ompA) (17%) and glycine betaine/L-proline transport ATP binding subunit (16%) genes constituted the maximum number of ESTs in the library. During salt-stressed condition, the glycine betaine/L-proline transport gene showed the highest up-regulation in RT-qPCR analysis indicating that this transport system has a major role in *Mangrovibacter* spp. at salt-stressed conditions. Other important up-regulated genes identified include, outer membrane protein A, mechanosensitive channel, outer membrane protein X, UDP-3-O-[3-hydroxymyristoyl] glucosamine N-acyltransferase, enolase and translation elongation factor G (EFG).

Detection of enterotoxin producing *Bacillus cereus* in fish: A PCR-based method for rapid detection of enterotoxin producing *B. cereus* was developed based on *hbla* gene, which yielded 834 bp amplified product from both the naturally positive and artificially spiked samples. The conventional method for detection of enterotoxin producing *B. cereus* requires imported expensive kit. This *hbla* gene specific PCR method is cost-effective and takes less time as compared to conventional RPLA-based method, which takes 3 days for detection of entertoxin producing *B. cereus* in food. ❑

6. Crop Improvement

High-yielding crop varieties and hybrids with tolerance to pests /diseases and to various farming constraints such as soil and water salinity, soil acidity, drought, flood and such other factors have been developed.

For different designated agro-climatic regions/zones of the country, improved varieties of cereals, oilseeds, pulses, fruits, vegetables and commercial crops have been notified for cultivation.

Cereals

Two rice hybrids, VNR 2245 and VNR 2355, were released by the Central Sub-committee of Crop Standards, Notification and Release of Varieties. The State Variety Release Committees have recommended 21 rice varieties and two hybrids, Sahyadri 5 and CO(R) H 4.

During 2012, nine rice hybrids and two varieties were

Rice hybrids/varieties released

Variety/hybrid	Grain type	Reaction to pests/diseases	Ecosystem
		Central Releases	
VNR 2245 (Hybrid)	LS	MR–LBl	Irrigated areas
VNR 2355 (Hybrid)	MS	MR–LBl, NB	Irrigated areas
		State Releases	
Ratnagiri 5	SS	MR–BLB, BL	RUP, Konkan areas of Maharashtra
Sahyadri 5 (Hybrid)	LS	MR–BLB, BL	RSL, Konkan region of Maharashtra
Karjat 8	SS	MR–BL, NB, BLB, WBPH, G	RSL, Konkan region of Maharashtra
Improved Lalat	LS	R–G; MR–SBD	Irrigated areas of Odisha
Improved Tapaswini	SB	R–BPH, YSB, WBPH; MR–BB, SBD	Irrigated areas of Odisha
CR Dhan 200	SB	MR–LB, NB, BS, SBD, DH, RWM, G, LF	Aerobic conditions of Odisha
CR Dhan 902	LS	R–NB, G; MR–ShR, SBD	Irrigated areas of Odisha
CR Dhan 404	LB	R–LBl, SBD, LF, G; MT–BS, BLB, SBD, ShR, GLH, G, RT	RSL conditions of Odisha
CR Dhan 100	MS	R–SBD, LF, RWM; MT–WBPH, G, RH, RTV, LBl	RUP of Odisha
CR Dhan 503	MS	MR–LF, GLH, LBl, NB, BS, G, DH SBD, RWM	DW of Odisha
CR Dhan 502	MS	MR–LBl, NB, SBD, ShR	DW of Odisha
CR Dhan 301	LS	R–G; MR–ShR, RTD, G1	Irrigated areas of Odisha
CR Dhan 406	MS	T–LBl; MT–LF, SBD	CS of Odisha
CR Dhan 405	MS	T–LBl, MT–SBD	CS of Odisha
Jyotirmayee	MS	MR–LBl, SBD, G	RUP of Odisha
Hiranmayee	MS	MR–SBD, ShR, RTV, BLB, BS, G1	Irrigated areas of Odisha
Tanmayee	SB	MR–NB, LBl, SBD, RTV, BLB, G1	RSL of Odisha
Nua Acharamati	SB	MR–SBD, RTV, BLB, G, BPH	Irrigated areas of Odisha
CO(R) H 4 (Hybrid)	MS	R–BL, BS; MR–WBPH, GLH ShR, RTD	Irrigated areas of Tamil Nadu
Shalimar Rice 2	MB	R–BL	Irrigated lowlands of Jammu and Kashmir
Shalimar Rice 3	MB	R–BL	Irrigated lowlands of Jammu and Kashmir
Puspa	SB	R–BL, ShBl, ShR, BLB, BS, BPH; MR–RTV, LF, SBD	RUP of West Bengal
Dhiren (BNKR 1)	SB	R–LBl, NB, BS, ShR, LF	Irrigated areas of West Bengal

BL: Blast; BLB/BB: Bacterial Leaf Blight; BPH: Brown Plant Hopper; BS: Brown Spot; CS: Coastal Saline; DH: Dead Heart; DW: Deep Water; G: Gall Midge; GLH: Green Leaf Hopper; LB: Long Bold; LBl: Leaf Blight; LF: Leaf Folder; LS: Long Slender; MB: Medium Bold; MR: Moderately Resistant; MS: Medium Slender; MT: Moderately Tolerant; NB: Nodal Blast; R: Resistant; RSL : Rainfed Shallow Lands; RT: Rice Thrips; RTD: Rice Tungro Disease; RTV: Rice Tungro Virus; RUP: Rainfed Uplands; RWM: Rice Wheat Maggot; SB: Short Bold; SBD: Stem Borer Disease; ShBl: Sheath Blight; ShR: Sheath Rot; SS: Short Slender; T: Tolerant; WBPH: White Backed Planthopper

identified for release. Hybrids are US 382, NPH 924-1, PNPH 24, 27P 31, 25P 25, JKRH 3333, TNRH 174, HRI 169 and RH 1531, and the varieties are RP 3644-1-19-5-5 and RP Bio 4918-2485.

Nine wheat varieties were released for commercial cultivation in different production conditions of the country.

A six-row malt-barley variety DWRUB 64 has been recommended for cultivation in the North-Western Plains

DWRUB 64, first six-row malt- barley variety

DPW 621-50 wheat for timely sown irrigated areas of the North-Western Plains Zone

Barley for malting quality

Malting quality is a combination of several grain and malt quality traits. Based on the overall score of 30, barley entries DWRB 102, DWRB 103, DWRB 104, RD 2848, RD 2849, DWRUB 52 showed better overall malting quality score under timely sown areas. In the late-sown trials, BH 968, DWRUB 52 were promising.

Entries BK 306, BCU 4966, BCU 5070, BCU 5474 and DWR 49 showed higher protein content coupled with good grain development. And entries with low protein content and good grain development were DWRUB 68 and VM 152. Among the entries included on the basis of beta- glucan content, DWRUB 76 (high beta glucan) was found with good grain development.

Wheat varieties released

Variety	Production condition	Area of adaptation
HD 2985	Late sown, irrigated	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Odisha, Asom and plains of north-eastern states
DPW 621-50	Timely sown, irrigated	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and *tarai* region of Uttarakhand
WH 1080	Timely sown, rainfed	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and *tarai* region of Uttarakhand
HD 2967	Timely sown, irrigated	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and *tarai* region of Uttarakhand
HD 3043	Timely sown, restricted irrigation	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and *tarai* region of Uttarakhand
PBW 644	Timely sown, rainfed	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and *tarai* region of Uttarakhand
HD 2987	Timely sown, rainfed and restricted irrigation	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
UAS 428 (durum)	Timely sown, irrigated	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
MP 3288	Timely sown, rainfed and restricted irrigated	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh

Zone (Punjab, Haryana, western Uttar Pradesh, Delhi and Rajasthan) in the irrigated late sown areas. This will provide an option to the farmers under late sown conditions, where only DWRB 73, a two-row malt-barley, was available so far.

Nineteen maize hybrids, including 9 late-maturing, 8 medium-maturing and 2 extra-early maturing, were released and notified for cultivation in different parts of the country. HM 12, a medium-maturing, white-seeded semi-dent type single-cross hybrid, was released for Uttar Pradesh, Bihar, Jharkhand and Odisha. Co 6, a late-maturing hybrid, was notified for cultivation in Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh. For Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka, four late-maturing single-cross yellow-seeded hybrids KMH25K60, NK 30, NK 6240 and X8B562 were released.

Maize hybrids released

Hybrid	Area of adaptation
Co 6	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
HM 12	Uttar Pradesh, Bihar, Jharkhand and Odisha
Vivek 43	Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, West Bengal, Odisha, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh
Vivek 39	Uttarakhand and Himachal Pradesh
KMH 218 Plus	Uttar Pradesh, Bihar, Jharkhand and Odisha
KMH 3426	Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
NMH 731	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
NMH 803	Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
KMH 25 K 60	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
KMH 3712	Uttar Pradesh, Bihar, Odisha, Jharkhand, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
NMH 920	Uttar Pradesh, Bihar, Odisha and Jharkhand
Bisco 506	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu
X8B 691	Punjab, Haryana, Delhi, western Uttar Pradesh, Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
X8B 562	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
NK 30	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
NK 6240	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
Bio 9682	Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh, Punjab and Haryana
SMH 3904	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh
P 3501	Uttar Pradesh, Bihar, Odisha, Jharkhand, Madhya Pradesh, Rajasthan and Gujarat

Maize hybrids HM 12 (*top*); Vivek 39 (bottom *left*) and Vivek 43 (bottom *right*)

Dual-purpose (grain and stover) *kharif*-sorghum variety CSV 27 was notified by the Central Sub-committee of Crop Standards, Notification and Release of Varieties. It recorded a grain yield of 2,802 kg/ha and a fodder yield of 19.3 tonnes/ha.

Kharif grain-sorghum hybrid CSH 30 (SPH 1655) is an early-maturing hybrid, recommended for Maharashtra, Karnataka, Madhya Pradesh, south Gujarat and north Andhra Pradesh. It showed good tolerance to grain moulds.

CSH 30, an early-maturing sorghum hybrid

Rabi-sorghum CSV 29 R (SPV 2033), recommended for Maharashtra, Karnataka and Andhra Pradesh in deep-black soils in *rabi* season, is a tall (210 cm), semi-compact variety with cylindrical, epearly-white, lustrous seed. It matures in 115–120 days. It showed tolerance to shoot-fly, stem-borer, shoot-bug, sugarcane aphid, charcoal-rot and rust, besides, moderate tolerance to drought.

Nine pearl millet hybrids and two varieties were notified for various agro-ecologies of the country.

Pearl millet hybrid RHB 173

Pearl millet hybrids/varieties

Hybrids/varieties	States
Shine (VBBH 3040) (MH 1578)	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
86 M 66 (MH 1617)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh
PAC 909 (MH 1435)	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
Mandor Bajra Composite 2 (MBC 2)	Western Rajasthan and drier parts of Gujarat and Haryana
HHB 226 (MH 1479)	Western Rajasthan and drier parts of Gujarat and Haryana
RHB 177 (MH 1486)	Western Rajasthan and drier parts of Gujarat and Haryana
RHB 173 (MH 1446)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh
Pusa Composite 612	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
MH 1540 86 M 53	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
MH 1541	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
MSH 203	In summer season in Rajasthan, Gujarat, Maharashtra and Tamil Nadu

Minor millets

VL 351 of fingermillet, SiA 3121 of foxtail millet and TNAU 86 and RK 390-25 of kodo millet were identified for release.

Surya Nandhi is one of the earliest-maturing varieties of foxtail millet. It matures in 70 days, and is suitable for double cropping in rainfed areas

PPR 2700 (Vakula) and VRW 936 (Hima) of fingermillet, and SiA 3088 (Surya Nandhi) of foxtail millet in Andhra Pradesh; KMR 204 of fingermillet in Karnataka; Indira Ragi 1 of fingermillet, and Indira kodo 1 of kodo millet in Chhattisgarh; and Phule Nachni (KOPN 235) of fingermillet variety in Maharashtra were identified for release.

KMR 204 is a short-duration variety of fingermillet, maturing in 95–100 days. It is resistant to blast disease and is suitable for late *kharif* sowing

Oilseed crops

Fifteen varieties/hybrids of oilseed crops were released, including four varieties each of groundnut and Indian mustard; two varieties each of castor and sesame; and one variety each of linseed, soybean and niger.

Fusarium-wilt resistant high-yielding castor variety DCS 107 with 11% yield increase over DCS 9 (1,602 kg/ha) was notified for release across the country. Safflower variety SSF 748 showing 11% and 7% superiority in terms of seed and oil, respectively, over the best check, PBNS 12, has been identified for safflower regions of the country, and NARI-H 23, a hybrid with 11% superiority in oil yield, has been identified for all safflower-growing areas, except Uttar Pradesh. Him Alsi 2 linseed gave maximum retted straw yield along with the best fibre softness and fineness in reduced

Oilseeds varieties/hybrids

Crop	Variety	Maturity days	Recommended state/ season/situation	Special traits
Castor	DCS 107	100–135	Castor-growing areas of the country; both rainfed and irrigated	Non-lodging, non-shattering type; responsive to fertilizers; resistant to *Fusarium* wilt; tolerant to leaf hoppers
	JI 273	–	Gujarat; irrigated	Highly resistant to *Fusarium* wilt
Linseed	Mau Azad Alsi 2	–	Chhattisgarh, Odisha Maharashtra and Karnataka in timely sown rainfed areas	Resistant to rust
Soybean	SL 744	139	Timely sown irrigated conditions of Punjab	Resistant to yellow mosaic virus and soybean mosaic virus
Groundnut	Divya	–	Uttar Pradesh and Rajasthan; timely sown *kharif* (irrigated) areas	
	ICGV 00350	114	Tamil Nadu and Andhra Pradesh in *rabi*-summer (irrigated) and *kharif* (rainfed)	Resistant to late leaf spot and rust; tolerant to stem-rot diseases
	HNG 123	123–125	Rajasthan, Uttar Pradesh and Punjab in *kharif* (rainfed) timely sown	Tolerant to collar-rot, stem-rot, early leaf-spot diseases, *Spodoptera litura* and leaf miner
	Raj Mungfali 1	112–138	Rajasthan and Punjab in *kharif* (rainfed)	Tolerant to collar-rot, stem-rot, early leaf spot, rust, peanut stem necrosis diseases, thrips, jassids and grass hopper
Indian mustard	Pusa Mustard 28	97–131	Jammu and Kashmir (Plains), Punjab, Haryana, Rajasthan, Delhi and western Uttar Pradesh, early sown irrigated areas	Tolerant to stem rot, white rust and powdery mildew
	Pant Rai 19	99–133	Jammu and Kashmir, Punjab, Haryana, Delhi in irrigated *rabi*	Average yield under normal condition
	CORAL 437	140–150	Punjab, Haryana, Delhi, Jammu and Rajasthan in irrigated condition	Tolerant to white rust *Sclerotinia* rot, *Alternaria* and downy mildew
	RLC 2	142–150	Punjab, Haryana, NCR, parts of Rajasthan	–
Sesame	Gujarat Til 4	80–82	North Saurashtra	White-seeded variety, high-yielding, early-maturing
	DSS 9	85–90	Karnataka, *kharif* season	White bold seeded
Niger	Utkal Niger 150	105–110	Odisha	Black-seeded, tolerant to *Alternaria*, *Cercospora* and *Cuscuta*

time when it was inoculated with *Bacillus subtilis* strain (identified for microbial retting).

Pulse crops

Total of 19 varieties were released, including five of chickpea; three each of urdbean(Co 6, VBN (Bg) 7, VBN 6) and field-pea (IPF 4-9, Gomati, HFP 529); two each of lentil (VL Masoor 514, LL 931), pigeonpea (TS 3R, Anand Grain Tur 2) and horsegram (Indira Kulthi1, Gujarat Dantiwada Horsegram 1); and one each of mungbean (IPM 02-14) and guar (RGC1033).

Commercial crops

Three new improved sugarcane varieties were released—Co 0403 was for Peninsular Zone and Co 0237 and Co 05011 were for the North-West Zone. Co 0403 (Samriddhi) is an early, high-yielding and a high-quality clone with a good ratoon potential and showed resistance to red-rot and smut. Co 0237 (Karan 8) was found superior to standards, CoJ 64 and CoPant 84211, for crude cane sugar (CCS) (tonnes/ha) and cane yield (tonnes/ha). Improvement in cane and CCS yields was more in the ratoon-crop than in the plant-crop.

NBD 119 bidi-tobacco variety

NBD 119 identified as an early, high-yielding most promising

Varieties/hybrids of pulses

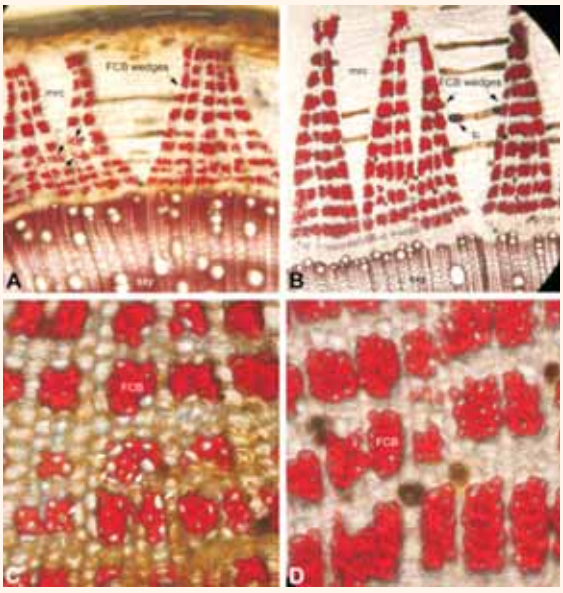
Crop	Variety	Maturity days	Recommended state/ season/situation	Special traits
Mungbean	IPM 02-14	62–70	Tamil Nadu, Andhra Pradesh, Karnataka, Odisha in summer	Resistant to Mungbean Yellow Mosaic Virus (MYMV) and leaf crinkle virus (LCV)
Urdbean	Co 6	70	Rainfed/irrigated conditions in *rabi* season in Southern Zone	Resistant to powdery mildew (PM)
	VBN (Bg) 7	63–90	Tamil Nadu, Andhra Pradesh, Karnataka and Odisha in *kharif*	Resistant to MYMV, PM, LCV and root-rot diseases
	VBN 6	70–80	Tamil Nadu	Resistant to MYMV
Lentil	VL Masoor 514	140	Uttarakhand	Resistant to lentil rust
	LL 931	146	Timely sown irrigated conditions in Punjab	Resistant to lentil rust; tolerant to pod-borer
Chickpea	Raj Vijay Kabuli gram 101	105	Timely sown semi-irrigated conditions in Madhya Pradesh	Moderately resistant to *Fusarium* wilt and tolerant to *Helicoverpa* pod-borer
	Raj Vijay gram 201	105	Timely sown rainfed conditions in Madhya Pradesh	Resistant to *Fusarium* wilt; tolerant to *Helicoverpa* pod-borer
	HK 4	136	Eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal under rainfed/irrigated condition	Moderately resistant to wilt disease
	Raj Vijay Gram 202	100-105	Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh and southern Rajasthan; irrigated	Suitable for late sown condition, resistant to wilt and moderately resistant to dry-root rot and collar-rot
	Raj Vijay Gram 203	100	Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh and southern Rajasthan; irrigated	Suitable for late sown condition, moderately resistant to wilt and dry-root rot
Field-pea	IPF 4-9	125	Uttar Pradesh	Tall tendril type; PM and rust tolerant
	Gomati	139	North-eastern states under irrigated conditions	Tall; tolerant to pod-borer and stem-fly
	HFP 529	120–125	Uttar Pradesh, Haryana, Punjab	Resistant to PM and tolerant to rust
Pigeonpea	TS 3R	155–160	Karnataka	Medium-large seeded
	Anand Grain Tur 2	155-160	Gujarat	Wilt resistant
Horsegram	Indira Kulthi 1	92	Chhattisgarh, *kharif* rainfed	Black-seeded variety, tolerant to shattering
	Gujarat Dantiwada Horsegram 1	94	Gujarat, Rajasthan, Uttara-khand, Jharkhand, Uttar Pradesh and Maharashtra under *kharif* rainfed	Moderately resistant to PM. Dark brick-red bold seeded with 26.4% protein
Guar	RGC 1033	95–106	Guar-growing areas of Rajasthan	Plants are branched with non-serrated leaves and pink flowers. Seeds contain 34–35% gum

Sugarcane varieties — A. Co 0403 (Samriddhi); B. Co 0237(Karan 8); C. Co 05011(Karan 9)

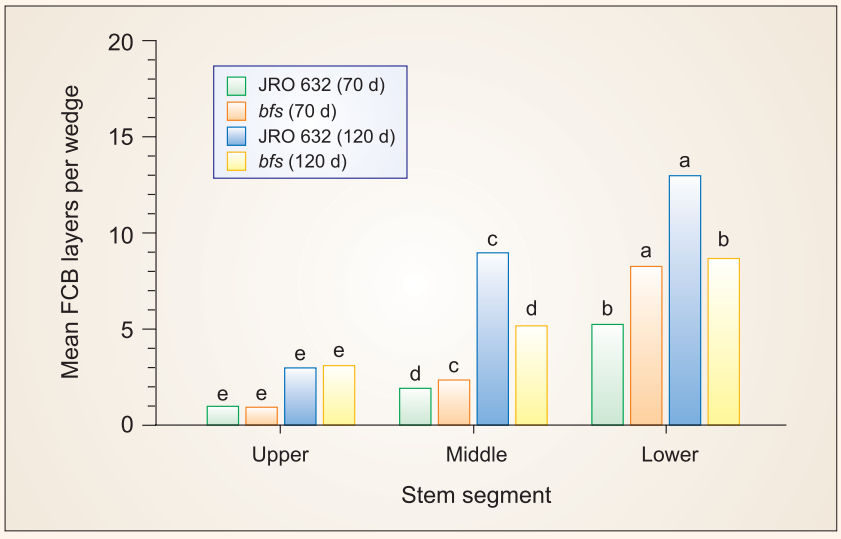
Secondary phloic (bast) fibre(SPF)-shy (*bfs*) mutant of dark jute

Bast fibre development in jute involves differentiation of secondary phloic fibres from cambium, followed by lignification of fibre-wall. A unique radiation-induced bast fibre-shy (*bfs*) mutant of dark jute (*Corchorus olitorius*) has been identified. It is defective in differentiating SPF and secondary xylem (wood) but develops lignified fibre cells. A multi-fold reduction of bast fibre yield in the mutant is related to development-specific loss of cambium function along the length of the stem from top to bottom. Lignification of the fibre wall in the mutant is not only normal but uniform; this indicates cambium function may be unrelated to lignification process. The architecture of mostly triangular fibre cell bundle (FCB) wedges is governed by a balanced growth between radially elongating FCBs and tangentially expanding ray cells due to development-specific activation of the fusiform and ray initials of the cambium; conditioning fibre fineness. Mutation could specifically impair cambial activity by rendering those initials nonfunctional that differentiate SPF and secondary xylem.

Diagnostic morphology of dark jute *bfs* mutant (A, C) in comparison with its wild-type JRO 632 (B, D). The mutant is characterized by trilobed dissected ribbon leaves and a spreading-type root architecture



$KMnO_4$-HCl-stained (Maüle reaction) lower stem segments of 120-d-old dark jute mutant *bfs* [A (× 100), C (× 400)] and its wild-type JRO 632 (B (× 100), D (× 400)]. Arrows indicate fibre cell ultimates with large lumens. (ca, cambium; ep, epidermis; FCB, fibre cell bundle; PPF, primary phloic fibre bundle; mrc, medullary ray cells; pp, pith parenchyma; SPF, secondary phloic fibre bundle; sxy, secondary xylem; tc, tannin-containing cell)



Mean layers of fibre cell bundles per triangular wedge in the transversal sections of the three different stem segments of dark jute mutant *bfs* and its wild-type JRO 632 at the two different growth stages (70 and 120 days after sowing). Means with common letters at a growth stage are not significantly different at $P \leq 0.05$, according to Tukey's honestly significant difference (HSD) test

Cotton leaf curl virus resistant cotton transgenics

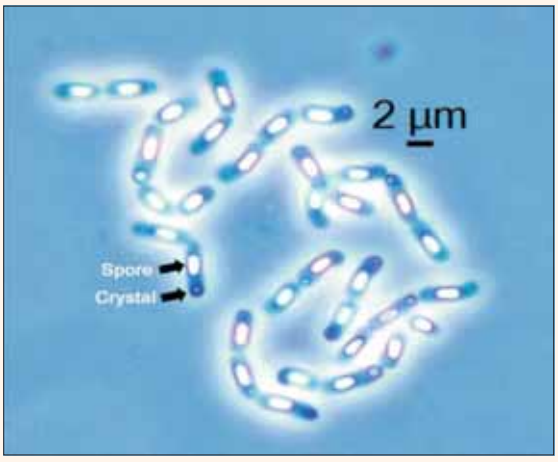
Cotton leaf curl virus (CLCuV) resistant transgenics were developed in elite genotypes of cotton, H777, HS 6, F 846, with sense coat protein, antisense coat protein, antisense *rep* (replicase protein) gene via *Agrobacterium*-mediated transformation. Gene integration was confirmed by PCR, RT PCR and Southern blot.

The transgenic plants screened in the polyhouse with viruliferous whiteflies (24 hours after acquisition period) did not show any symptoms, and were resistant to cotton leaf curl disease.

CLCuV resistant transgenic plants showing no symptom of the disease

New *cry8* gene harbouring *Bacillus thuringiensis* isolated

A new *cry8* gene harbouring *Bacillus thuringiensis* (*Bt* 62) with 130 kDa protein has been isolated from India, which can encode insecticidal proteins that are toxic to white grub, *Holotrichia serrata*. Preliminary bioassay studies against first instar *H. serrata* indicate potential to use this gene for further research on means of sowing sugarcane. This is the first report of *Bt* exhibiting toxicity to *H. serrata.*



Cells of a new coleopteran isolate of *Bacillus thuringiensis* (Bt 62) showing spores and crystals

bidi-tobacco variety is found suitable for cultivation in rainfed areas, especially in deep-black cotton soils of Kurnool (Andhra Pradesh). It has more leaf thickness as compared to A 119, and has higher burning quality, good colour and higher smoking quality.

Biotechnology

Isolation and characterization of wound- inducible promoter in rice: The expression patterns of four wound-inducible genes, *chitinase*, *PR1a*, *PR10* and *HRGP*, were analyzed using real time PCR; expression of *PR10* was found highly induced through wounding compared to other three genes. Relative expression of *PR10* was the highest at the adjacent site of wounding also, immediately after wounding. After 3 hours of wounding, relative systemic expression of *PR 10* was highest in unwounded next lower leaf. The upstream of *PR10* gene has been cloned and sequenced. In-silico analysis has shown the presence of different putative promoter elements. The promoter sequence isolated was fused with *gus* gene, and was transferred to heterologous systems to study efficacy of this sequence for expression on wounding.

DNA fingerprinting

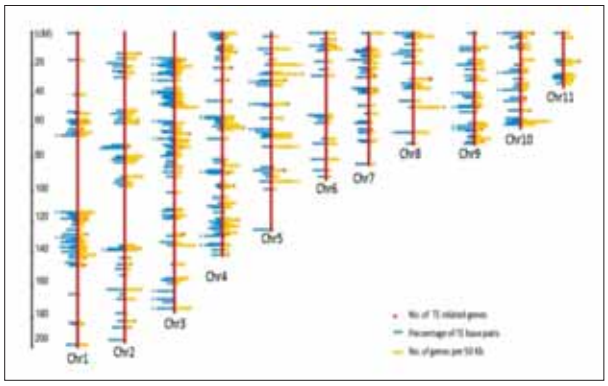
With the use of amplified fragment length polymorphism, simple sequence repeat and expressed sequence tag-derived simple sequence repeat markers, 285 genotypes of *Jatropha curcas* were identified into five distinct and diverse groups. SSR markers were used to characterize wheat, cotton and flax (32, 25 and 15, respectively) germplasm, and mini-core collection of fingermillet (using two genomic and six functional markers), and of sesame for identification of twelve yield-related quantitative trait loci.

Marker development: New SSR markers were developed through genomic library construction in fingermillet, *Andrographis*, *Tinospora*, bittergourd and mungbean, and by transferability from related species in bottlegourd and jute.

GM detection: Detection protocols were developed for GM maize events, including stacked events (using simplex/multiplex PCR assays), and for *Bt* brinjal and *Bt* cabbage (construct-specific PCR-based using nested PCR). Molecular testing was done of imports (18 samples) including transgenic rice (429 samples) for specific transgene/promoter/terminator/marker genes and for ensuring absence of embryogenesis deactivator gene with primers specific to *cre-lox* system.

Seed-specific gossypol reduction in cotton-seed: To silence gossypol biosynthesis in cotton-seed through RNA interference, RNAi construct was generated for target gene coding for δ Cadinene synthase under seed-specific promoter and was confirmed through restriction analysis.

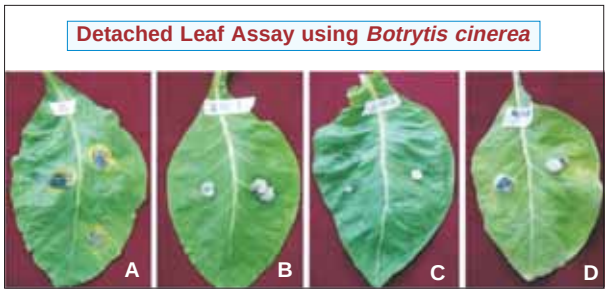
Pigeonpea genome: This Whole Genome Shotgun project has been deposited at the DDBJ/EMBL/GenBank under the accession AFSP00000000. The 454 GS-FLX large sequence contigs, containing ~511 Mb of high quality sequence, were used for gene prediction using FGENESH software. Total 59,515 genes have been predicted; out of which 47,004 are protein-coding genes



High density intra-species reference genetic map of pigeonpea

and 12,511 genes are TE related. All protein-coding genes are further classified into several functional categories.

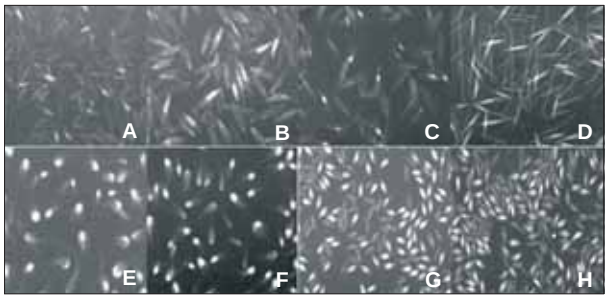
***Botrytis* resistance in castor:** Multigene cassettes were developed for imparting tolerance against *Botrytis*, a major disease in castor. Each of these cassettes carries three introduced genes, *BIK 1*, *ERF 1* and *EBP 1* which were previously reported to impart partial resistance against *Botrytis* pathogens.



BIK 1, *ERF 1* and *EBP 1* tobacco transgenics were more tolerant to *Botrytis cinerea* than control (Four days of infection with *Botrytis cinerea*). A. Control; B., C., D., transgenic tobacco leaves

Seed technology

Quick method for determining seed-setting in grasses: Soft X-ray radiography method was used for determining filled and unfilled seeds of range grasses. Filled seeds were shining, whitish, and unfilled or partially filled seeds were dull-gray or dark. In all the grasses, Deenanth grass (*Pennisetum pedicellatum*), guinea grass (*Panicum maximum*), anjan grass (*Cenchrus ciliaris*), lampa grass (*Heteropogon contortus*), *Chrysopogon fulvus*, *Brachiaria decumbens*, *Dichanthium annulatum*, filled/ unfilled grains ranged from 6 to 44%.



Seeds of different grass species: A. *Sehima nervosum*, B. *Pennisetum pedicellatum*-BD 1, C. *P. pedicellatum*-BD 2, D. *Heteropogon contortus*, E. *Cenchrus ciliaris*-CAZRI 2178, F. *C. ciliaris*-CAZRI 75, G. *Panicum maximum* – BG 2, H. *P. maximum*-BG 2 DC.

Seed production: New areas for hybrid-seed production, identified based on the favourable climatic conditions, higher seed yield and better benefit : cost ratio for different crops, are as follows.

Rice	: New areas are Koppa, Tumkur and Kollegal districts of Karnataka; Bagpat district of Madhya Pradesh
Sunflower	: Bagepalli taluk of Chikkaballapur district in Karnataka
Sorghum	: Akola in Maharashtra
Pearl millet	: Bundi area of RAU, Durgapura
Pigeonpea	: Jabalpur and Seoni in Madhya Pradesh

Seed germination: Seed treatment with *Trichoderma viride* at 6 g/ kg of soybean-seeds was found most effective in increasing seed germination by 15.71% and reducing seed-rot-causing pathogens by 72.73% and seedling blight by 87.50%.

Treatment of maize, soybean, hybrid rice and cotton seeds with vitavax 200 at 2 g/kg of seeds or Polykote^{TM} at 3 ml/kg + vitavax 200 at 2 g/kg of seeds and storing in poly-lined gunny bags was found most effective in improving seed germination and in reducing mycoflora associated with seed storage.

Seed storage: Seeds stored in 40% CO_2 can provide complete protection against *Rhizopertha dominica* in wheat up to 9 months storage and *Sitotroga cerealella* in paddy up to 6 months, *Callosobruchus* spp. in mungbean and urdbean up to 12 months of storage without affecting seed quality.

Soybean seed processed at 12–14% moisture content showed minimum mechanical damage and maximum seed quality.

Breeder seed production: In 2011–12, 9,838.30 tonnes of breeder seed, 13,228.20 tonnes of foundation seed, 20,540.80 tonnes of certified seed, 14,860 tonnes of truthfully labelled seed and 4,436.60 tonnes of planting materials were produced. Besides this, 402.84 lakh planting materials and 0.39 lakh tissue culture plantlets of field crops were produced.

A total of 309.1 tonnes seed-cane of released sugarcane varieties was produced and supplied to farmers. Eight hundred and sixty tonnes of sugarcane seed of recently released varieties was produced at Lucknow for distribution to farmers in the subtropical regions through sugar-mills.

Pollinators

In pigeonpea, bumblebees *Megachile* spp. were relatively abundant, followed by *Xylocopa* spp. and in sunflower, *Apis dorsata* was dominant, followed by *Megachile* spp. and *Xylocopa* spp.

The weed, *Spermacoce hispida*, supported pollinators on pigeonpea and sunflower, and the main pollinators were *Apis cerana*, *A. florea* and *A. dorsata*.

HORTICULTURE

Fruit crops

Banana selection (NRCB Sel-003) for second consecutive year was superior in all biometric traits and recorded 17.53% yield increase over local Monthan. Of the 30 hybrids screened, hybrids 4 and 15 were observed resistant to nematode, *Pratylenchus coffeae* and *Meloidogyne incognita*, respectively.

Two clones of Nagpur mandarin, one early-maturing-N_2 (February first week) and another less-seeded-N_4 (lesser than 3 seeds/fruit), were identified and are being further evaluated at different locations.

Inter-generic papaya hybrid progenies, confirmed through molecular characterization using ISSR markers [(cv. Surya (*Carica papaya* L.) and *V. cauliflora*] were evaluated for field tolerance to papaya ring spot virus (PRSV). The progenies, viz. R_1P_{16}, R_1P_{17}, R_2P_{17}, R_1P_{20} and R_1P_{24}, were selected and sibmated for advancing to next generation (F_5).

Intergeneric papaya hybrid, Arka Surya x *V. cauliflora*, selected in F_4 generation, has good TSS (12-13°Brix), pink pulp and field tolerance to PRSV

In apple, 14 new indigenous Ambri selections were made, and CITH-A-37, 38, 39, 40 and 41, were superior in yield and quality. In almond, CITH-Almond 7, 10, 22, 23, 24 and 25, and apricot, CITH-Apricot 7, Erani, Afghani and CITH-Apricot 32, were promising.

In cherry, 21 new clones superior in yield and quality have been identified through extensive survey and CITH-Cherry 24, CITH-Cherry 25 and 28, were most promising. In pear, two high-yielding sweet and juicy Kashmiri Nakh selections, CITH-Nakh 1 and CITH-Nakh 2, were collected and maintained in field gene bank.

CITH-Cherry 24 CITH-Cherry 25 CITH-Cherry 28

Promising cherry selections

Six hybrid crosses with 609 pomegranate plants were screened for resistance to bacterial blight using challenge inoculation. Sixty plants of hybrid [Bhagawa × (Ganesh × Nana)] × Daru, 13 of Bhagawa × 3/3 [(Ganesh × Nana) × Daru], 12 of Bhagawa × 3/5 [(Ganesh × Nana) × Daru] and 10 of NRCP hybrids were free from bacterial blight after inoculating them with a local strain of *Xanthomonas axonopodis* pv. *punicae*. Two accessions of Rambutan (CHES-R 27 and CHES-R 31), a promising future fruit was identified. These are early-maturing, having higher Brix (17.5°) and yield potential of 1,000–1,500 fruits/plant.

Strawberry hybridization was effected in 21 parental combinations for introgression of fungal disease resistance; 416 fruits were harvested to yield 3,266 seedlings. Three hundred forty-four hybrids with various degree of tolerance to different fungal diseases (based on one season of screening/field survival) are being furthered for rigorous screening. The survival rate of hybrid population derived from Howard 17 as one of the parents was higher compared to either Gorella or Earliglow.

Over 3,000 hybrid passion fruit (cv. Kaveri) seedlings crossed using pollen from two different yellow types were raised and evaluated. High variability and heterosis for yield and most of the characters were observed. Fruit weight ranged from 2.15 to 124.1 g and TSS from 13 to 21° Brix. Some low acid-sweet types (direct consumption as table fruit) have been identified for further evaluation.

Vegetable crops: Improved chilli varieties (Arka Kyati), cauliflower (Arka Vimal and Arka Spoorthi), pole type dolichos (Arka Swagath), yard long bean (Arka Mangala) and garden peas (Arka Priya and Arka Pramodh) were identified for release. Yellow vein mosaic virus (YVMV) disease resistant lines in okra (IIHR 285-54-11-1, IIHR 296-22-4 and IIHR 299-52-5), powdery mildew resistant lines in ridge gourd (RGDMR 1 and RGDMR 2) and mungbean yellow mosaic virus resistant lines in French bean (IC 525283 × IC 525260)–09-1-5-2) were further evaluated. Two varieties of chilli (Kashi Sinduri and Kashi Gaurav) and one hybrid of tomato (Kashi Abhimaan) were notified by the central varietal release committee.

Three onion (Bhima Shubra, Bhima Shweta and Bhima Shakti) and one garlic (Bhima Purple) varieties were released. Further, haploid induction in onion was tried through gynogenesis. Root tip squash from a few gynogenic regenerants were evaluated. In garlic, five collections of long day type having higher yield and quality were made. The clone, CITH-G 5, recorded highest plant height (109.75 cm) and number of leaves/plant (8.25), while highest yield was recorded in CITH-G 2 (212.25 q/ha), closely followed by CITH-G 1 (202.99 q/ha).

Marker-assisted selection was carried out to identify pyramided lines in F_6 and F_7 families, segregating for three major genes against tomato leaf curl virus (TLCV). The marker assays included the CAPS marker for *Ty-1* and SCAR markers for *Ty-2* and *Ty-3* genes. A total of six lines carrying all three major genes in homozygous state were identified. Evaluation of these lines for agronomic and morphological traits was completed in two seasons. Pyramided line, D6-1-4, was observed superior to other lines in resisting TLCV infection.

To develop moisture-stress tolerant tomato, '*BcZAT12*' gene, (Accession no. DQ166621), driven by drought-specific promoter '*lea1*' cloned in *Agrobacterium tumefaciens* strain GV 3101, was used for transformation. A total 16 lines from 10 independent events were obtained and rooted on 100 mg/litre rooting medium. These lines were tested for gene integration by PCR and southern blot using P^{32} labelled *BcZAT12* probes. Physiological and biochemical data of these events revealed significant moisture tolerance.

Ornamental crops: In gladiolus, five promising selections and a mutant were selected based on qualitative traits. The promising hybrid selections, i.e. in orange-red group (IIHRG 3), in yellow group (IIHRG 4), and in purple-violet group (IIHRG 12), which are suitable for cut flower purpose, were further multiplied. Further, IIHRR 7-1, IIHRR 7-2, IIHRR 7-7, IIHRR 204 and IIHRP 3-18-2 entered AICRP trials.

Spices: Eight cardamom hybrids, NKE 12 × MB 5 (1,499 kg/ha), MB 5 × NKE 19 (1,461 kg/ha), GG × NKE 12 (1,350 kg/ha), RR 1 × CCS 1 (1,245 kg/ha), CCS 1 × RR 1 (1,022 kg/ha), ASH (1,930 kg/ha), NKE 12 × GG (1,746 kg/ha), GG × NKE 19 (1,635 kg/ha), were identified for high yield and resistance to mosaic and rhizome rot diseases. Two unique mutants, AFgM-3 and AFgM-4, for powdery mildew resistance were isolated in fenugreek. In ajwain, AA 93 has been developed which flowers 40 days earlier compared to other varieties. Thirty-two elite saffron clones were selected and evaluated for fresh and dry weight of pistil, stigma and style length, and weight. CITH 125 (4.5 kg/ha), CITH 123 (4.3 kg/ha), CITH 124 (4.3 kg/ha), CITH 122 (4.0 kg/ha), CITH 12 (4.5 kg/ha), CITH 121 (3.9 kg/ha), CITH 107 (3.8 kg/ha), CITH 120 (3.8 kg/ha) and CITH 104 (3.7 kg/ha), having higher saffron yield were identified.

Elite saffron clones in flowering

Palms and nuts: Three coconut varieties (IND 045S, IND 048S and IND 058S), two arecanut varieties (VTL

The 6 -year old promising dwarf oil palm

62-Shriwardhan selection and VTL7-Nalbari) and two selections of cocoa (VTLC 1 and VTLC 57) were identified for commercial cultivation. Coconut variety, Kalpa Samrudhi, was recommended for commercial cultivation in Kerala and Asom, and Kalpa Sankara and Kalpasree for coconut root (wilt)-affected tracts in Kerala. Molecular-markers associated with hybridity in coconut, dwarfness and resistance to root (wilt) and yellow leaf diseases were utilized. Homology-based modelling of somatic embryogenesis receptor-like kinase (SERK) protein in coconut, development of a computational tool for detection of microsatellites in whole genome sequences, development of algorithm for gene annotation and genome-wide analysis of microsatellites in strains of plant growth promoting (*P. fluorescens*) are achievements in bioinformatics.

To develop dwarf and compact oil palm, Dwarf Tenera 1 from Palode (Kerala) was selfed and its progeny was evaluated. Of the 58 palms evaluated, 23 recorded lesser than 40 cm and of which 4 palms recorded increased height of lesser than 30 cm per annum. One palm which recorded lesser than 25 cm height increment had a Bunch Index of 0.43 against the standard value of 0.3 for normal D × P material.

Medicinal crops: A pure line selection of *aswagandha* (IIHR-WS-3) was released having significantly high dry root yield (12 q/ha) and withanolide content (0.58%) for Karnataka. Of the 13 *Coleus forskholii* hybrids evaluated, Hy 08-129 recorded significantly higher root yield (95.53 g) over control (K 8).

❑

7. Livestock Improvement

Cattle

Frieswal cattle: The total population of Frieswal females at 37 Military Farms (MFs) at the end of reporting year was 16,714 including 10,043 adult cows, 5,096 young stock and 1,575 calves. The strength of elite cows at various Military Farms was 1,021. The highest number of elite cows (99) was at MF Pimpri followed by Ambala (98) and Lucknow (97). Frozen semen doses (55,635) of high genetic merit Frieswal bulls were distributed to different Military Farms. Besides this, frozen semen doses were sold to different stakeholders for improvement of farmers' animals. The overall least square means of 300 days milk yield (MY300), total milk yield (TMY), peak yield (PY) and lactation length (LL) were 3,273.77 kg, 3,355.05 kg, 15.14 kg and 334.32 days, respectively. Mature 300 days lactation milk yield of 3,612 kg was achieved.

Conservation of indigenous cattle: So far 65 Ongole bulls have been inducted in the programme and 3,410 daughters were produced from them. Bulls (32) of first four sets were evaluated for their genetic worth on the basis of their daughters' first lactation milk yield. Kankrej (8), Sahiwal (7) and Gir (6) bulls were introduced in first set under the programme, and semen doses were used for artificial inseminations.

Field progeny testing programme: Genetic improvement of crossbred cattle in field conditions under FPT programme is in operation at Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana; Kerala Veterinary and Animal Sciences University (KVASU), Thrissur, Kerala; BAIF Research Development Foundation, Uruli-Kanchan, Pune; and GB Pant University of Agriculture and Technology (GBPUA&T), Pantnagar. The average 305 days first lactation milk yields of the progenies of bulls under test in different batches were 3,133.8±38 kg at GADVASU, 2,715.0±71 kg at KVASU and 3,065.65 kg at BAIF, and the average age at first calving was 1,127.4±17.1, 1,435.1±21 and 952.52 days, respectively. The average first lactation 305 days milk yield of the HF crossbred progenies in adopted villages of FPT areas increased by 27.9% at GADVASU Ludhiana, 83% at KVASU Thrissur, and 11.76% at BAIF Pune.

Cattle calf 'Holi' produced through OPU-IVF technique: Using Ovum Pick-Up technique first time, a cattle calf was produced in India. The female Sahiwal calf born on 7 March 2012 with a normal birth weight of 23 kg, was named 'Holi'. This technology will be useful for harnessing valuable germplasm from live infertile and aged dairy cattle.

A cow with calf at Field Progeny Testing Unit, Pune

Buffalo

Semen conservation and dissemination: Field champion buffalo bulls available with farmers were identified for semen collection at farmers' door. Doses (20,271) of frozen semen were produced and supplied/ sold to farmers.

Field progeny testing programme: Under the field progeny testing programme AI were done on farmers' buffaloes in the field, which resulted in 6,510 calvings. Till date, test day monthly milk yield on 236 progenies has shown average age at first calving of 41.67 months, and average milk yield of 7.83 kg/day was recorded from farmers' animal in the field.

Sheep

Improved prolific sheep: Crosses of Garole and Malpura (GM) produced 47.92% multiple births. In GMM (GM × Malpura), the body weights at birth, 3-, 6- and 12-months of age were 2.25, 11.80, 16.80 and 25.88 kg respectively. Tupping and lambing rates were 94.93 and 90.78 with twining rate of 43.01%. In GMM ×

Crosses of Garole and Malpura (GM) produced 47.92% multiple births

Patanwadi (three-breed cross), body weights of lambs were 20.15 and 32.5 kg at 6 and 12 months of age and 21.47 kg at 6 months in the reciprocal cross (Patanwadi × GMM).

Network Project on Sheep Improvement

Chokla: The birth, 3-, 6-, 9- and 12-month body weights of the lambs were 2.73, 12.88, 21.41, 23.76 and 25.74 kg respectively. The greasy fleece yield in first 6-monthly clips, adult 6-monthly and adult animal were 1.25, 1.36, and 2.52 kg respectively. Tupping and lambing per cent on ewe's available basis was 99.13 and 103.74, respectively.

Marwari: The average birth, 3-, 6-, 9- and 12-month weights for the year were 3.13, 17.24, 24.37, 27.35 and 30.07 kg respectively. The overall tupping and lambing per cent on ewe's available basis were 96.56 and 94.37 respectively. The average fibre diameter and medullation were 37.01µ and 57.9% respectively.

Muzaffarnagari: The birth, 3-, 6-, 9- and 12-month body weights of the lambs were 3.72, 16.92, 21.63, 26.52 and 31.71 kg respectively. Tupping was 103%, and lambing per cent based on ewes available and tupped was 91 and 88.2 respectively**.**

Deccani: Average body weight at birth, weaning, 6-, 9- and 12-months of age were 3.42, 15.55, 21.84, 23.02 and 24.41 kg respectively. The tupping per cent was 93.88 while the lambing based on ewes available was 84.17%. Survey of Deccani sheep was conducted in the breeding tract for identification of farmers' flock, selection of flocks, establishment of centres and collection of baseline data.

Nellore: The overall means for body weight at birth, 3-, 6-, 9- and 12-months of age were 3.20, 14.03, 18.56, 23.23 and 24.44 kg respectively.

Magra: The average body weights at birth, 6 and 12 months and adult stage were 3.05, 21.71, 30.84 and 39.71 kg respectively. Average greasy fleece weight at 6-month age and the adult animal were 1,012 g and 2,243 g, respectively.

Madras Red: Overall mean of body weights for lambs born during the year were 2.83, 11.36, 15.46, 19.28 and 22.31 kg, respectively, at birth, weaning, 6, 9 and 12 months of age.

Ganjam: The body weights at birth, weaning, 6 and 12 months of age were 2.70, 11.62, 16.98, 21.51 and 24.64 kg; and 84.29 % lambing was observed during the year.

Sheep Seed Project

Flocks of Chottanagpuri, Mandya, Mecheri and Sonadi sheep were built up for production of superior sheep seed. Surveys were conducted in their breeding tract for identification and selection of flocks, their registration and collection of baseline data. Breeding rams of Chottanagpuri (61), Mandya (45), Mecheri (84) and Sonadi (34) were distributed to the field units to cover breedable ewes.

Goats

Selective breeding has resulted in significant improvement in body weight, kidding rates, milk yield and population growth both under farm and field conditions in Barbari, Jamunapari and Jakhrana goat breeds. The improved flocks maintained at institutional farms had 25-45% higher body weight at 12 months of age than the base population. Introduction of superior germplasm has enhanced body weight (up to 79%), population growth (up to 63.26%), and kidding per cent (up to 84.58%) in farmers' flock as well. A Barbari doe, under field conditions, produced record number of 13 kids in 3 kiddings—including two quintuplets born. Introduction of superior genetic resources has also facilitated conservation of indigenous goats with considerable enhancement in the income of goat keepers ensuring better nutritional and livelihood security.

Camel

An elite herd of 355 animals of Indian camel breeds comprising Bikaneri, Jaisalmeri, Kachchhi and Mewari has been established at Bikaner following continuous selection for two decades. The Bikaneri, Kachchhi and Mewari are good milch breeds. The Jaisalmeri breed is excellent for racing. The milk production potential of Indian dromedary breeds is 7 litre/day with some of the best milkers producing more than 10 litre/day. Although camels continue giving milk up to 24 months the average length of lactation is around 16 months.

Rabbits

In Angora rabbits, fibre yields of 151.33, 169.39, 155.96, 152.59, 182.21 and 176.57 g for first to sixth clips, respectively, with staple length, fibre diameter and gaurd hair of 65.86 cm, 12.66 µ and 3.75%, respectively were recorded. German Angora rabbits were distributed among farmers and NGOs for improving Angora wool production. In White Giant and Soviet Chinchilla broiler rabbits, body weight of 2.01–2.02 kg at 12 weeks of age was achieved. Broiler rabbits of both the breeds were also popularized among farmers for improving meat and fur production.

Poultry

The CARIBRO-Mritunjai bird was adjudged to be the best genetic group for production under hot-tropical climate as they exhibited highest means for production traits and also heat stress tolerance.

Genetic improvement of poultry for eggs

Under the AICRP on Poultry Breeding, six pure lines of White Leghorn chicken (IWH, IWI, IWD, IWF, IWN and IWP) were improved through intra population selection. At the KVASU, Mannuthy centre the hen house egg production up to 40 weeks of age increased in both IWN (by 3.4 eggs) and IWP (by 4 eggs) over the previous generation. The average genetic response for egg production to 40 weeks of age in IWN (2.99 eggs) was higher than IWP (2.18 eggs) in the last nine generations. The average genetic response of egg production to 40 weeks of age (1.95 in IWN and 2.08 in IWP) in both the selected strains was positive over the last nine generations

at the AAU, Anand centre. The average genetic response for egg production up to 64 weeks of age for last 11 generations was 0.99 egg in IWD and 0.58 egg in IWF, respectively, at the SVVU, Hyderabad centre. The genetic response of egg production up to 64 weeks of age was –1.67 eggs in IWI and 1.37 eggs in IWH in the last eight generations at the CARI, Izatnagar.

The rural poultry centers evaluated different native and exotic germplasm for field conditions. The MPPCVV, Jabalpur centre evaluated a cross having Kadaknath (25%) and Jabalpur Colour (75%) with promising performance and acceptance by the farmers. At the MPUAT, Udaipur centre, terminal crosses (RIR × Native) × RIR (RNR) and (Broiler × Native) × RIR (BNR) were produced and evaluated. These two crosses will be used for backyard poultry farming.

Genetic improvement of poultry for meat

Under the AICRP on Poultry Breeding, five synthetic colour broiler populations were improved through mass selection for 5-week body weight in sire lines (PB 1 and CSML) and 5-week body weight along with egg production in dam lines (PB 2, CSFL and SDL). The average genetic and phenotypic responses in PB 2 were 3.71 and 12.07 g, respectively, over last seven generations at the KVAFSU, Bengaluru centre. Over the last six generations, the 5-week body weight in PB 2 improved by 30.14 and 15.2 g per generation on phenotypic and genetic scale at the GADVASU, Ludhiana centre. Commercial cross in the field attained body weight of 1,552 and 1,996 g at 6 and 7 weeks of age, respectively. Body weight at 5 weeks was improved in Coloured Synthetic male line (CSML) and Coloured Synthetic female line (CSFL) at the CARI, Izatnagar centre. The genetic response was 16.61 g in CSML and 16.05 g in CSFL line per generation for 5-week body weight over last 11 generations. The body weight of Synthetic Dam line (SDL) at 5 weeks of age was 1,088 g and was improved over previous generation by 18 g at the OUAT, Bhubaneshwar. The strain cross from Bengaluru centre recorded 1,476 g and 1,742 g at 6 and 7 weeks of age, respectively, in Random Sample Poultry Production Test (RSPPT), Gurgaon.

At the Project Directorate on Poultry, three coloured broiler lines namely, PB 1, PB 2 and control broiler were conserved and evaluated. In PB 1, the genetic response over the last generation was 36 g (S 22). In PB 2 (S 21) there was an improvement of 16.8 g on genetic scale in 5-week body weight over the last eight generations.

Fish

Open sea cage farming: Marine fin fish cobia (*Rachycentron canadum*) was evaluated for its potential for cage farming because of its rapid growth rate and high quality lean flesh. Cobia cage aquaculture was initiated in circular open sea floating net cages. Cobia juveniles, ranging in size from 13 to 15 cm, with weights of 10 to 15 g, respectively, attained a body weight of 24.85 kg after 2 years of rearing with average FCR of 1:1.6. The fish grew @ 7.75 g/day in initial 4 months,

Cobia (*Rachycentron canadum*) has potential for cage farming

26.35 g in next 11 months and 44.78 g in second year of rearing. Its successful farming can provide opportunity for export earnings as it is highly prized fish across the world.

Strategies for fisheries enhancement in reservoirs: A working module was developed to enhance the fish production in Dimbhe reservoir, Pune, Maharashtra through community co-management. Production of reservoir was improved by plantation of green manure crop, *Sesbania aculeata* (*dhencha*), which increased primary production from 250 mgC/m^3/d, to 300 mgC/m^3/d, soil organic carbon from 0.45 to 0.85%, nitrate nitrogen and phosphorous from 0.12 to 0.20 mg/litre and 0.01 to 0.05 mg/ litre, respectively, reflecting comparatively more availability of nutrients during the course of project period. Seed reared in cages within the reservoir was used for stocking the reservoir. The community was trained for aquaculture practices for rearing fry to fingerlings and for taking up stocking programme of the reservoir resulting in enhancement of fish production.

Dimbhe Reservoir with *in situ* seed rearing in cages

Seed production of chocolate mahseer: The breeding and rearing of chocolate mahseer (*Neolissocheilus hexagonolepis*) available mainly in North-Eastern Himalyan streams was successfully carried out at Bhimtal (Central Himalaya). The fecundity of chocolate mahseer was found to be 6,000-8,000 eggs/kg body weight, breeding period August-September, fertilization 95%, hatching 80%, incubation period 38-

Egg and larval development of chocolate mahseer (*N. hexagonolepis*)

40 hr, egg color light yellow- lemon yellow. The study revealed that chocolate mahseer under temperature 19°–23°C (March) gained high body weight as compared to the other months in both the culture systems.

BRD for the bagnets: Based on the length weight relationship and using linear regression analysis of the juveniles of fishes caught in stationary bagnets, the optimum mesh size for the BRD for the bagnets operated along the Hoogly estuary, Kolkata, was fixed as 50 mm for conservation of *Tenualosa ilisha*. Selectivity trials are being carried out using 50 mm mesh size square mesh windows and cover in the bagnets in Hoogly estuary for the first time and the juveniles of several species could be eliminated through the BRD.

❑

Success story

Black pearls produced through culture

The black pearls were cultured for the first time under the MOES funded black lip pearl oyster farming project operated from Port Blair in Andaman and Nicobar Islands. The oysters *Pinctada margaritifera* were seeded and after more than 300 days, the pearls were harvested. The pearls were oval/baroque in shape, measuring 4.8 mm × 3.7 mm and weighed nearly 80 mg. The pearls which were grey-black with golden hue were valued at US$ 40–50 each.

8. Crop Management

PRODUCTION

Cost-effective farming systems for field crops cultivation for increasing production and productivity in different agroecologies have been developed.

Cereals

High temperature stress at the panicle initiation stage in rice gave 40% seed-set in female-plants, and it was 60% in male-plants. System of rice intensification (SRI) method (12-day-old seedlings, 25 cm × 25 cm spacing, organic source through FYM at 5.0 tonnes/ha and weeding by cono-weeder) was compared with the practices when various nutrient- and weed- management practices were taken separately, keeping unchanged seedling age and spacing of the SRI method. Chemical fertilizers at 120% RFD significantly enhanced yield over organic manure. Herbicide azimsulfuron at 35 g a.i./ha (low dose high efficacy and safe) gave rice yield on a par with cono-weeder.

Rice yield of Sampada variety in the system of rice intensification with application of only organic fertilizers or both organic and inorganic fertilizers was significantly higher (8.16–8.32 tonnes/ha) than that obtained under the best management practices (6.99 tonnes/ha).In rice hybrid KRH 2, application of micronutrient-enriched compost, field-fortified poultry or vermi compost manure resulted in enhanced grain yields.

Nitrogen management plays an important role in aerobic rice production. Leaf colour chart-based N recommendations resulted in higher agronomic N- use efficiency (17–18%) and its recovery efficiency (26–30%) over the recommended doses of fertilizers. In aerobic rice, pre-emergence application of pendimethalin (1.5 kg/ha), followed by post-emergence application of bispyribac sodium (20 g/ha) lowered weed population and increased biomass and grain yield.

Highest production efficiency (REY 14.9 tonnes/ ha) and lowland utilization efficiency were observed in Odisha in rice–potato–sesame cropping system, although rice–maize–cowpea was found the most economical system.

Crop diversification in waterlogged rice fields

Crop diversification in the rice field was possible by using jute-reinforced soil columns of different dimensions. Early season vegetables were grown successfully in rice-vegetable relay system to fetch better market price (₹1.5 to 3 lakh/ha) without affecting rice yield. Raising seedlings of field crops (mustard, *arhar* etc)/vegetables (cucurbits, okra, rajmash) in small jute-bags was found effective to cope with late harvest of rice and timely planting of sequential crops in waterlogged situation.

Rice–fish–horticultural crops–agroforestry-based integrated farming system model developed at Cuttack for deep-water ecology generated a net income of ₹ 1 lakh/ha. Integrated rice–fish farming system, developed for flood-prone areas at Gerua (Odisha), gave gross income of ₹1.63 lakh/ha.

For maximizing wheat production in the North-Western Plains Zone (except Durgapura), two irrigations (30 and 85 DAS) are enough, and so are for the North-Eastern Plains Zone also. For long-term sustainability in the Northern Hills Zone, substitution of 25% of inorganic fertilizers with organic fertilizers (vermi compost) should be adopted in place of the practice of 100% inorganic fertilizers use.

Nitrogen applied just before irrigation gave higher wheat yield compared to its application after irrigation, and three split applications were better than two splits.Urea coated with 1,000 ppm karanj oil/ palmarosa oil/citronella oil/neem oil saved 30 kg N/ha (recommended dose is 150 kg N/ha).Thus, resulting in saving of 20% in fertilizer cost.

For controlling multiple herbicide-resistant *Phalaris minor* populations in wheat-crop, pendimethalin as pre-emergence or pyroxasulfone as post- emergence has been found promising practice.

In malt-barley, row spacing of 18 cm with seed rate of 100 kg/ha should be adopted in timely as well as late sown production conditions of the North-Western Plains Zone to maximize productivity.

In pearl millet–pigeonpea (2 : 1) intercropping system in Karnataka, a medium-duration pigeonpea variety (160–165 days) gave higher pearl millet equivalent yield, net returns and B : C ratio.

Small millets

In Odisha, zinc at 12.5 kg/ha and in Jharkhand and southern Karnataka, boron at 5 kg/ha enhanced productivity of fingermillet in rainfed areas. Fingermillet with pigeonpea (4 : 2) in Jharkhand, fingermillet with pigeonpea (8 : 2) in Odisha and kodo millet with pigeonpea (2 : 1) in Madhya Pradesh were promising systems. In medium-black soils of Andhra Pradesh, foxtail millet (*kharif*)–chickpea (*rabi*) sequence proved remunerative compared to fallow–chickpea system.

Under low fertility rainfed areas, little millet varieties RLM 36 and RLM4 1 in Madhya Pradesh and Sabara in Odisha; fingermillet GPU 66 in Karnataka, PR 202 in Odisha and Jharkhand, GPU 28 in Tamil Nadu and Maharashtra, HR911 in Chhattisgarh and PRM 2 in Uttarakhand improved productivity of the areas.

Oilseed crops

Arbuscular mycorrhizal fungus, *Glomus mosseae*, application resulted 13% increase in groundnut yields. Newly isolated groundnut rhizobia RH 11, RH 17 and RH 20 inoculation enhanced pod yield of groundnut TG 37A; RH 11 was the best.

To achieve higher productivity from the newly released soybean varieties, optimum sowing date is from 20 June to 5 July for the North Plain and Central Zones and 15 June to 30 June for the North-Eastern and Southern Zones. The optimum seed rate recommended is 65 kg/ha in all zones, excepting North-Eastern Zone (its 55 kg/ha). And row spacing is 45 cm for Central, North Plain and North-Eastern Zones and for the Southern Zone, it is 30 cm.

Optimum nutritional levels recommended for soybean in the North Plain and North-Eastern Zones are 125% RDF + FYM at 5 tonnes/ha, and for Central and Southern Zones are 100% RDF + FYM at 5 tonnes/ha. Two irrigations at seedling (15–20 DAS) and pod-filling (20 days after flower initiation) are recommended for the North Plain, Central and Southern Zones.

In Alfisol irrigated areas in Bengaluru, sunflower responded significantly up to 120 kg N and 90 kg P_2O_5/ha.

At Mandor (Rajasthan) in the irrigated areas, 75% RDF + 25% N through FYM + seed treatment with *Azospirillum* + phosphate-solubilizing bacteria mixed with FYM applied in furrows gave maximum castor-seed yield, besides improving soil quality. In light-textured soil and assured irrigated conditions at Sardar Krushi Nagar (Gujarat), castor hybrid GCH 7 fertilized with 150% RDF (180-37.5-0 kg NPK/ha) gave higher seed yield and economic returns.

Pendimethalin or fluchloralin at 1 kg a.i./ha + 1 hand weeding at 40 DAS proved to be the best weed management practice for castor in irrigated areas.

Intercropping of mustard+maize (1 : 1/1 : 2) at Bhubaneshwar and Dholi; wheat + mustard (9 : 1) at Varanasi, Kanke and Nagpur, and mixed cropping of wheat+mustard (9:1) at Chatha proved remunerative than sole crops. However, sole wheat at Kanpur and Morena was comparatively more promising.

For chickpea + linseed (4 : 2) intercropping system, linseed varieties Padmini (Sagar), PKVNL 260 (Nagpur), J 23/Indira Alsi 32 (Raichur), Suyog/RL 914 (Kota), Shekhar/Sweta/Shubhra (Shillongani) and Padmini /JLS 67/JLT 26/JLS 9 (Tikamgarh) were found suitable. At Kota (Rajasthan), Raichur (Karnataka), Palampur (Himachal Pradesh), Shillongani (Asom), soil-moisture conservation through available straw at 10 tonnes/ha as mulch in rainfed linseed gave higher net monetary returns of ₹ 18,926, 6,369, 14,866 and 9,113, respectively

Pulse crops

Maize–wheat–mungbean and pigeonpea–wheat systems resulted in a significant increase of 11 and 10% in organic carbon (respectively) and of 10 and 15% in soil microbial biomass carbon as compared to maize–wheat system. Inclusion of pulses in rice-based system also improved soil organic carbon.

Under moisture stress, *Mesorhizobium ciceri* strain 13 and 30 enhanced yield of chickpea RSG 888 up to 27% and 20%, respectively, over uninoculated control. Bacterial isolates No. 1-13 and 1-14a with ACC deaminase activity have been identified as potential candidates to mitigate moisture stress impact on chickpea root development.

The system productivity in terms of chickpea equivalent yield was highest in rice–wheat–mungbean (5,733 kg/ha), followed by rice–wheat (4,211 kg/ha), and was lowest in rice-chickpea (3,738 kg/ha). PGPR strains, CP 11, PSB 11 and J 7, showed consistent response in increasing chickpea grain yield from 14 to 27% over control in the fields for the last two years, and have been identified for commercial use in chickpea.

Commercial crops

In the northern cotton-growing zone, poor plant-stand, mainly due to seedling mortality under high temperature, is a serious problem. By transplantation of raised seedlings, plant stand up to 92.3% and yield up to 3.18 tonnes/ha were observed, which were significantly higher than the normal sown crop (87.5% plant-stand and yield

Sugarcane bud-chip technology for higher seed multiplication

The technology has been developed and standardized for quick multiplication of quality seed-cane as well as to reduce quantity of seed-cane required per unit area. It ensures seed multiplication rate of 1 : 60 in comparison to 1 : 10 under the conventional method. In bud-chip technology, freshly harvested sugarcane stalks of 10 months' age are used to scoop out bud chips and these bud chips are soaked in specially formulated PGR solution for 2 hr, followed by fungicidal treatment for 20 min. They are then planted upright in plastic-trays/cups filled with soil mixture; 25–30 days old settlings are transplanted in well prepared fields to obtain high tillering and uniform plant population. The quantum of seed material required per hectare could be reduced by about 60–80% by weight. The technology ensures higher number of millable canes per clump, and thereby result in cane yield over 100 tonnes/ha under subtropical conditions.

HDPS for maximizing productivity of cotton

Thirty-four promising cotton lines were identified on the basis of compact plant body and short sympodia. These lines showed determinate growth of lateral branches and reduction in boll numbers (6–8 bolls/plant) and possessed good fibre properties. Among the ten genotypes of *G. hirsutum* evaluated under high density (45 cm × 15 cm) on rainfed Vertic Inceptisols of Nagpur; Suraj, ADB 39 and 28I were promising in terms of yield, morphology, earliness and nutrient-use efficiency. Eight cultivars of *G. arboreum* (AKA 07, CINA 404, JK 5, HD 123, PA 183, JLA 794, JLA 802 , JLA 505), CINA 404, HD123, and JLA 505 performed well under high density planting (HDPS) (222,000 plants/ha). Among ten genotypes (Anjali, C 1412, CCH 724-5, TCH 1608, KC 3, F 2383, NH 615, MCU 7, SVPR 3, PKV 081) under HDPS under irrigated conditions, KC 3 recorded the highest seed- cotton yield (2,655 kg/ha), followed by PKV 081 (2,253 kg/ha), Anjali (2,215 kg/ha) and NH 615 (2,121 kg/ha) compared to 1,596 kg/ha obtained with RCH 2 Bt.

of 2.6 tonnes/ha). The net income of ₹ 4,175 was earned due to extra yield from the transplanted crop.

A talc-based dry formulation of microbial consortium for jute was developed for easy handling and use in farmers' fields, and the formulation could ret jute within 13–15 days with fibre strength of 27.8 to 29.9 g/tex.

A mechanical ramie-planting technique has been developed. This technique helped reduce 60–70 % labour cost, and also saved on planting time.

Gum arabic production using gum-inducer technique

In arid western Rajasthan, *Acacia senegal*, which yields gum arabic, is distributed abundantly on the forest land, farmers' fields and common property resources (CPRs). Gum arabic production potential of the area even though immense, has not been fully tapped. Gum-inducer method with mechanization of boring facilitated rapid treatment of trees. Studies have indicated that gum from *A. senegal* is maximum quantity on sandy terrain and best time of treatment is during late March to April.

HORTICULTURE

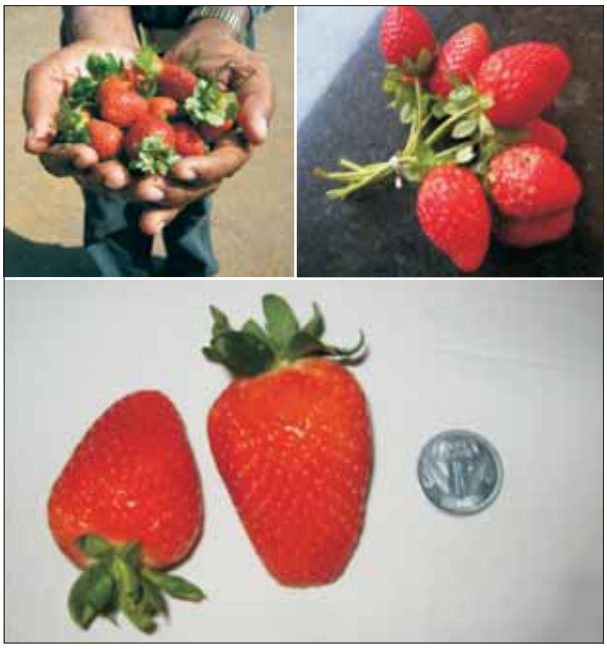
Fruit crops

In banana, planting of 2 suckers/pit at 2.7 m × 3.6 m (2,057 plants/ha) spacing recorded a highest bunch yield (55.13 tonnes/ha), while planting of single plant/pit at 2.4 m × 2.4 m (1,736 plants/ha) (52.43 tonnes/ha), and planting of three suckers/pit at 3.6 m × 3.6 m spacing (2,314 plants/ha) yielded less bunch (49.8 tonnes/ha). In Poovan, soil application of 20 kg FYM + 0.9 kg neem cake + 2.0 kg vermi compost + 0.9 kg groundnut cake advanced fruit maturity (118.3 days) and recorded highest bunch weight (21.8 kg) with more number of hands (12.7) and fingers (201.2) per bunch. Among banana genotypes, Saba exhibited less salt injury (5.78–9.71%) compared to Nendran and Red Banana which exhibited more than 80% of salt injury with 150 mM NaCl treatment.

Intercropping of cabbage and cauliflower with mango

Among different grape stocks scion combinations, Thompson Seedless grafted on 110 R rootstocks and own rooted vines imparted maximum budburst rate after forward pruning which was attributed to increased peroxidase polyphenol oxidase activity and proline in their buds.

Highest yield per vine was recorded on 110 R rootstock while least was on St. George. Sodium in juice was the highest on vines grafted on Dogridge and own rooted vines, while it was least on 110R rootstock. Further, combination of canopy management practices such as cluster thinning, leaf removal, shoot thinning either alone or in combination improved fruit composition parameters (increased TSS, anthocyanin concentration, phenolic contents and reduced pH, and juice potassium) in Cabernet Sauvignon and Sauvignon Blanc grapes.



Soilless culture of strawberry protects crop from soil-borne diseases

Leaf nutrient norms for commercial citrus cultivars (Malta sweet orange, acid lime and Kinnow mandarin) was developed using DRIS (Diagnosis and Recommendation Integrated System) based analysis. To harness solar energy and other natural resources, different plant architectural systems were tried in apple varieties grafted on M-9 rootstock. The cultivar, Starkrimson, recorded maximum proportion of fruits having more than 90% coloured surface, 'A' grade fruits and maximum number of intense colour fruits from surface, middle and inner canopy region. In vertical axis and espalier training system, Coe-Red Fuji registered highest flowers and fruits/tree, followed by Granny Smith. Similarly in peach, maximum fruit setting, fruit yield/ tree, fruit yield/ha and

fruit quality were recorded in tatura trellis system of training. In pomegranate, application of microbial consortium resulted in higher increase in plant biomass as compared to individual microorganism. Further, inoculation of *Penicillium pinophilum* with *K-feldspar* resulted in increase of available potassium and phosphorus content in soil.

Good growth, yield and quality were better with open-trough compared to either Lay-Flat-Bag system and/or Verti-Gro systems. Earliness in flowering (43 days) and highest TSS (10.61°Brix) were also achieved along with higher marketable fruits (78.33%). However, Verti-Gro system accommodated 48% more plants per unit area.

Vegetable crops

Significantly higher yields of 11.45 and 34.98 tonnes/ha were achieved in cowpea and tomato, respectively with zero tillage on permanent ridges and residue retention, as compared to conventional tillage with flat planting and residue removal. In cowpea-tomato cropping system, net benefit obtained was ₹163,208/ha/year with zero tillage on permanent ridges and residue retention as against ₹111,429/ha/year under conventional tillage with flat planting and residue removal. Organic carbon, labile organic carbon, non-labile organic carbon, carbon pool index and carbon management index were higher by 1.98 g/kg, 0.06 g/kg, 1.80 g/kg, 0.34 and 17.5, respectively, under zero tillage with residue retention compared to conventional tillage with flat planting and residue removal.

Seed pelleting techniques for onion, tomato and carrot were standardized. Pelleted onion, carrot and tomato seeds could be stored for 3 months under ambient conditions without reduction in seed germination and vigour. A carrier-based microbial product which contains N fixing, P and Zn solubilizing and plant growth promoting microbes was developed, evaluated and commercialized. The specialty of this technology is that farmers need not to separately apply N fixing, phosphorous solubilizing and growth promoting bacteria individually. Farmers can apply this product conveniently, either through seed, soil, water or nursery media like coco peat.

Ornamental crops

The protocols for *in-vitro* multiplication of selected orchid cultivars were refined. About 21,000 plantlets of Cymbidium and Cattleya hybrids, were produced for demonstration and setting up of quality orchid farms.

Mushroom

Technology is being standardized for production of iron-rich mushrooms through bio-fortification of the growing substrate. The iron content of mushrooms produced on substrate fortified with 0.05% ferrous sulphate significantly increased iron content (167 ppm) over the control (114 ppm). Indigenous strain of tropical edible mushroom species, viz. *Macrocybe gigantea*, was successfully cultivated on pasteurized and composted wheat straw. Different casing materials, viz. FYM, garden soil, spent mushroom substrate, coir pith and rice husk ash were evaluated and successful fructification was observed with all casing material except rice husk ash. The *M. gigantea* has better shelf and better aroma. It could be recommended in tropical and subtropical regions as an alternative to *Calocybe indica* in summer. Zero energy polytunnel composting process was standardized and it produced higher quantum of quality compost in 16–18 days with only 3–4 turnings. The productivity of this compost is around 20–22 kg mushroom per 100 kg compost which is at par or higher than all other available methods. In addition, a cost-effective, small and farmer-friendly passive aeration structure designed for compost production for button mushroom was also developed. It reduces number of turnings required from 8 to 4 and time requirement from 28 to 20 days compared to normal method of composting.

Palms and nuts

In coconut-based cropping system, elephant-foot yam cv. Gajendra yielded high amount of corm. Guinea grass (var. GGCo 3) produced higher green fodder (89.2 tonnes/ha/year) under husk application. There was lower specific volume of soil and soil porosity (higher soil compaction), and soil dehydrogenase activity (an index of biological activity) as important abiotic pre-disposing factors in incidence of root wilt disease. Growing *Gomphrena globosa* as intercrop in root wilt- affected coconut gardens has been shown to be cost-effective and sustainable. In areca-based mixed farming system, total cash inflows and outflows from arecanut + dairy (3–4 milch cows) amounted to ₹4.41 and ₹5.96 lakh, with a net profit of ₹1.55 lakh. The system productivity of arecanut + cocoa system (3,127 kg/ha) was 30% higher per unit area than arecanut alone (2,405 kg/ha). Integrated nutrient management on four improved arecanut varieties recorded highest chali yield (4.19 kg).

Studies on spore associated bacteria (SAB) in coconut/arecanut based cropping systems under organic management practices revealed an increase in AMF spore load with the number of intercrops. Identification based on BIOLOG revealed the presence of bacteria, viz. *Citrobacter amalonaticus, Staphylococcus arlettae, Bacillus subtilis* and *B. amyloliquefaciens,* in association with spores of *Glomus* spp. The potent phosphate solubilizers isolated from coconut rhizosphere were identified as *Enterobacter cloacae* RNF 267, *Pseudomonas plecoglossicida* KnSF 227 and *P. putida* Biotype B HSF 132 by conventional biochemical tests and confirmed by BIOLOG Microbial Identification System and 16S rRNA gene analysis.

Of the 90 genotypes of walnut, 38 found protogynous and rest were protandrous. Forty-two genotypes showed 7–14 days of male and female bloom overlapping, indicating synchronized flowering while the rest were non-synchronous. The genotype, CITH-W 40, showed maximum synchronizing phase of 14 days, followed by CITH-W 37 and Nugget of 13 days while genotypes CITH-W 10, CITH-W 19, CITH-W 24 and CITH-W 48 showed non-synchronization with respect to male and

female blooming period, indicating need for pollinizer varieties. The most suitable rootstock and scion girth for grafting in walnut was found to be rootstocks with the girth of 25–30 mm and scion of 15–20 mm size, which are fully developed and plumpy.

Foliar sprays on cashew at three different stages, viz. flushing, flowering and nut development, with urea (3%) + H_3PO_4 (0.5%) + K_2SO_4 (1%) and foliar spray of secondary and micronutrients, viz. $ZnSO_4$ (0.5%) + $MgSO_4$ (0.5%) + Solubor (0.1%) recorded highest number of bisexual flowers and nut yield/tree. However, application of paclobutrazol (0.5, 1 and 1.5 g a.i./plant) showed reduction in growth of plants with respect to plant height, canopy spread and internodal length. High-density planting showed significantly higher (3.23 times) nut yield (2,841 kg/ha) as compared to the normal density (880 kg/ha). Intercropping in cashew with Amorphophallus gave highest net returns (₹139,639/ha), followed by tapioca (₹129,992/ha).

Spices

An organic package for production of black pepper, ginger and turmeric by applying farmyard manure, vermicompost, ash, rockphosphate, *Azospirillum* sp. and phosphobacteria and *Trichoderma* sp. and *Pseudomonas* sp. as biocontrol agents for disease control was developed. Further, a foliar spray of 1% solution of complex fertilizer 19 : 19 : 19 (N : P : K) during spike initiation period (April second week, May first week and May fourth week) during lean cropping season under irrigated condition enhanced black pepper (cv. Panniyur I) yield by 20–25%. Soil application of zinc up to 10 kg/ha or foliar spraying of $ZnSO_4$ (0.25%) and Borax (0.2%) twice (60 and 90 days after planting) was recommended for higer yield and quality for turmeric in zinc and boron deficient soil.

Among all the treatments, sprinkler and drip irrigation methods caused early sprouting, early flowering with increased plant height and more number of leaves and flowers/plant as compared to the control (rainfed). Also, stigma fresh weight, dry weight, length and saffron yield were improved in sprinkler and drip irrigation methods over the control. Raised beds resulted in early sprouting, early flowering with increased plant height and more number of leaves and flowers/plant.

In cumin, irrigation with microsprinkler and drip irrigation methods not only enhanced the yield but also improved the water productivity by 47.8 and 14.7 kg/ha cm irrigation water than flood. Among land configuration treatments, sowing of 3 rows of cumin on raised beds (75 cm) enhanced grain yield by 38.4 and 12.3 % and water productivity by 16.6 and 8.9 kg grain/ha cm irrigation water than flat bed and wider raised beds (150 cm). Further, coriander grown in plastic walk in tunnel resulted in higher yield over open condition and gave higher net return of ₹97,700 with a benefit : cost of 1.93. In cumin, low pressure drip irrigation yielded higher by 19.31% (663.28 kg/ha) as compared with flood (555.94 kg/ha), whereas water savings were 30%. In coriander, low pressure drip irrigation produced higher yield (703 kg/ha) as compared with flood (612 kg/ha) with a water saving of 30%.

Tuber crops

Drip irrigation at 100% CPE was found best for obtaining higher tuber yield in cassava. Further, organic farming of cassava produced 9% higher tuber yield (29.4 tonnes/ha) over conventional practice (26.9 tonnes/ha). Decision support systems-Plausible Potato Growing Seasons Estimator (PPGSE) and Yield Estimator were developed for spatial and temporal diversification of potato cultivation. These give the growing seasons and their durations, climatic features of seasons and estimated yield potential for important locations in India. Further, winter potato acreage and production were estimated through remote sensing, GIS and crop modelling. The acreage forecast under winter potato during 2011–12 in Punjab, Uttar Pradesh, Bihar and West Bengal was 90.6, 516, 322.5 and 345 thousand hectares, respectively, while the total production was predicted as 2,071.1, 11,439.7, 5,262.4 and 8,266.2 thousand tonnes, respectively.

CROP HEALTH MANAGEMENT

Crop health management research has brought out tangible and effective methods to suppress various pests in major agro-ecosystems. Indigenous knowledge in this regard has been tested and validated for its suitability.

Cereals

For providing support to wheat-breeding programme, evaluation of disease-/pest-screening nurseries was undertaken under artificially inoculated conditions at various hot-spot locations for identification of resistant genotypes.

Multiple disease-resistant wheat genotypes

MR to leaf blight (LB) + R to Karnal bunt (KB) + Powdery mildew (Pm)	HPW 347, VL 930
MR to LB + R to FS (Flag smut)+ Pm	HPW 317, VL 931, VL 943, VL 944
MR to LB+Pm	HUW 635
MR to LB	GW 1255
MR to LB + KB	HS 525
R to KB + FS	NIAW 1395, PDW 313, AKDW 4021 (d)
R to Pm + FS + KB	HI 8692 (d), HI 8702 (d), HI 8709 (d), MACS 3742 (d)
R to FS + KB + PM + MR to LB	PBW 615, DBW 62, HS 522, HUW 629, KRL 250, TL 2963 (T), MACS 3744 (d), NIDW 577(d), NW 4091, PBW 635, HI 8708 (d), HS 533, UAS 327, UAS 432(d), PDW 315 (d), PDW 317 (d)
R to FS	HPW 289, HD 3002, HD 2982
R to KB	PBW 628, HUW 638, NW 4081
R to Pm	DBW 58, HI 1653, HI 1569
R to Pm + FS	RSP 561, HS 534

MR: Moderately resistant; R: Resistant

The following barley genotypes have been confirmed for resistance against the diseases.

Diseases	Genotypes
Stripe and stem rusts (ACI = 0)	RD 2809
Stripe rust (ACI = 0)	RD 2715, RD 2816, RD 2786, RD 2787, RD 2828
Stem rust (HS = 0)	BH 943, BH 944, DWR 85, HUB 115, NDB1516, PL 863, RD 2552, RD 2668, RD 2794, RD 2811, RD 2813, RD 2815, RD 2819, RD 2829, VLB 124
Leaf blight (HS ≥ 57)	BH 932, BH 942, PL 860
Stem rust and leaf blight	BH 945, BH 946, VLB 123

Oilseed crops

Groundnut genotypes CS 402 and CS 409 showed resistance to stem-rot. For collar-rot, three genotypes (CS 421, CS 426, CS 428) tolerant in summer and nine (CS 422, CS 364, CS 427, CS 386, CS 377, CS 432, CS 433, CS 421, CS 431) tolerant in *kharif* were identified. In summer, application of arbuscular mycorrhizal fungi in seed-furrows brought down stem-rot incidence from 80.5% (untreated plots) to 29.4% (treated plots).

In *kharif* and *rabi* groundnut, seed-treatment with imidacloprid at 5.0 g /kg of seeds lowered jassids and thrips incidence and also gave highest pod yield (2,612 kg/ha). Among seven insecticides evaluated, lowest jassid (3.2/ five-sweeps) and thrip (1.5/five-sweeps) populations were recorded with acetamiprid 20SP.

In rapeseed-mustard, seed treatment with *Azotobacter* + phosphate-solubilizing bacteria each 250g in formulation/ha-seed along with 100% NP resulted in 2 to 14.7% higher seed yield in comparison to 100% NP at Morena, Varanasi, Hisar, Kota, Shillongani, Jobner, Bhubaneshwar, Khudwani, Sardar Krushinagar and Kanke. Soil application of $ZnSO_4$ at 15 kg/ha + borax at 10 kg/ha + sulphur as per recommendation combined with foliar application of carbendazim (0.1%) + mancozeb (0.2%) was most effective in controlling *Alternaria* blight, downy mildew, powdery mildew and sclerotial rot and improving seed yield. Multi-gene cassettes were developed for imparting tolerance against *Botrytis* disease in castor.

For effective management of yellow mosaic virus in soybean, ST with thiamethoxam 70 WS at 3 g/kg of seeds + spray of Imazethapyr 100 g. a.i/ha in plot and bunds at 25 DAS + barrier crop of sorghum/maize + yellow sticky traps 15 DAS + spray of quinalphos at 2 ml/lit at 30-35 DAS have been recommended. For charcoal-rot and *Rhizoctonia* aerial blight management in soybean, deep summer ploughing + ST *Pseudomonas fluorescens* 10 g/kg or *Trichoderma harzianum* at 5 g/kg or carbendazim 2 g/kg + pendimethalin at 1 kg a.i/ha + vermi compost to raise soil organic-carbon up to 0.5% + foliar spray of carbendazim at 0.05% at 30 to 35 DAS have been recommended.

For powdery mildew management in sunflower, two sprays of propiconazole (0.1%) or difeconazole (0.05%) were effective. Spraying dichlorvos 76 WSC 0.15% (2 ml/litre) or methomyl 40 SP 0.04% (1g/litre) twice at 10 days interval was effective in controlling mealy bugs.

For effective and economical management of *Alternaria* leaf spot/blight in safflower in western Maharashtra region, spray formulation of carbendazim 12% + mancozeb 63% (0.2 %) immediately after disease appearance, if needed, followed by the second spray after 15 days.

Pulse crops

Nucleopolyhedrosis virus (NPV) was first time isolated in India in early pigeonpea from spotted pod-borer *Maruca vitrata* under natural epizootic conditions. Application of rynaxypyr 20 EC at 30 g a.i./ha or flubendiamide 20 WG at 60 g a.i./ha or indoxacarb 14.5 SC at 73 g a.i./ha alone or rynaxypyr 20 EC at 30 g a.i./ha in combination with DDVP 76 EC at 200 g a.i./ha or garlic-bulb extract at 1% at 25–30% flowering and podding was found to save crop from *Maruca* infestation.

Eighteen chickpea lines (IPC 2004-3, -8, -52, IPC 2005 -15, -19, -27, -30, -35, -37, -41(A), -41(B), -43, -44, -52, -62, -64, GNG 1861, and CPS 1) screened against 6 races of *Fusarium oxysporum* f. sp. *ciceri* under artificially inoculated sick-tank conditions were found to possess multi-race resistance.

A partial distribution map of *F. oxysporum* f. sp. *ciceri* races identified in different states of India has also been prepared. New molecules such as emamectin benzoate 5 SG at 11 g a.i./ha, flubendiamide 480 SC at 60 g a.i./ha, rynaxypyr at 18 g a.i./ha were found better than currently recommended chemicals for chickpea pod-borer management.

Seven variants of *Fusarium udum* were identified and their distribution maps have been prepared. Uttar Pradesh has all the seven variants, followed by Maharashtra, Karnataka (6 each), Madhya Pradesh, Bihar (5 each), Andhra Pradesh, Rajasthan (4 each), Haryana (3), Tamil Nadu, Jharkhand (2 each); and West Bengal has only one.

Commercial crops

Beauveria bassiana has been introduced as an endophyte in *tossa* jute (*Corchorus olitorius*). And this has been found to reduce stem weevil infestation in white jute (*C. capsularis*). Out of nine strains evaluated, seven *B. bassiana* strains—ITCC 6063, ITCC 4512, ITCC 4563, ITCC 5562, ITCC 4796, ITCC 5408 and ITCC 4705—were established as an endophyte in white jute (*Corchorus capsularis*) through seed treatment.

Suitable constructs were developed by cloning three promoters AtACS4, AtACS5 and AtACS7, sourced from *Arabidopsis*, in pCAMBIA1381z vector, and tobacco transgenic plants were raised and analyzed for the expression pattern of the promoters.

Bio-intensive management of white grub in sugarcane: For management of white-grub beetles, light traps were modified, fabricated and installed for testing against them in sugarcane agrosystems of Uttar

Resistance in jute against Bihar hairy caterpillar

Possible source of resistance in jute against Bihar hairy caterpillar (BHC) was determined on the basis of the antibiosis effect on the pest. Larval growth rate was significantly impaired on the wild jute species, particularly *Corchorus tridens* and *Corchorus aestuans*. The growth of 5-day-old larvae indicates maximum antibiosis effect of *C. aestuans* on BHC. There was no pupation on *C. tridens* and *C. aestuans* because of high larval mortality. The pupation on *C. pseudo-olitorius, C. tricularis and C. fascicularis* was to the extent of 37.5%, 22.5% and 20%, respectively, as compared to 62.5% on the cultivated species, *C. olitorius* (JRO 204). The pupation was significantly less in wild hosts (15–37.5%) compared to 62% in *C. olitorius*. The pupal weight of larvae fed on *C. olitorius* was 95–180 mg more than wild hosts. Among wild species, *C. pseudo-olitorius* only supported adult emergence (27%). Wild jute species as the host manifested adverse effects on larval and pupal growth and survival along with on the pupation clearly indicate antibiosis mechanism of resistance of wild species on Bihar hairy caterpillar.

Pradesh (Saharanpur and Lakhimpur–khiri Districts) and Pravaranagar in Maharashtra. The insect trap (having a combination of light and pheromone) was found very effective in trapping predominant species, *Holotrichia consanguinea*, along with other species of white grubs.

Integrated pest management

An area-wide pest management was implemented in pigeonpea and chickpea for IPM awareness campaigns through conventional and electronic media and through the establishment of the "National Pest Reporting and Alert System" covering more than 35,000 ha in five major pulse-growing states—Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh.

The e-pest surveillance system through dedicated server was validated under the Accelerated Pulse Production Programme (A3P) in different states. A total number of 17,961 SMSs were sent to A3P registered farmers by using centralized server. Maharashtra was enabled for 'crop pest surveillance and advisory programme (CROPSAP)' including horticultural crops also – pomegranate, banana and mango.

Rice: In wet direct- seeded rice, tank-mix application of bensulfuron methyl + pretilachlor (applied as post-emergent 18 DAS at 50 + 450 g a.i./ha) was found effective in controlling predominant weeds (weed control efficiency 91%), and yields (5.67 tonnes/ ha) produced were comparable with hand-weeding twice (5.77 tonnes/ ha).

Profenophos was the best pesticide to manage rice panicle mite *Steneotarsonemus spinki* in the field. Foliar blast disease of rice in the experimental plot was reduced to a minimum of 5% with propiconazole EC spray at 2.5 ml/litre compared to untreated check with 80% disease.

Cartap 4 G at 1 kg a.i./ha treatment recorded lowest percentage of dead heart (3.87%), gundhi bug damage (8.75%), leaf-folder damage (3%) and highest grain yield of 5.25 tonnes/ha. Root-knot nematode was reduced by 84.3% in cartap-treated plot.

Molecular detection of key parasitoid in lac insects

Aprostocetus purpureus is one of the key parasitoids causing economic damage to lac-insect crop. This parasitoid has become a major threat to lac cultivation in recent years. The incidence is severe in summer *baisakhi* crop of rangeeni lac insect. The parasitoid mainly attacks during early stages of lac insect. A sensitive polymerase chain reaction (PCR)-based method requiring small sample of parasitoid was developed, using specific primers for the parasitoid. The PCR reaction yields an *A. purpureus* specific product of ~ 500 bp (base pair) in the lac insects infested with this parasitoid.

Agricultural acarology

In Mashobra (Himachal Pradesh), out of the five horticultural mineral oils tested against winter eggs of European red-mite on apple, Rilso-999 at 1.5% proved very effective (84.7% eggs remained unhatched), followed by Mak All Season and Orchol-13 (77% un-hatched eggs). The lowest mortality of predatory mite *Neoseiulus longispinosus* was recorded with horticultural mineral oil (28.2%), followed by hexythiazox (39.2%), endosulfan (43.8%), fenazaquin (54.7%) and carbosulfan (59.5%), when sprayed at half-bloom stage in apple.

White grubs and soil arthropods

Popillia sp. attacked pigeonpea flowers during October, and has tentatively been identified as a new species and named *P. shivashankari*. A new species of sub-family, Hopliini was recorded for the first time from Karnataka; no other species of the tribe is known from south of Himalayas. *Anomala nandikrishna* has been recognized as a new species collected from Nandi Hills, near Bengaluru.

Clothianidin 50 WDG at 2 g/kg of seeds as seed dresser before sowing is recommended for management of white grubs in groundnut.

As a seed dresser on groundnut, imidacloprid 600 FS at 833.33 and 416.66 ml/80 kg of seeds was found effective against grubs.

Imidacloprid 17.8 SL at 500 ml/acre and fipronil 5 SC at 1 litre/acre are promising insecticides to manage white grubs in arecanut; they gave 75 and 80% mortality of 1st instar grubs of *Leucopholis* sp. These chemicals also performed well against sugarcane white grubs in Karnataka.

Rodent control

Diversity of rodents: Predominance of *Bandicota bengalensis* was noticed in rice–wheat–sugarcane and cotton–sugarcane cropping systems in Punjab over *Millardia meltada*, *Mus booduga* and *Golunda ellioti*. The major rodents in Andaman and Nicobar islands are Miller's long-footed rat, *Rattus stoicus* and Zelebor's Nicobar rat, *Rattus palmarum*; and nocturnal and arboreal species are the major rodent species of Car Nicobar. Nuts

damage due to rodents was significant in coconut plantations between 5.66 and 35.5% in Car Nicobar (A&N Islands) due to lack of food diversity.

Rodent management: Among various botanicals evaluated for efficacy against rodents infesting rice, castor-based repellent ecodon® gave promising results at tillering and panicle initiation stages. Exposure of *Tatera indica* (both sexes) to wax blocks encapsulated with 4 and 6 drops of castor-oil revealed significant (Pd" 0.01) repellent effects of the blocks with 6 drops of the oil. Repellency index was more during 8–12 days, indicating that the oil may have secondary repellent effect, developed from 1 to 7 days period.

Exposure to nifedipine (anti-fertlity compound)-treated bait (at 0.1% and 0.05% concentration) for 12 days in no-choice revealed 33.3% and 50% breeding respectively in *B. bengalensis* as compared to 83.3% breeding in untreated male rats. Feeding triptolide-treated baits at 0.1, 0.2 and 0.3% to male *R. rattus* for 5 days in no-choice resulted in significant reduction in sperm motility (80.65%) and viability (75.14%) at 0.2% treatment, which was 51.67 and 58.33%, respectively, in untreated group.

In field trials at farmers' fields in *rabi* crops in arid zone, rodents control success of 64.28 and 53.85% in cumin and wheat was observed, respectively, on the 4th day after treatment with zinc phosphide (2%). After 2 weeks, control success in zinc phosphide treated fields was reduced to 55.35% (cumin) and 50.76% (wheat). Bromadiolone treatment recorded success of 72 and 68.52% in respective crops within 2 weeks. Integrating acute and chronic rodenticides recorded highest rodent control success of 78.88% (cumin) and 82% (wheat) on the 15th DAT. The seed yield increased by 10.18 and 7.14% due to rodenticidal treatment in wheat and cumin.

Rodent management operations like cultural practices, burrow fumigation in all the crop-growing seasons and bromodiolone baiting at panicle initiation stage were most promising modules showing highest efficacy in suppression of rodent population (86.5%) and damage incidence (83.4%). In sugarcane, treatment with bromodiolone (0.005%) bait significantly reduced rodent population (70.2%) and damage 68.6%. Bromodiolone burrow baiting + burrow fumigation proved effective in reducing nut damage in cocoa and coconut plantations with a control success of 85.2% and 68.7%. In Andaman and Nicobar Islands, crown baiting with bromadiolone reduced damage from 85.7 to 29%. The non-chemical method of polythene trunk banding in coconut recorded 94.5% control success in rodent infestation and 100% control success in nut damage in Andhra Pradesh. Trunk banding of coconut trees with aluminium sheet in Andaman reduced damage from 71.42 to 42.85%.

Rodenticide trials in sugarcane-crop with delayed harvesting in Punjab indicated for three treatments, one during July, second during October–November (each with 2% zinc phosphide, followed by 0.005% bromadiolone after 15 days at 400 g/acre each) and third during January–February with 0.005% bromadiolone at 800 g/acre.

Burrow fumigation with aluminium phosphide (1.5 g tablet per burrow) and baiting with 2% zinc phosphide at germination/growth stage in pea proved effective in managing rodents.

HORTICULTURE

Fruit crops

In mango, there was no interspecific association between two hopper species breeding and feeding in identical niches due to unlimited resources. Area-wide IPM of mango fruit fly and stone weevil demonstrated in 57,000 ha across Karnataka, Tamil Nadu, Andhra Pradesh and Kerala, showed potential of eradicating these pests. Surveys on species composition of mites attacking Nagpur mandarin and bioagents revealed the presence of three species of phytophagous mites, *Eutetranychus orientalis*, *Brevalpus pheonicis* and *Polyphagotarsonemus latus*. A cocinellid predator, *Stethorus* sp. (Coccinellidae) of *E. orientalis* was recorded. Observations on incidence of phytophagous mites in nursery and grown-up Nagpur mandarin orchard showed that incidence of *Polyphagotarsonemus latus* on rough lemon seedlings in nursery was more in spring seasons, whereas incidence of *Eutetranychus orientalis* was more in Nagpur mandarin during winter. Different biorational insecticides/acaricides evaluated against citrus mites revealed that propargite (0.057%) followed by abamectin (0.0007%) and ethion (0.05%) recorded significantly less mite infested fruits than other treatments.

Direct PCR assay without isolating DNA from the sample for molecular diagnosis of *Fusarium oxysporum* f. sp. *psidii* causing wilt disease in guava (*Psidium guajava* L.) was developed and validated. Two sets of species-specific primer were used for accurate and early detection of pathogen for timely management of disease and also for prophylactic treatment/application in potting mixture.

Seventeen *Xanthomonas axonopodis* pv. *punicae* causing pomegranate nodal blight isolates were added from Maharashtra, Karnataka, Andhra Pradesh and IARI,

New Delhi. Eight of the nine isolates from Andhra Pradesh were confirmed to be *X. axonopodis* pv. *punicae*. Variability among *X. axonopodis* pv. *punicae* isolates was observed with respect to lesion size, chlorosis and leaf fall under pot culture. The disease severity was positively and significantly correlated with weekly hour temperatures ranging from 25 to 35°C at RH> 50%. Regression analysis of weekly hour temperatures 25–35°C at RH > 50% and rainfall gave the best fit for predicting disease severity. Further, IDPM (Integrated Disease and Pest Management) spray schedule comprising Streptocycline (500ppm) /Bronopal (500ppm) + copper oxychloride (0.25%) at 15 days interval was found most effective in the management of bacterial blight. Isolations obtained from pomegranate wilt-affected samples revealed presence of *Ceratocystis fimbriata* in 86.36% of the samples. Other pathogens associated were shot hole-borer (*Xyleborus fornicates*, 9.0%), *Fusarium* spp. (9%) and root-knot nematode (*Meloidogyne incognitia*) infestation (9%). Wilt was managed effectively in a wilt-affected orchard (2.16% incidence) in Solapur by soil drenching the plant basin of affected plants and adajacent healthy plants with Carbendazim (0.2%) + Chlorpyriphos (0.2%) at monthly interval, as the treatment revealed no new infection.

Maximum banana stem weevil mortality (76%) was recorded by the strain endo *Metarrhizium anisopliae*–66, while maximum corm weevil mortality (54%) was recorded by the strain endo *Beauveria bassiana*–32. The *Metarhizium anisopliae* strains, viz. NRCB-145 *Ma* (Endo) and 162 *Ma* (Endo), recorded maximum aphid mortality of 80%, while chemical control (Imidacloprid) recorded 100% aphid mortality as against heavy devastation in the untreated control. Native *Trichoderma harzianum* of rhizospheric and endophytic origin colonized root, corm and pseudostem tissues of banana and colonization of root and corm tissues by *Trichoderma harzianum* started only 2 weeks after inoculation and 100% colonization of banana tissues was achieved 5 weeks after inoculation. This information would help in formulating strategies for effective control of Fusarium wilt disease in banana. Lateral flow immune assay (LFIA) based dipstick has been developed for cucumber mosaic virus infecting banana. Using IgG purified from polyclonal antiserum raised against CMV recombinant coat protein, lateral flow strips (dipstick) were prepared and these dipsticks detected the virus in positive samples and not from healthy negative samples.

The *Colletotrichum gloeosporioides* was confirmed by DNA sequence analysis as the dominant pathogen causing grape anthracnose. Increase in mean and minimum temperature during monsoon season could be the possible reason for replacement of *Elsinoe ampelina* by thermophillic *Colletotrichum gloeosporioides* as the anthracnose pathogen. In dual culture, several tested *Trichoderma* isolates could overgrow and parasitize the isolates of *Colletotrichum gloeosporioides* and *C. capsici*, indicating their potential as biocontrol agents.

Persistence and dissipation of picoxystrobin and fosetyl-Al were studied. PHI for single and double dose of picoxystrobin was 3 and 5.5 days respectively, whereas fosetyl-Al residues were below MRL on the date of application itself. Similarly, persistence and dissipation of four growth regulators, viz. Forchlorfenuron, 6-benzyl adenine, Gibberellic acid and homobrassinolide was studied and their half-life and PHI were estimated. A GC-MS/MS based residue analysis method was developed and validated in 5 matrices for targeted screening and quantification of 375 agrochemicals. Further, a LC-MS/MS based method was developed and validated for 250 chemicals.

Two formulations of fungal pathogens, viz. Metarhiziumanisopliae and Beauveriabassiana, were found to be having better efficacy on a par with chemicals like Thiamethoxan and Acephate for effective management of grape thrips. Biopesticide Bt (Halt) @ 2 g/litre gave superior control to bud-borer (76.5 %) and leaf-webber (54.8%) over the control in sapota. Incidence of anthracnose on fruits (*Colletotrichum gleosporioidis*) at harvesting stage was 0–10%. The incidence of leaf spots (in nursery) and twig blight were 31.94–50.3% and up to 61.8%, respectively. The average post-harvest loss (cracking + disease) at transport level in Delhi market was 15.83 %. At the level of retailers the loss varied from 17 to 45%.

Vegetable crops

The PCR-based diagnosis was developed for quick detection and identification of Phytoplasma infecting Cucurbitaceous crops (ash gourd, bitter gourd, bottle gourd and cucumber). *Candidatus phytoplasmaasteries* specific primers based on rDNA conserved region were designed and synthesized. This technique is highly suitable as phytoplasma can be detected before symptom appearance, and even in insect vectors which transmits phytoplasma. In okra, use of petroleum 2T oil @ 2 ml/litre + 5 g surfactant gave superior control of mites (52.8%) and jassids (52.1%) over the control. The lowest bacterial wilt incidence (20%) was reported in tomato grown on cocopith: vermicompost: lime (1 : 1 : 0.01), while it was 56.7% in the control plots.

Invasive mealy bug, *Phenacoccus solenopsis*, is emerging as one of the major sucking pests in vegetable crops. The major biological control agents identified for this invasive pest were nymphal endoparasitoids (*Aenasius bombawalei*) Hayat and *Promuscidea unfasciati* Girault, and their cumulative parasitization was 22.35%. These endoparasitoids attack the second or third instar nymphs of mealy bug and complete their life-cycle during fifth instar of their host. Different insecticide molecules, viz. Imidaclorpid 70 WG @ 0.1 g/litre, 17.8 SL @ 0.5 ml/litre and Chlorpyriphos 20 SC @ 2 ml/litre were highly effective against mealybugs.

A severe incidence of minor and sporadic lepidopteran leaf eating caterpillar *Diaphania indica* on cucumber and bitter gourd was observed from August to October. The infestation was 60–70%. *Cotesia glomerata* was identified as an important larval endoparasitoid of *D. indica*. The microbial pesticides, *Bacillus thuringiensis* var. *kurstaki* @ 2 g/litre and *Metarrhizium anisopliae* @

5 g/litre and insecticide molecules rynaxpyr 18.5 SC @ 0.3 ml/litre, flubendamide 40 SC @ 0.5 ml/litre, emmamectin benzoate 5 SG @ 0.5 g/litre, spinosad 45 SC @ 0.5 ml/litre, fipronil 5 SC @ 0.25 ml/litre and thiacloprid 21.7 SC @ 0.6 ml/litre were found to be most effective against leaf-eating caterpillar (*D. indica*).

The vegetable samples collected from farmers' fields and local markets showed pesticide residues (23%) in which 14% contained residue levels exceeding the prescribed MRL. Cabbage and cauliflower grown in the dry season, accounted for 43% of the samples found to contain residues followed by brinjal and bhendi. Among the organochlorine (OC) compounds, α-endosulfan, β-endosulfan and endosulfan sulfate were detected in 7% of the samples and synthetic pyrethroid (SP) compound residues, such as α-cypermethrin and λ-cyhalothrin were detected in 12% of the samples tested. Organophosphorus (OP) compound residues, such as profenophos, chlorpyriphos, monocrotophos and triazophos were found in 12% of the samples found in brinjal, cauliflower, bhendi, green chilli and French bean.

Ornamental crops

IPM module M 5 (tobacco extract 5%, neem oil 0.03 EC and bifenthrin 10 EC 0.25%) and M 3 (tobacco extract 5%, econeem 3,000 ppm 2 ml/litre and imidacloprid 17.8 SL 0.003%) were effective for controlling mites and aphids, respectively in orchids. Bt (Dipel) 0.012 % and neem oil 0.03% EC 5 ml/litre were found effective for shoot-borer management in *Dendrobium chrysotoxum*.

Palms and nuts

Among the 137 *Phytophthora* isolates collected from bud rot/fruit rot affected coconut gardens in Tamil Nadu, Kerala and Karnataka, four isolates from bud rot affected gardens were identified as *P. nicotianae* and one as *P. capsici*. Since, *P. nicotianae* is found associated with bud rot disease of coconut in three districts representing three states, it is expected that this may emerge as a major pathogen of coconut. Further, placing *Trichoderma* coir pith cake in the innermost leaf axils of coconut palm in disease endemic areas just before the onset of southwest monsoon (May-end) and thereafter at two months interval was found to be very effective in the management of bud rot disease of coconut.

An organic and biodegradable pesticide slow release product, using coir pith was developed, for slow release of Mancozeb to coconut crown and preliminary field trials show that it could effectively replace the polythene sachets. Copper oxychloride (Blitox 0.5%), Metalaxyl + Mancozeb (Ridomil Gold 0.5%) and potassium phosphonate (Akomin 0.5%) were observed to be effective in the management of black pod disease. Isolation and characterization of ABC transporter system in coconut root (wilt) phytoplasma has been accomplished. In phylogenetic tree based on *sec*A gene, the YLD phytoplasma clustered with sugarcane grassy shoot, coconut root wilt and napier grass stunt phytoplasma, all members of 16SrXI group. A novel nanomatrix with ordered pore channels was developed for loading the pheromone and kairomone for controlling red palm weevil. Similarly, a nanomatrix and polymer composite was also developed to load the rhinoceros beetle pheromone (ethyl 4 methyl octonate), which could extend the life-span to 6–8 months.

Surveillance for Eriophyid mite (*Aceria guerreronis* Keifer) infestation was undertaken in five districts of Asom. The highest incidence of mite (35.7%) was recorded in Morigaon, followed by Nagaon (17.67%). The hymenopteran solitary ecto-larval parasitoid recovered from parasitized (*Leucopholis coneophora*) grub was identified as *Campsomeriella collaris collaris* (Fabricius) and the solitary endo-larval parasitoid as *Prosena* sp. nr. *siberita* (Fabricius).

Chemical control of pest complex in cashew increased nut yield from 28.34 to 41.68 % and maximum (41.68%) being with L-Cyhalothrin (0.003%). Similarly, in post-extraction prophylaxis trial for management of cashew-stem- and root-borer (CSRB), with chlorphyriphos (0.2%) treatment, the treated trees without reinfestation varied from 80 to 93.3%. Spiders were observed as one of the most abundant natural enemies of tea mosquito bug (TMB) in cashew agro-ecosystem. A total of 104 species spread over 56 genera and 11 families were identified. The virulence study of entomopathogenic nematodes (EPN), viz. *Heterorhabditis indica, Steinernema abbasi* and *Steinernema bicornutum*, against grubs of cashew stem- and root-borers (CSRB), *Plocaederus* spp. revealed mortality of grubs at a mean duration of 14.1, 12.9 and 12.4 days respectively. *Steinernema bicornutum* induced more than 50% of mean mortality of bait species (wax moth) even after 150 days under simulated conditions.

Spices

A protocol for SYBR green based real-time RT-PCR for detection of Piper yellow mottle virus and Cucumber mosaic virus infecting black pepper and Cardamom mosaic virus (CdMV) and Banana bract mosaic virus (BBrMV) infecting cardamom was developed. A native isolate of *Phytophthora capsici* (Is. No. 98-93) infecting black pepper was completely sequenced using next generation sequencing platform, Illumina-Solexa GA II. The sequence data was assembled by taking Joint Genome Institute's *P. capsici* as reference genome. The treatment of black pepper cuttings with Carbendazim + Mancozeb (0.1%) was effective for the management of anthracnose disease in nursery.

Medicinal crops

Azadiractin (1%) was found effective for the control of Hadda beetle on *Ashwagandha*. Nineteen arthropods were recorded on isabgol. Among them, 13 were phytophagous species belonging to order Lepidopteran (09), Hemipteran (03) and Homopteran and six predatory species belonging to order Coleoptera (03), Neuroptera (01) and Odanata (02). The sequential occurrence of arthropods revealed the presence of aphid (*Aphis gossypii*) from second week of January to fourth week of February, whereas Lepidopteran (*Helicoverpa armigera, Trichoplusia ni,*

Thysanoplusia oricalchae, Spliarictia sp. *Hyposidra successari* and *Olene mendosa* and true bugs (*Graptostethus servus* and *Spilostethus pandurus*) were observed associated during early crop growth stages (i.e. from second week of December). Infestation of aphid was uniformly severe, whereas that of Lepidopterans and true bugs were sporadic and less severe. However, presence of these pest arthropods caused significant reduction in seed yield.

Tuber crops

The new population of *Phytophthora infestans* (mt DNA haplotype Ia), which was introduced in 2002, has almost replaced the old population (Ib haplotype) in all the locations. There is no host-specificity among *P. infestans* isolates of tomato and potato. Further, effect of elevated temperature on efficacy of R genes revealed that resistance of R1 and its combinations may be eroded if *P. infestans* adapts to higher temperature. Validated molecular markers for late blight, potato virus Y and cyst nematode resistance in 165 genotypes and identified 18 genotypes with PVY resistance (*RYadg*), 84 genotypes with late blight resistance genes (*R1* and *R3a*) and 79 genotypes with cyst nematode resistance genes (*HC*, *H1* and *Gro*1-4). Besides, 16 genotypes were identified possessing multiple resistant genes for late blight, PVY and cyst nematodes.

Potato hybrids (LBY 15, LBY 17 and SM/92-338) possessing combined resistance to late blight and potato virus Y, and hybrid, OS/01-497, having combined resistance to late blight and cyst nematode were introduced for multilocational trials. The application of Pencycuron (0.25%) on potato tubers at planting was most economical and effective against black scurf of potato, while that of Thiacloprid (0.4%) alone or in combination with summer oil against sucking pests.

Tuber information café (TIC) in Malayalam, web-based early-warning system for mealy bug incidence in cassava (http://www.ctcri.org/mbug.php), yield prediction model-based on fuzzy logic for elephant-foot yam and a learning system for the same crop using Artificial Neural Networks were developed.

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9. Livestock Management

Animal Nutrition

Feed database: A structured methodology and software platform was developed to launch the refined livestock feed resources database with national acceptability for cattle and buffaloes. The livestock population and the feed balance (2009-10) were estimated for various states. Indian livestock feed portal is being developed to include the information on feed resources, nutrient requirements, feed standards, feed markets, imports and exports and feed assessment. A matrix of 712 feed resources with composition, mineral topography, rumen degradable and un-degradable protein contents and amino acid profile, was developed.

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Linear time series models were developed to assess and forecast the feed resources availability for better management of livestock. The projected figures of total dry matter (DM), crude protein (CP) and total digestible nutrients (TDN) for 2025 would be 580, 49.5, 300 M tonnes, an increase of 13.5, 10.6 and 13.3%, respectively, over 2011. The share of dry fodder and concentrates to the total DM, CP and TDN availability by 2025 is showing an upward trend.

Feed safety and biosecurity: Feed microscopy was used in cataloguing microscopic structures of wheat and rice bran and usual adulterants (paddy husk, sawdust) were documented. The particle measurements and surface characteristics of some ingredients were documented which can be used in detection of adulterants.

As fluoride toxicity is quite rampant in different parts of the country and water being a major source of the contaminant, a study was conducted to investigate the effect of fluoride in rats. Supplementation of graded levels of fluoride in water to rats beyond six-months, lowered the antioxidant (superoxide dismutase, ceruloplasmin) and immune status at higher levels of fluoride ingestion (30 and 60 ppm). Feeding of boron, calcium carbonate and silicate binder partially improved the liver antioxidant activity and radiology of femur bone.

Cattle and buffalo

Lignin degradation: White rot fungi *Pycnoporous sangeus, Coriolus versicolor, Pleurotus flabellatus, Pleurotus floridanus, Lenzites striata* and *Poria plascenta* were promising for lignolytic enzyme production. Immobilized enzymes had greater purity, control over enzymatic reaction and high volumetric productivity with lower residence time. Enzyme treatment of *ragi* straw improved its digestibility as compared to that of enzyme supplementation. Fungi species *Ganoderma lucidum* and *C. versicolor* yielded the best results.

Mitigation of methane production by livestock

Database on methane production from livestock: Methane production potential (MPP) of several feed samples and diet combinations was determined through *in vitro* gas production technique using rumen liquor. MPP was lowest in rice polish and highest in *jowar kadbi*. The MPP ranged from 1.03 in *kum kum* cake to 7.80 in home-made compound feeds.

On the basis of these data, an equation was developed to estimate methane production based on the nutrient composition of feed ingredients:

Methane =14.346 +0.010* CP + 0.002* NDF-0.069 *ADF-0.001 *ADL-0.136 * IVDMD

(CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; ADL, acid detergent lignin; IVDMD, *in vitro* dry matter digestibility)

Plant tannins as methane suppressants: The effect of PEG (tannin binder) on *in vitro* incubation established that medicinal and aromatic plants such as *Clerodendrum inerme* (57%), *Gymnema sylvestre* (34.3%) and *Sapindus laurifolia* (30.0%) have the potential to suppress

Copyright applications filed

- Livestock and poultry disease information system (5473/2011-COSW).
- Digital *Pashu swasthya avaum pashupalan prashnottri* (5474/2011-COSW).
- *Pashudhan Avam Kukkut Rog Suchna* (5475/2011-COSW).

Design registrations applied

- Thresher-cum-treatment machine (238547).
- Multi-nutrients feed block making machine (238548).
- Bulk milk feeder for kids (240116).
- Grass cutter (240117).

Patent applications filed

- Novel Sindbis RNA dependent RNA polymerase based Self Replicating DNA vaccine vector for humoral response (160/DEL/2011).
- Attenuated *Pasteurella multocida* with determinant marker (2195/DEL/2011).
- An eco-friendly herbal acaricide to control ticks including acaricide resistant species infesting livestock and pet animals (2196/DEL/2011).
- Pestivirus replicase-based self-replicating RNA-replicon vector for heterologous gene expression in mammalian cells (3805/DEL/2011).
- A novel foot-and-mouth disease viral Asia 1 (Indian vaccine strain) replicon based viral vector for vaccine research and development (3806/DEL/2011).
- A novel ready-to-eat (RTE) salty crisp milk product (Milk Nimiki) (3807/DEL/2011).
- A novel bio-marker based detection of bovine sub-clinical mastitis (3808/DEL/2011).
- Ready-to-cook milk chips (3809/DEL/2011).
- Full-length infectious cDNA clone for Indian vaccine strain of foot-and-mouth disease virus serotype O (IND-R2/75) (626/DEL/2012).
- A rapid, sensitive and user-friendly visual LAMP-based assay for detection of infectious bovine rhinotracheitis (IBR) virus in bovine semen (627/DEL/2012).
- Recombinant antigen based sero-diagnosis of Newcastle disease (628/DEL/2012).
- An essential oil for inhibition of methane emission in buffaloes (methane suppressor) (629/DEL/2012).

methanogenesis. The tannins contained in these plants could be of interest in the development of new additives in ruminant nutrition.

Supplemention of sodium sulphate: Supplementation of sodium sulphate (Na_2SO_4) in the ration of buffaloes reduced methane production. Reductive acetogenesis was higher in the Na_2SO_4 supplemented groups.

Rumen microbial diversity and impact of plant extracts on utilization of fibrous diets: The diversity of fibrolytic bacteria and methanogenic archaea were studied from the metagenomes of buffalo rumen. *Methanobacterium* was observed as the predominant methanogenic archeal genus (79.2%) and the other genera detected were *Methanomicrobium* and *Methano-brevibacter*. Among the fibrolytic bacteria, *Prevotella* was the predominant bacterial genus (27%) and the other major genera detected were *Fibrobacter, Clostridium* and *Ruminococcus.*

Plants containing secondary metabolites appeared to have the potential to improve rumen fermentation in positive direction by reducing methane production (29 - 94%) and increasing propionate production (15 - 25%). Extracts of leaves of siris (*Albizia lebbek)*, guava (*Psidium guajava*), *lasoda* (*Cordia dichotoma*), *sahjan* (*Moringa oleifera*), and fruits of clove (*Syzygium aromaticum*) showed anti methanogenic activity to varying extent in an *in vitro* rumen fermentation system. The reduction potential was highest (94%) in aqueous extracts of *siris* leaves and *lasoda* ripe fruit. Suitable dose level of these need to be decided before use in the diet of ruminants to get maximum reduction in methane production without affecting the feed digestibility.

Sheanut by-products contained about 7 MJ/kg ME and around 12 % CP. The rate of degradation of Sheanut cake (SNC), expeller (SN-E) and solvent extracted (SN-SE) suppressed methane production by 62, 44 and 66 % *in vitro*. There is a great potential for SNC to be incorporated in ruminant feeding not only as a source of energy and protein, but also as an anti-methanogenic compound.

Inclusion of deoiled mustard cake (DMSC) and *guar* meal @ 5% in complete compressed feed block (CCFB) showed improvement in performance of crossbred calves and reduced methane production (13.75 to 17.57%).

Enhancing shelf life of agro-industrial by-products: Application of mechanical pressure on high moisture content spent grain has positive effect on drying. Greenhouse can also be used for drying high moisture content feeds. The relative drying capacity of milling by-products was graded as de-oiled rice bran > rice bran > wheat bran at different ratio. Microbial mould was inhibited in tomato pomace with urea (0.03 % level; shelf life 3 days) and propionic acid (0.05 % level; shelf life 2 days). Mould growth in spent brewery grain was arrested with urea (0.03 % level; shelf life 4 days) and propionic acid (0.05 % level; shelf life 2.5 days).

Rumen biotechnology

Feruloyl esterase enzyme was purified from modified rumen microbes pet32-FT3-7 BL21 strain. The dialyzed enzyme enhanced the *in vitro* digestibility of finger millet straw.

Sheep

Economic reconstituted milk for lamb feeding: The cost of reconstituted milk to be fed to lambs born to prolific sheep was reduced to nearly half by replacing skimmed milk powder by 3% soy oil and coconut oil by 2% linseed oil.

Feed detoxification trials: Feeding of detoxified neem (*Azadirachta indica*) seed cake replacing soybean meal for five months in growing lambs had no adverse effect on daily gain, feed conversion efficiency, nutrient digestibility, N- balance as compared to soybean meal fed group.

Goat

In goats, studies on detoxified Karanj cake revealed that after removal of karanjin, pongamol and trypsin inhibitors, it can safely replace soybean meal protein moiety up to 50% without any adverse effect on DM intake, nutrient utilization, growth rate, FCE (feed conversion efficiency), metabolic profile, immune response, carcass characteristics and meat quality in kids.

Yak

Vitamin E-selenium: A study carried out to observe the effect of antepartum administration of vitamin E - selenium on reproductive and productive efficiency

revealed — a significantly higher birth weight of the calves; no calf mortality up to 1 month of age; and enhanced milk yield.

Poultry

Antifungal effects of herbal supplementation: Work undertaken to identify herbal products that can prevent the growth of *Aspergillus parasiticus* (NRRL 2999) fungi and aflatoxin production in poultry feed revealed that supplementation of leucas (plant leaves) and *Hemidesmus indicus* (roots) significantly protected against aflatoxin in broilers.

Nutritional value of quality protein maize: Supplementation of the quality protein maize (QPM) in poultry feed proved more beneficial to poultry farmers compared to the conventional maize (CM). The protein, lysine and tryptophan contents were 15.44, 44 and 33% higher, respectively, in QPM than CM. Lysine and threonine digestibilities were significantly higher in QPM compared to CM. Replacement of CM by QPM in the layer chicken diet resulted in 3.3% higher egg production and 4.9% improvement in feed conversion (g egg produced/g feed consumed) compared to normal maize. Eggs laid by hen fed QPM based diet, had darker yolk colour compared to conventional maize.

Physiology and Reproduction

Stem cell research: Bone marrow derived mesenchymal stem cells (BM-MSCs) from bubaline and caprine bone marrow were isolated and characterized according to morphology, growth dynamics, cell surface antigen profile, and differentiation repertoire *in vitro*. Transgenic mesenchymal stem cells expressing green fluorescence protein were generated, which could be further propagated through passaging.

When caprine mesenchymal stem cells after tagging with tracking dye, were transplanted in myocardial infarction in rabbit, it was observed that these cells stayed in the rabbit heart and helped in regeneration.

Cattle and Buffalo

Potential effect on induction of estrus and cyclicity in delayed pubertal heifers was demonstrated by feeding *Aegle marmelos* and *Murraya koenigii* leaves and area specific mineral mixture. Herbal plants showed beneficial effect on follicular development and corpus lateum formation.

Sheep

Egg yolk tris glycerol (EYTG; pH 7.0) is a relatively better semen diluter for ram semen in comparison to egg yolk citrate glycerol (EYCG; pH 6.3) for short term semen preservation (24 hr) as evident by percentage motility, percentage of rapid motile spermatozoa, sperm velocity, sperm head area and beat frequency.

Antioxidants (catalase 100 units/ml and reduced glutathione 10 mM) on fortification of EYCG semen diluter improved the preservability of ram semen in terms of sperm proteins integrity, sperm motion characteristics like percentage motility, percentage of rapidly motile spermatozoa, sperm velocity, beat frequency and sperm head area.

Goat

Standardized frozen semen technology for AI: The AI procedure is difficult in goats due to complex anatomy of the reproductive tract. The technology of freezing goat semen for AI application was standardized. On the basis of actual kidding, conception rate was 23.33 and 25.92% in Sirohi and Barbari, respectively.

Production of superior germplasm: Using embryo transfer technology, morphologically normal, good quality embryos were flushed from a superior Sirohi goat and transferred to estrus synchronized recipients (2 embryos/recipient) of non-descript goats. On completion of gestation, three surrogate mothers produced four kids (2 male and 2 female) from this Sirohi donor. Earlier kids of Jakhrana and Jamnapari breed were successfully produced using MOET technology; present findings, therefore confirmed and validated MOET technology for use in other breeds as well for multiplication of superior germplasm.

Pig

Use of glucose edate potassium sodium tartarate and sodium citrate dihydrate (GEPS) semen extender that is capable of preserving boar semen for 7 days in liquid state, has popularized use of AI in pigs. Scientists from NRC on Pig have also innovated the technique of AI in sows by sitting on loin simulating the back pressure at service.

Mithun

Birth of first ever mithun calf using ETT: Superovulation in mithun cows was carried out after synchronizing estrus using CIDR and $PGF_2\alpha$. All the mithun cows were inseminated with cryopreserved mithun semen. Flushing was carried out on day 6 of following estrous cycle followed by searching and evaluation of embryos. Five embryos were recovered and transferred to synchronized recipient mithun cows. Out of the four embryos transferred to the recipient cows, one cow delivered a male calf, the first ever mithun calf produced using ETT.

First Mithun calf born through embryo transfer technology with mother

Technologies Ready for Commercial Transfer

Biotechnology products

- A novel peptide as transfection reagent for protein and nucleic acids
- A noval transfer vector for transferring genes into sheep-pox virus; useful for developing vectored vaccines
- 3 AB protein of foot-and-mouth disease virus expressed in *Pichia pastoris* as a diagnostic tool to differentiate infected animals from the vaccinated (Complete)
- A process for expression of variable surface glycoprotein of *Trypanosoma evansi* in *Pichia pastoris*
- Hybridoma clones for monoclonal antibodies against PPR virus (H and N proteins)
- Live attenuated homologous *Peste des petits ruminants (PPR)* vaccine for small ruminants
- A low-volume saponified haemorrhagic septicaemia (HS) vaccine
- A vero cell based live attenuated vaccine for control of goat pox in goats
- Vero cell based sheep pox vaccine
- Swine fever virus cell culture vaccine
- Aluminum hydroxide gel-concentrated, oil adjuvanted vaccine for FMD

Diagnostics and diagnostic kits

- Monoclonal antibody based sandwich ELISA kit for detection of *Peste des petits ruminants* virus antigen
- Monoclonal antibody based competitive ELISA kit for detection of *Peste des petits ruminants* virus antibodies
- Recombinant antigen based ELISA for diagnosis of animal leptospirosis
- Recombinant yeast expressed VP2 antigen based latex agglutination test for the sero-diagnosis of Infectious bursal disease virus infection
- Diagnostic kit for caprine pleuropneumonia for field use

Herbal drug formulations

- Development of post milking teat dip based on a novel herbal formulation for the prevention of bovine sub clinical mastitis
- Herbo-mineral acaricide formulations against *Boophilus* ticks in cattle
- A process of preparing a bio-organo-mineral formulation for the therapy of skin ailments in animals

Yak

Progesterone estimation in yak blood plasma: Progesterone hormone is a marker for onset of the cyclic activities of the ovaries in postpartum animals. Antibody microplate coating based competitive enzyme immunoassay was standardized for estimation of progesterone in blood plasma of yak. The detection limit of the assay was 0.4 ng/ml that could measure the minimal blood progesterone levels as found on the commencement of estrus. The assay could also measure up to 10 ng/ml blood progesterone concentrations as exhibited during the luteal phase of estrous and in pregnancy.

Poultry

Providing artificial lighting at the poultry houses using longer wavelength lights (red spectrum- 675 nm) than incandescent (425 nm) lights improved egg production in commercial layer flocks by about 8%.

Enhancing egg production also warrants improved egg shell quality since increased ovulations should not interfere with the time spent on deposition of egg shell in the uterine shell gland. Zinc oxide fed at 2% level to layer hens of 70 weeks of age for 10 days resulted in molting due to a reduction in feed intake and duodenal calcium uptake.

Tolerance to tropical stress: Naked neck broiler CARIBRO- Mritunjai exhibited better tolerance to tropical stress than CARIBRO-Vishal (normal plumaged), and CARIBRO-Tropicana (naked neck and frizzle plumaged).

CARIBRO-Mritunjai (Naked neck) exhibited better tolerance to tropical stress

Livestock Protection

Vaccines and RNA interference

Pox vaccines: Long-term immunity trial of sheep pox vaccine revealed that the vaccine was protective against challenge with virulent virus even after 2 years of vaccination in sheep.

Haemorrhagic septicaemia (HS): New generation mutant vaccine for HS, an *aroA* deletion mutant of *Pasteurella multocida* was developed as potential vaccine candidate.

Rabies: RNA targeting rabies virus (RABV) nucleoprotein (N) gene delivered using replication-defective adenoviruses and lentiviruses effectively inhibited RABV multiplication *in vitro* in BHK-21 cells and *in vivo* in mice.

Disease diagnostics

IBR: Loop-mediated isothermal amplification (LAMP) test for the rapid detection of IBR virus in bovine semen was developed. The test had the sensitivity of 10 fg viral DNA or 0.2 $TCID_{50}$/0.4 infective virus particles per reaction.

Freedom from rinderpest

The freedom from rinderpest globally is a tribute to the skill and efforts of the veterinarians and researchers who fought rinderpest in remote and difficult terrain in various parts of the world. Eradication of rinderpest in India has increased livestock productivity and enhanced the food security and livelihood of livestock owners. The voluminous research work of scientists of IVRI, Mukteswar, over several decades has helped eradication of this deadly disease from India and globally also. A commemorative ceremony of Rinderpest global eradication was organized at IVRI, Mukteswar, Uttarakhand on 2 June 2012 by unveiling the memorial pillar at IVRI Mukteswar Campus. The OIE certification was awarded, which is recognized as a prestigious international honour for notable contribution in achieving zero Rinderpest status for India (2011).

PPR: LAMP assay for rapid detection of PPR virus from clinical sample was standardized.

Pox viruses: A *Taq*Man hydrolysis probe based real time PCR (rt-PCR) assay targeting the ankyrin repeat protein (C18L) gene sequences was developed for the detection and quantification of camelpox virus (CMLV) nucleic acid and compared with conventional methods. The assay was specific with an efficiency of 99.4%.

Bluetongue: A sandwich ELISA was developed for detection of BTV antigen in blood, tissue materials and culture fluid.

Newcastle disease: Recombinant nucleoprotein based single serum dilution ELISA kit for serological profiling of Newcastle disease virus was developed.

Salmonellosis: LAMP test was standardized for specific detection of *Salmonella* Enterica subsp. enterica serovar typhimurium.

Coccidiosis: Multiplex PCR based on SCAR markers and ITS-1 based nested PCR for species level identification of *Eimeria* oocysts of poultry were standardized.

Greasy pig disease: This disease caused by *Staphylococcus hyeius* is responsible for considerable degree of piglet mortality. A PCR method for its rapid detection in pigs was developed.

Pasteurellosis: A PCR method for the rapid detection of *Pasteurella multocida* from pigs was standardized for screening of pigs against pasteurellosis.

Exotic diseases

Avian influenza: High Security Animal Disease Laboratory, Bhopal is designated as OIE Reference Laboratory for avian influenza. Highly pathogenic avian influenza virus (H5N1) was recorded in crows (Jharkhand, Maharashtra, Odisha, Bihar, Uttar Pradesh and Tripura) in addition to chicken and ducks. A total of 86 H5N1 viruses from nine states (Asom, West Bengal, Bihar, Jharkhand, Maharashtra, Meghalaya, Odisha, Uttar Pradesh, and Tripura), six H9N2 from Odisha, Gujarat and Maharashtra and one each of H11N6 and H4N6 viruses (Jharkhand) were isolated. The phylogenetic analysis of HA genes indicated that the 2011-2012 H5N1 viruses belonged to clade 2.3.2.1 whereas 2008 viruses belonged to clade 2.2 H5N1 viruses.

Malignant catarrhal fever: Malignant catarrhal fever was diagnosed in a Wild bison from Zoo at Bengaluru and cattle from State Veterinary Hospital at Bengaluru.

Crimean-Congo hemorrhagic fever virus (CCHFV): Molecular Beacon based real-time PCR assay for detection of Crimean-Congo hemorrhagic fever was developed. CCHFV was detected in ticks collected from a cattle calf from Vadnagar Taluq, Mehsana District of Gujarat. Phylogenetic analysis of 'S' segment sequence of CCHFV revealed that the Indian isolate is closest to Tajakistan virus (AY049083/TAJ/HU8966) falling in Asia 2 group of the CCHFV.

Veterinary biologicals

Doses of vaccines, antigens and serum were produced, quality tested and supplied to various organizations. Details are as follows.

Vaccines — Ranikhet disease 'F' strain (159,000); R_2B (3,200); fowl pox (4,200); lapinized swine fever (352,565); cell culture sheep pox (966,000); PPR (8,186,100); *Brucella abortus* strain-19 (59,983); enterotoxaemia (1,000); HS adjuvant (6,000 ml); tuberculin PPD (79,290); Johnin PPD (44,120); mallein PPD (27,500) were produced.

Antigens— 98,000 ml of *Brucella* agglutination test; 67,240 ml of *Brucella abortus* Bang ring; 22,620 ml of rose Bengal plate test; and 4,560 ml of *Salmonella* Pullorum coloured and 3,000 ml of plain were produced.

Serum— 2,000 ml of *Salmonella* Abortus equi 'H'; 86 ml of *Brucella abortus* positive serum; 7 ml of *Salmonella* Pullorum positive serum, were produced.

Herbal medicine

Sheep: EO-S1 and EO-S2, herbal formulations, showed marked efficacy against clinical infection of *Haemonchus contortus* in sheep.

Diarrhoea in goats: An anti-diarrhoea powder (Herbodin) was developed by mixing the extract of three native plants on the basis of chemical compatibility and without antagonistic effect. This product was effective in management of diarrhoea @ 10mg/kg body weight. This herbal product helped in reducing the dependence of antibiotic in management of diarrhoea and helped to overcome the problem of drug resistance.

Success story

Validation of recombinant protein (p26) based AGID/ELISA for equine infectious anaemia (EIA)

Control of EIA is based on identification of in-apparent carriers by detection of antibodies to EIA virus (EIAV) by internationally accepted standard serologic tests, generally the agar gel immunodiffusion (AGID) test. To ensure the continuous availability of diagnostic reagents and to serve as a national resource for its availability to disease diagnostic laboratories for sero-monitoring of EIA, recombinant p26 protein based ELISA and AGID assay were developed. Under OIE Training Collaborative programmes at NRC Equines, three proposals, viz. Equine influenza, Glanders and Equine piroplasmosis were initiated. The OIE has approved these projects to strengthen the infrastructural capabilities at the institute and also enhance the technical accumen of the persons engaged in research in these areas. The collaborative research initiative will help in designation of the said laboratories as Reference laboratory in equine influenza, glanders and equine piroplasmosis. One workshop under the programme was organized in December 2012 for SAARC personnel.

Surgical and clinical interventions

Venereal tumour in street dogs, regressed with use of recombinant VP3 gene construct of chicken infectious anaemia virus.

Four unique horn cancer specific ligand sequences were identified using phage display method for developing horn cancer specific peptide nano-delivery vehicle.

Epidemiology and surveillance of diseases

Livestock disease database: The livestock disease database at PD_ADMAS has 90,104 records at present. As per the analysis of cumulative disease data HS, FMD and babesiosis were ranked as the top reported diseases, while earlier HS, PPR and ET were the most reported diseases. During the year under report anthrax and haemorrhagic septicaemia were selected for detailed analysis.

Anthrax disease records available in National Animal Diseases Referral Expert System (NADRES) from 1991 to 2010 were subjected for epidemiological analysis. During this period anthrax was reported in eighteen states, viz. Andhra Pradesh, Asom, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Odisha, Rajasthan, Tamil Nadu, and West Bengal. Although there is a constant variation in the percentage of states reporting anthrax (calculated as percentage of total states reporting disease data), overall increase was seen 1999 onwards which might be due to the gradual spread of the disease. The occurrence of anthrax, however, showed a gradual increase in the number of outbreaks with a peak between 2000 and 2002. From 2002 onwards, there is a gradual decline in the occurrence of anthrax. This could be attributed to awareness amongst the farming community and the control measures taken up by the authorities.

Haemorrhagic septicamia (HS) occurred in all the six zones of the country. Though there was a lot of variation in the number of outbreaks reported across the years in different zones, a peak was seen every three years and trend of HS occurrence seemed to follow a similar pattern in south, west and central zones. Among the states of south zone, Tamil Nadu and Kerala have effectively contained the disease with proper vaccination and most of their districts fall under medium or low HS pathozone. There was an overall decrease in the HS outbreak reports in the different states of the country during 2001–10 compared to 1991–2000.

Serological studies conducted to determine the prevalence of *Peste des petits ruminants* (PPR) in cattle and buffaloes indicated 4.58% prevalence of PPRV antibody in different parts of Southern peninsular India.

Phylogenetic analysis of 52 *Leptospira* isolates based on *rpoB* gene sequences revealed that 31 isolates belong to either *L. borgpetersenii* or *L. interrogans* species, 13 to *L.inadai* subgroup or subspecies and 8 to *L. kirschneri* species. The overall observed prevalence of *Leptospira* species, viz. *L. borgpetersenii/L. interrogans, L. inadai* and *L. krischneri* in animals and human are 59.62, 25 and 15.38%, respectively.

Brucellosis screening of random sera samples from cattle (1,056), buffaloes (332), sheep (180), goats (828) and swine (307), received from 10 AICRP centers, revealed that 12.46% samples were positive in ELISA.

The database of the Directorate has large number of data on outbreaks/cases of parasitic diseases of livestock. Among cattle, buffaloes, sheep and goats, ascariasis appeared as the highest occurring parasitic disease followed by strongylosis, fascioliasis, babesiosis, amphistomiasis, trypanosomiasis, theileriosis; and trypanosomiasis caused highest mortality.

Under the bovine mastitis project (NAIP funded) of the 117 different samples, a total of 174 staphylococci were isolated with predominant being coagulase negative methicillin resistant staphylococci. Of these, the various *Staphylococcus* spp. including *S.sciuri* (n=61), *S. epidermidis* (n=47) followed by *S. aureus* (n=40) were identified.

Molecular archiving of *Brucella melitensis* from goats: Molecular archiving of *Brucella melitensis* strains was done using phylogenetic tree, genetic relatedness and amino acid sequence studies. Molecular archiving was based on seven *Brucella melitensis* genes, viz. omp31, omp16, omp25, omp2b, BP26, L7/L12 and 16s rRNA.

***Cutaneous papillomatosis* in yaks:** Papillomatosis, caused by BPV-1 and BPV-2, is reported in cattle and buffaloes from India. Cutaneous warts were observed in field and farm reared yaks. Papillomatosis was confirmed by histopathology, and presence of BPV-1 and BPV-2 was confirmed by PCR. BPV-1 and BPV-2 were detected for the first time in Indian yaks.

First detection of zoonotic parapoxvirus (pseudocowpox) in cattle: Parapoxvirus was detected by semi-nested PCR and PCR-RFLP targeting B2L

envelop gene in samples collected from cattle and a human from Modipuram area in Meerut in Uttar Pradesh. Lesions were observed only in milking cows with vesicles, scab and ulcers on udder and teats. Clinical samples were collected from the affected animal and human cases.

Whole genome sequencing

Japanese encephalitis virus: To decipher the genetic characteristics, the complete genome of the Japanese encephalitis virus (JEV) strain JEV/eq/India/H225/2009(H225)/ isolated from an infected horse in India was sequenced and compared to previously published JEV genomes. The comparison of amino acids associated with neurovirulence in E protein and non-structural protein, with known virulent and attenuated JEV strains, suggested H225 to be highly virulent strain. This is the first report of whole genome sequencing of genotype III JEV genome isolated from equines. The study confirmed that JEV genotype III is circulating among equines and is associated with clinical cases in equines in India.

***Pasteurella multocida* sub spp. multocida B:2 serotype:** Many isolates of *Pasteurella multocida* are available in the VTCC, Hisar repository. To strengthen the passport information of the isolates, the genome of a novel pathogenic B:2 serotype of *Pasteurella multocida* isolated from a buffalo in an outbreak of haemorrhagic septicaemia was sequenced. Previously, 3 isolates of *Pasteurella multocida* were isolated from that outbreak, and confirmed biochemically as well as by PCR. The isolates were accessioned in repository with the accession nos. VTCCBAA264, VTCCBAA265 and VTCCBAA266. The sequence analysis revealed that the genome of *Pasteurella multocida* (VTCCBAA264) consisted of 207,386 bp nucleotide sequence distributed in 953 contigs.

Veterinary type culture collection: The VTCC repository presently has 546 accessioned veterinary microbes including 440 bacterial and 106 viral cultures along with 180 accessioned recombinant clones.

Foot-and-mouth disease

Foot-and-mouth disease (FMD) research in the country is being carried out at the PD-FMD, Mukteswar which includes epidemiology, diagnosis and surveillance. PD-FMD has been designated as FAO Reference laboratory for FMD. It is a leading diagnostic laboratory in the region; and has imparted four trainers' training programmes for SAARC participants as part of FAO Reference Laboratory functioning. During this period, 335 outbreaks were recorded. Maximum outbreaks were reported from Southern region followed by Eastern, Western, North Eastern and Central regions. Serotype O caused maximum outbreaks (69.6%) followed by serotypes Asia 1 (25.4%) and A (5%). The outbreaks occurred round the year with maximum occurrence from October to March. Serotype O was the most prevalent in all the geographical regions except western region where, serotype Asia 1 dominated the scenario with almost 83% prevalence.

Landscapping of FMD virus: Phylogenetic analysis of serotype O virus showed that 'Ind2001' strains, which re-emerged in later part of the year 2008, out-competed PanAsia lineage in causing outbreaks in the country. During the year, a new group of virus named 'Ind2011' with more than 11% mean nt. divergence from rest of the lineages emerged in the southern region. These virus strains first emerged probably in September 2011 and rapidly spread to Karnataka, Tamil Nadu, Andhra Pradesh and Kerala. Antigenic evaluation relative to vaccine strain indicated that the new lineage is antigenically close to vaccine strain. In serotype A, the isolates clustered within the genotype 18, but grouped both in the non-deletion and the Clade 18c of $VP3^{59}$-deletion lineage. The Asia 1 field isolates were of lineage C reiterating the supremacy of this lineage since 2005. This has been a very stable serotype.

Some of the isolates in $VP3^{59}$ -deletion group of genotype 18 showed low r-value in routine vaccine matching exercise. In the initial screening, antigenic analysis of 19 serotype A field isolates with the alternate vaccine candidates and currently used vaccine strain, IND40/2000, and previous vaccine strain, IND17/1982, was carried out. The study identified a panel of 2 candidate vaccine strains from genotype 18 as potential alternate vaccine candidates for use in case of necessity/emergency.

Under National FMD Serosurveillance, 39,434 bovine serum samples collected at random from various parts of the country were tested for assessing NSP-antibody (NSP-Ab) response, which is an indicator of FMD virus exposure regardless of vaccination status. The test revealed overall DIVA positivity of ~ 27% in the country during 2011-12, similar to the previous year.

FMD control programme: Under this programme 47,510 pre- and post-vaccinated serum samples were tested and of these 24,970 serum samples were from first phase FMDCP districts representing XI, X, XI and XII phases of vaccinations. Remaining 22,540 serum samples were from expanded FMD CP districts representing Phases I and II of vaccinations.

Under collaborative programme entitled "Antigenic and genetic characterization of foot-and-mouth disease viruses in India: Application to effective molecular vaccines", replication defective human adenovirus serotype 5 (hAd5) based FMD vaccine was produced using Indian vaccine strains. Such vaccines are thought to be safe to produce, also stable and can elicit both humoral and cellular arms of immune response.

Fish

Replacement of fish meal in fish feed: The study on the effect of replacement of fish meal with chicken waste meal (CWM) indicated that CWM is a potential ingredient in feed for seabass and it can be included up to 5–10% in replacing fish meal. Similar studies with corn protein concentrate (CPC) indicated that it can be included up to 15% in the diet without affecting growth of seabass fingerlings. Assessment of effect of replacement of fish meal with corn gluten meal (CGM)

indicated that this ingredient could be included up to 10% in the diet of seabass fingerlings. Incorporation of CGM and meat and bone meal (MBM) @ 7.5% each by replacing 15% of fish meal, along with individual supplementation of lysine @ 0.3% and methionine @ 0.15% and also in combination, resulted in superior growth compared to feeds without any supplementation.

Mullet diet prepared with locally available ingredients (rice bran, mustard oil cake, sunflower cake, sesame cake, leucaena leaf meal, and azolla) was fermented with three potential gut bacteria that had been isolated and characterized. The studies revealed that the fermented ingredients could replace 75% of fish meal in diet of *Mugil cephalus* without affecting growth rate, FCR, PER and survival. Supplementation of live bacterial mixture of the three bacteria also improved growth rate, FCR and PER.

Field testing of improved pearlspot feed: Improved pearlspot feed was evaluated under cage culture. The results revealed that animals attained 21.1± 3.6 g at the end of 58 days of rearing with FCR of 1.6. This is an improvement over the growth observed under cage culture practiced by farmers where it takes three to four months to reach a size of 20 g from 2 g.

Managing fishery resources through pop-up satellite tags (PSAT): India joins the elite group of countries engaged in satellite tracking of yellowfin tuna (*Thunnus albacares*) a migratory fish. Movements of yellowfin tuna in oceanic waters near and away from Indian waters remain untested and exchange rates are still unidentified. Tagging was done to study growth and migration of marine fishes. Tuna, mainly the bluefin tunas, are tracked using tags in the Atlantic Mediterranean and Australian waters but not in Indian waters. To know about the telemetry studies on migration patterns of tunas in Indian sea, the tagging programme funded by INCOIS under the project entitled "Satellite Telemetry studies on migration patterns of tunas in Indian sea" (SATTUNA) was taken up by the CMFRI. The tags are attached externally and have a release mechanism that causes the tag to detach from the fish at a predetermined time and "pop-up" to the sea surface where the data can be recovered via the ARGOS system aboard polar-orbiting NOAA satellites, therefore provide fisheries-independent measure of the straight-line distance traveled from the point of tagging. A total of 15 tags were used in two phases along the Bay of Bengal and the Arabian Sea with the Pop-up time ranging from 4 months to a year. Tagging was done in the Bay of Bengal Region from Visakhapatnam and along the Arabian Sea off Lakshadweep.

Tuna with pop up satellite tag

Success story

Feeds for fish growth

Feeds developed by CIFA for rearing of *Pangasius* fry (Pongas Grow I) and fingerlings (Pongas Grow II), were successfully tested in farmers' pond. These feeds resulted in over 80% seed survival when fed to fry and fingerlings, and were found suitable for fish growth.

Potential bacterial pathogens in rainbow trout: Potential pathogenic bacteria profile of rainbow trout mainly cultured in North western Himalayan states of Jammu and Kashmir, Himachal Pradesh and Uttrakhand, was investigated for better maintenance of the stock. The bacterial samples were collected from diseased or moribund rainbow trout. *Aeromonas hydrophila*, *A. veronii*, *A. soberia*, *Pseudomonas lurida* and *Streptococcus* spp. were isolated and identified. In bacterial infection the most affected organ was kidney, where degradation of kidney tubules and massive infiltration of mononuclear cells were observed. All the other organs were found moderately affected. The isolated bacteria were sensitive to most of the antibiotics used in aquaculture. Total 18 isolates of fish pathogenic bacteria were stored in glycerol stock for long-term preservation, after assigning a laboratory strain name.

Horizontal transmission and infectivity of WSSV: Protocols for concentration and enumeration of white spot syndrome virus (WSSV) in water and sediment were developed to comprehend the horizontal transmission of WSSV in aquaculture ponds and study the duration of infectivity of host-free WSSV virions. Efficacy of recovery from water by tangential flow filtration (TFF) was 100% (at all times WSSV could be recovered) and 7.5 to 51.6% of WSSV was recovered. Virus enumeration by epifluorescence microscopy was standerdized. The viral counts ranged from 1.6 to 4.9 × 10^7/ml in ponds, 1.3 to 1.5 × 10^5/ml in hatcheries and 3.3 to 4.2 × 10^9/g in sediments. Role of bivalve mollusks in the removal of WSSV was examined by using *Meretrix meretrix*. The virus could be detected up to 48 h by nested PCR and quantitative real time PCR. Clam faecal matter and tissue were devoid of the virus.

Mass spectral libraries of antibiotics: Mass spectral libraries of commonly used antibiotics used in aquaculture were developed for rapid screening of these antibiotics and its metabolites in muscle, water and sediments. Mass spectral library for histamine was developed for rapid identification and low level screening of this biogenic amine.

m-Krishi® fisheries service: Mobile service, m-KRISHI®-Fisheries, was developed to disseminate potential fishing zone (PFZ) and wind advisories to fishers in local language in public private partnership (PPP). Satellite data on thermal and wind speed as well as algal movement were utilized to provide exact location of PFZ areas to reduce excessive fuel consumption in search of fish.

Current services available on the prototype are: Potential fishing zone (PFZ) advisories generated from INCOIS website regularly; Oceanic wind speed and direction advisories generated from INCOIS website four times daily; Improvised early warning advisories of wind speed and direction for a period of 5 days in advance; Regional wind speed and direction advisories generated from IMD website daily; and Early warning system (weather alerts/storm warnings).

❑

10. Mechanization and Energy Management

Mechanization of Indian farms not only increases production and productivity, but also reduces drudgery and increases labour productivity. This results in increased savings and higher income to the farmer. The quest for improved machines and equipment for farm operations has been driving the scientists to come out with many innovations and adaptations to existing machinery. In addition to individual ownership of farm machinery by the farmers, sophisticated and capital-intensive machines are being introduced for various farm operations, which can be adopted only through custom-hiring. The developments made in this field and important findings are presented.

Controller for variable seed rate and fertilizer application

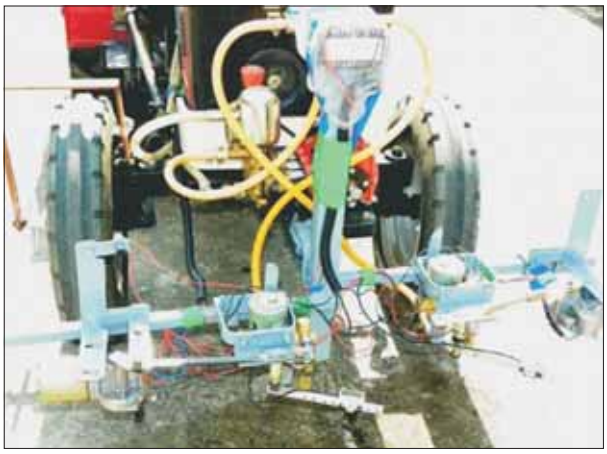
A micro-processor-based controller and appropriate decision-support system was developed for varying seed and fertilizer rate independently at different forward speeds. The decision-support system can be trained to sow seeds of five different crops and five different varieties of each crop. Similarly, it is capable of applying five different types of fertilizers. A small screen-based selection board was provided, through which the farmer/operator can select crop, variety, row-to-row spacing, type of fertilizer and application rate of seed and fertilizer.

Variable seed-cum-fertilizer applicator

The system was tested with JS 9305 variety of soybean sown at 350 mm row-to-row spacing and fertilizer (diammonium phosphate) @ 80 and 100 kg/ha. The variation in seed rate over the set seed rate varied from 2.43 to 3.14%, while the observed variation in fertilizer rate was 1.61 to 4.85% against 10 to 20% variation being observed in conventional seed-cum-fertilizer drills. The field capacity of equipment was 0.28 ha/h at forward speed of 2.5 km/h.

Colour sensor-based site-specific herbicide applicator

A two-row tractor-mounted inter-row site-specific herbicide applicator was developed in which laser sensor



Colour sensor-based site-specific herbicide applicator

registers the presence of green weeds. This signal operates a solenoid actuated flow control valve which permits herbicide spray at the points where needed. To avoid crop to be sensed by laser sensor, guards were provided on both sides of each sensor and nozzle assembly. The row-to-row spacing can be adjusted from 150 to 450 mm for accommodating crops sown at different row-to-row spacing. It was tested at different operating speeds (1.28-3.30 km/h). Pot plants were kept at a distance of 1.5 m for testing purpose with average vertical plant height of 0.22 m (along with pot). The nozzles were operated at 294.2 kPa (3 kg/cm^2) pressure. The missing percentage varied between 5 and 26, being lowest at operating speeds of 1.5–1.7 km/h.

Nursery bag filling machine

A media sieving, mixing and bag filling machine was designed and fabricated for nursery operations with the capacity of 1,000 bags (10 cm × 30 cm)/h. The machine consists of integrated system of mechanized sieving with a capacity of 2 tonnes/h.

Onion seed drill

A seed-cum-fertilizer-drill for sowing onion on raised beds was also developed and evaluated. It is a seven-row machine with a row spacing of 13 cm. The operational speed was 5 km with field capacity of 0.5 ha/h.

Cono weeder

Systematic studies on women workers while operating cono weeder were carried out which included cone apex angle, number of blades and height of blades on the cone to determine the minimum force required for ease of operation. The working width of the unit was 125 mm which weighed 5.4 kg, costing about ₹ 1,100. Ergonomical evaluation of the improved unit carried out

with 12 woman workers in comparison to IRRI cono weeder revealed its superiority in ergonomical parameters. Field capacity and weeding efficiency values for improved unit were 0.028 ha/h and 74% as against 0.022 ha/h and 72% for IRRI cono weeder.

Power weeder for cassava

The power weeder suited to cassava was developed by improvizing a commercial light weight mini roto-tiller which is light in weight (13 kg) and can be operated by a woman worker easily. Width of coverage is 350 mm and depth of operation extends up to 50 mm. The main rotor removes the weeds on the flat bed in between rows while the offset rotor removes the weeds spread over the mounds effectively. It has a field capacity of 0.2 ha/day with the field efficiency of 79% and weeding efficiency of about 90%.

Self-propelled hydraulically hoisted platform for orchard management

A hydraulically operated three-wheel self-propelled platform system was developed for harvesting mango, oranges, oil palm, etc. It is powered by a 8.2 kW petrol engine which can swivel by 360° and has hand-controls and steering on the working platform. The hydraulically hoisted platform is capable of keeping the operator at various heights ranging from 1.8 to 6 m. Fuel consumption of the unit during harvesting of mango was observed to be 2 litres/h.

Self-propelled hydraulically hoisted platform for orchard management

Harvesting tool for oranges in NEH region

A manual orange harvesting tool was developed which consists of 335 cm long bamboo pole having a cutter at the top. The cutter is operated by rope and clutch-type mechanism. A basket for collecting the oranges and a long cloth chute was provided to allow the oranges to reach ground level without damage and frequent unloading. It weighs 2 kg and costs ₹ 350. The unit was evaluated with ten workers and the output using this unit was 425 fruits/h. The mean working heart rate was 107 beats/min and the increase in heart rate over rest was 32 beats/min, which was within acceptable work load limit.

Safety attachment to Chemperi model palm climbing device

Commercially available Chemperi model climber was modified to provide additional safety. A positive locking for Chemperi model was also provided to lock the device to the tree trunk to facilitate the climber to ascend/descend from the crown for cleaning and harvesting. The attachment provides full safety to the climber during these operations and also reduces the fear of height and risk of falling off.

Tractor-mounted pick positioner for fruit harvesting and pruning operations

A tractor-mounted pick positioner having a movable platform fitted on a tractor, with double acting hydraulic cylinder, was developed in which a person can reach to a height of 9.6 m for harvesting fruits and pruning trees.

Tractor-mounted pick positioner for fruit harvesting and pruning

The mechanism has provision for moving the platform in vertical plane only and horizontal movement of platform is achieved by positioning the tractor. Two persons are required for its operation, one on the platform and the other for driving the tractor, and the unit weighs 500 kg. It was evaluated on gooseberry (*aonla*) tree plantation and one person could harvest about 120 kg fruits per hour. Cost of this unit is ₹ 90,000 and can be fitted on tractors of 30 to 40 kW size.

Header unit of combine harvesters for harvesting of soybean

Reel speed (15, 20, 25, 30 rpm); reel configuration (bat type and finger pick up) and combining direction (along and across rows) were tested for various

combinations to reduce losses. Shattering losses were observed to be minimum (ranging between 2.4 and 5.2 g/m^2) for reel speed of 25 rpm corresponding to reel index of 1.1. No apparent difference in header losses was observed while comparing combining direction, i.e. harvesting along and across the row. Stubble losses were observed to be lower for bat-type reel configuration in comparison to finger pickup-type reel. In all cases, loose plant losses were observed to be more in case of bat type reel than in finger pickup-type.

Pedal-operated ragi thresher-cum-pearler

Pedal-operated thresher-cum-pearler for finger millet or ragi has a capacity of 20 kg/h and pearling efficiency of 83% as against 3 kg/h and 70% in the traditional method of hand/foot pounding. The mean working heart rate and change in heart rate (Δ HR) values of the workers pedalling the machine were 126 and 46 beats/min which are within acceptable limit of workload.

Improved suspension system for tractor seat

An improved suspension system for the tractor operator's seat, for reduction in ride vibrations transmitted to tractor operator, was developed. This suspension unit is mounted below the seat and helps reduce ride vibrations by 15–30% under different operating conditions. Another method to attenuate vibrations being transmitted to the operator through tractor seat was developed using piezo-electric material blocks. Eight blocks sandwiched between two plates to act as the isolator unit are fitted beneath the tractor seat for reduction in vibrations. This piezo-electric material-based vibration isolator installed beneath the tractor seat was found to reduce the whole body vibration values by 27–55% in different operations. It was also observed that use of this isolator could reduce the body part discomfort score by 25–30%.

Vibration isolators for tractor steering wheel

Suitable vibration isolators at sub-assemblies of the tractor steering wheel were installed to isolate vibrations transmitted to tractor operators' hands. The steering wheel system was modified by inserting natural butadiene rubber (NBR) isolators at three points. The measured hand-arm vibrations transmitted from the tractor were evaluated as per ISO 5349 standard. The mounting of NBR isolators at steering wheel assembly reduces hand-arm vibrations transmitted to tractor operators by 20–40% under different operating conditions.

Agricultural Energy and Power

Briquettes of lantana biomass

Dried whole plant of *Lantana camara* were collected and further dried to moisture level of 20–25% in the open sun. It had a bulk density of 60 to 80 kg/m^3. The dried biomass was shredded and transported to the briquetting unit. Dried and ground biomass was then converted to briquettes of 60 mm diameter, having a density of 1,060 kg/m^3 for which energy consumption was 0.1 kWh/kg.

Success story

Briquetting Plant for Agro-residues: Entrepreneurship

With technical guidance of the Central Institute of Agricultural Engineering, Bhopal, Shri Ajay Gandhi has successfully established a biomass briquetting plant (500 kg/h capacity) at Mandideep, Bhopal district. This plant produces 3,000 kg briquettes per day using agro-residues such as soybean straw, pigeonpea stalk, *Lantana camara* stalk and other woody weeds and sells them to local industries for utilization as fuel for thermal applications in boilers an agro-industries, brick kiln etc. The energy consumption in briquetting has been estimated to be 0.1 kWh/kg. Market price of biomass briquettes is ₹ 4/kg, whereas total expenditure for producing the briquettes works out to ₹ 3/kg. Thus it is possible to earn about ₹ 60,000/month by operating the plant for 6–7 h/day for 20–22 days/month. This activity permits farmers of nearby villages to gain additional income from biomass, which was otherwise being burnt in the field.

Briquetting plant for agro-residues

Pilot scale non-electric pyrolysis unit

A pilot scale non-electric pyrolysis unit of 2 kg capacity for conversion of biomass into charcoal, consisting of pyrolytic chamber, combustion chamber, air inlet provision, chimney, protruding cylinder and pyrolysis gas outlet, was developed. The maximum calorific value of charcoal was found to be 7,110 kcal/kg for beefwood (*Casuarina equisetifolia)* and 6,570 kcal/kg for *malai vembu* (*Melia dubia*). A larger pyrolysis unit with 100 kg capacity was also developed.

Pilot scale non-electric pyrolysis unit →

Cashew shell cake-based draft gasifier

A cashew shell cake-based draft gasifier suitable for applications needing thermal requirement of 10–12 kW was developed. Various parameters influencing gasification process were analyzed and average flame temperature of gas generated was found to be 487°C.

Cashew shell cake-based up draft gasifier

Packed bed solar heat-storage system for solar dryer

A packed bed heat-storage unit coupled with a solar dryer (100 kg/batch capacity) was developed to continue drying beyond sunshine hours. The heat-storage unit along with solar air heating system was connected to the existing low height solar tunnel dryer. The solar air heating collectors (9.2 m^2 collector area) are attached to the packed bed to add solar heat to the pebbles. The packed bed heat-storage box holds about 8.5 tonnes of pebbles of 50 mm size. The box is covered with double glass on the top to allow sun light to heat the pebbles in the box. A reflector on one side of the box has been provided to reflect and further add solar energy to the collector. The heat-storage box is insulated with glass wool (50 mm thick) to reduce heat loss. A centrifugal blower is provided to recirculate the hot air from solar air heater to the rock storage box as well as for drawing hot air for supply to solar dryer. The average ambient temperature and relative humidity were 30.5°C and 43%. Under hot air retrieval test from heat storage unit, the average temperature at the exit of the heat-storage box was 44°C (47–41°C) and at inlet point of the solar dryer was 42.5°C (45–40°C) during six hours of operation after sunset.

Irrigation and Drainage Engineering

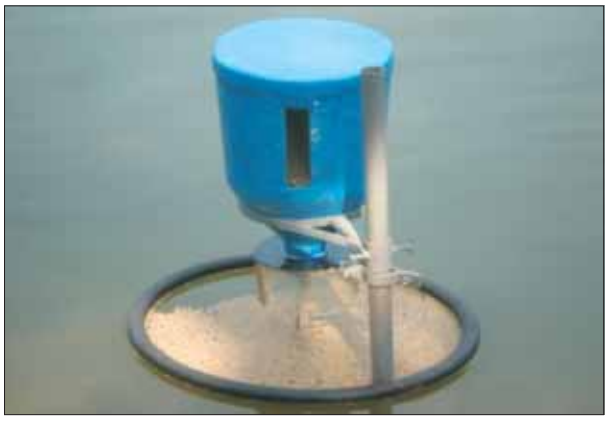
Performance evaluation of sub-surface drainage system

Pigeonpea has limited tolerance for excess water compared to other crops and is classified as a sensitive crop. The performance of surface and sub-surface drainage (SSD) systems were evaluated through field experiments for pigeonpea (variety TJT 501). The crop was cultivated in drained fields using recommended dose of NPK and standard cultivation practices of tractorized farming. The yields obtained under various treatments were 0.73, 0.93, 1.08, 1.21, 1.34 and 1.37 tonnes/ha in pigeonpea under farmers field (control), surface drainage, SSD without envelope, SSD with envelope, SSD, chimney with envelope and surface + SSD with envelope respectively.

The SSD system also resulted in increase of yield in the subsequent crop (wheat variety HI 1544) by 14.5% over control (4.2 tonnes/ha) during *rabi* 2011–12. The benefit:cost ratio for pigeonpea cultivation in temporary waterlogged Vertisols was 1.27 to 1.79 for different drainage systems and 0.47 for control (lowlying Vertisols).

FRP demand fish feeders

The demand fish feeder was designed and fabricated with FRP material for pellet feed for outdoor culture systems. Its main components are 30-litre capacity feed hopper, activating mechanism and hopper holding stand.



Demand fish feeder is usful for outdoor culture systems

Angle of repose was set at 50° in demand of feed drops by gravitational force. Demand fish feeders were installed in three different farms of Odisha.

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11. Post-harvest Management and Value-addition

Post-harvest management and value-addition is integral to agricultural production for reduction in post-harvest losses, meet consumer requirements, preserve nutritional quality, optimize the utilization of by-products and create employment opportunities. A number of machines, hand tools, gadgets, structures for safe handling and processing of farm produce, process protocols for value-added products, novel products and technologies for farmers have been developed and commercialized. The current research efforts emphasize on the development of equipment, process protocols and value-added products suiting the production catchments and meeting the health requirements of various sections of the population.

Autoclavable microencapsulation system: An autoclavable microencapsulation system was developed for microencapsulation of sensitive functional ingredients. The heart of the system is a two-fluid nozzle with multiple inlets for air or inert gas at different pressures. The kinetic energy of high pressure air or inert gas is used for breaking up of matrix fluid (containing functional ingredients) into small droplets which fall in reaction vessel. The reaction vessel contains divalent cations or polycationic substances which replace monovalent ions resulting in ionotropic gelification to yield microcapsules. It can be used for producing microcapsules having particle size in the range of 100 to 1,000 µm. The applications include microencapsulation of bacteriocins, enzymes, nutraceuticals, probiotics and prebiotics for food and feed applications. The system is cost-effective and an import substitute.

Autoclavable microencapsulator

Insulated and ventilated containers for National Horticulture Board: The National Horticulture Board (NHB) initiated collaboration with the CIPHET to overcome the problems associated with long-distance transportation of fruits and vegetables through trucks. Insulated and ventilated freight container to suit transport of fruits and vegetables over long distance was designed. Its fabrication and trial runs using trucks and rail wagons were conducted by the NHB. A 5–8°C drop in temperature was observed inside container as compared to outside air temperature. The reduction in post-harvest losses was observed around 4%, in case of modified container. The NHB has tested the design of the container for transportation of various fruits and vegetables through railways, and the train with these containers is called National Horticulture Train.

Fruit and vegetable grader: A fruit and vegetable grader of capacity 2 tonnes/h was developed, suitable for grading of apple, guava, mango, sapota, citrus, tomato, onion, potato etc. The rollers rotating in opposite directions are inclined for ease of forward movement while grading. Grading efficiency was more than 92%.

Fruit and vegetable grader

Rotary areca nut dehusker: A rotary areca nut dehusker was developed. Areca nuts are harvested and sun-dried to a moisture content of 6–7% before being dehusked. Graded nuts are fed to the dehusker. The mean values of throughput, working heart rate and change in heart rate (Δ HR) were 5.0 kg/h, 108 beats/min and 34 beats/min, respectively, and the dehusking efficiency was 88.5%.

Development of walnut planting material in polyhouse: Walnut is an important plantation crop of Kashmir valley. Grafted plant takes about 4 years for fruit bearing compared to 12 years for non-grafted one. The walnuts were grafted inside and outside the polyhouse (walk-in-tunnel, 17.5 m × 3.5 m × 2.2 m) at a spacing of 20 cm × 60 cm. Maximum grafting success of 68% was obtained inside polyhouse compared to 32% in open field conditions. Black plastic mulch (54%) was found better than hay mulch (46%). Basal

Walnut propagation inside walk-in-tunnel type polyhouse in Kashmir valley

application of fertilizers proved better (53%) than split fertigation (50% and 47%), respectively, for 100% and 70% of recommended dose of fertilizers. The combination of polyhouse with black mulch and basal fertilizer application showed the highest success (>75%). Walnut plants were ready for transplanting in field after one year. The analysis based on annualized cost indicated benefit : cost ratio of 2.54, which is economically viable.

Development of mulching sheet from jute nonwoven: Mechanically entangled jute nonwoven mulching sheet was developed and compared with different mulch materials including plastic for cultivation of strawberry at Abohar, Punjab. Jute nonwoven mulch sheets of different area density and thickness were tested and compared with black and white plastic of different thickness. It was observed that the availability of strawberry in the field was extended up to middle of May in case of jute mulching, whereas the fruits were no longer available in middle of April with plastic mulching. Jute mulching retains moisture, resists erosion, protects soil from strong impact of raindrop, and protects soil from atmospheric temperature. It enhanced yield by around 10% and improved quality of strawberry fruit.

In another trial, effect of different mulch materials, e.g. straw, saw dust, banana leaf, white plastic, black plastic and jute nonwoven, was studied on cultivation of heat-resistant (summer variety) tomato. Of these, jute nonwoven and straw mulches were found better for tomato production and health of plant. Thus, jute nonwoven mulching is suitable and economically viable for strawberry and tomato. The cost of waste jute nonwoven (500 g/m^2) is ₹ 8.75/m^2.

Eco-friendly hydrophobic and UV-protective finish for cotton fabrics: Cotton fabrics are hydrophilic in nature but for many applications such as raincoats, umbrellas, upholstery, uniforms, etc., they need to have hydrophobic finish. Generally, toxic fluorocarbon chemicals are used for this purpose. A new eco-friendly hydrophobic finish for cotton fabrics, developed using zinc oxide nano particles, silicones and organic acid, was durable up to 20 hand washes with spray rating of 70, indicating good hydrophobic characteristic. The fabric also provided protection from the harmful effects of ultra-violet rays (UPF rating 50) present in the light.

Litchi fruit peeling machine: Litchi fruits are perishable in nature and are processed to make juice and concentrates. A machine for peeling litchi was developed, consisting of two stainless steel rollers of 60 mm diameter; rotating in opposite direction at differential speed. Due to differential speed of the rollers, the peel is separated from the fruit. After removal of peel, the friction force between roller and pulp is reduced and moving belt guides the peeled fruit towards outlet. The peel passes through the rollers and moves down whereas peeled fruit is conveyed ahead. The capacity of the machine is 150 kg/h with peeling efficiency of 96%. It is operated by 750 W electric motor.

Litchi fruit peeling machine

Prefabricated grass carpet with natural fibre-based backing material: A study was conducted to eliminate the use of plastic for growing and transporting prefabricated grass carpet, using suitable 100% natural fibre-based backing material. In this case, coconut fibre-based net (489 g/m^2) and jute cloth (woven and nonwoven) are used as bio-friendly backing of the grass carpets. Use of jute also decreased the requirement

Jute-coconut fibre composite structured as backing material for making grass carpet

of soil during seedling plantation. The coconut fibre-based net acted as the binder of the grass-carpet base. Longevity of coconut fibre under soil is very high, sustaining its structure for even several months. The cost of the prefabricated grass carpet is 380/m^2.

Development of coconut-fibre segregator machine: A coconut-fibre segregator was developed for grading coconut fibres into various grades. These different quality grades can be used selectively according to the product need or blended with other fibres for making innovative and value-added products. The principle of air drag and gravity was used in the machine for quality-based segregation of coconut fibres. The opening roller of the machine initially opens the fibre and throws them into a chamber. The fibre mass is sucked through a dumb-bell shaped conduit by air flow. The geometry of the conduit is so designed that only light fibres are carried away by the airflow to the cyclone separator. The heavy fibres remain in the chamber and get carried forward by a conveyor. The outturn of the segregator is 50–60 kg/h.

Coconut fibre segregator machine (*top*) and segregated coconut fibres – a, segregated coarse fibres; b, unsegregated (bulk) fibres; c, segregated fine fibres

Value-added *bajra* products: Efforts were made to overcome storability constraints of *bajra* flour through pearling process using a simple pearler. Fat acidity of flour prepared from unpearled grain increased from 4.5 to 79 mg KOH/100 g, while it increased from 2.3 to 37 mg KOH/100 g in the flour from pearled grain after 20 days storage period. Similarly, free fatty acid was also higher in flour from unpearled grain (2.3 to 40%) compared to that made from pearled grain (1.2 to18%). Further, analysis of different fractions (pearled grains, partially pearled grains, partially pearled grains-fines, grit and fine bran) revealed that grit fraction had 4.3% ash content, 18.9% crude protein and 17% ether extract (lipid) indicating that these are good sources of dietary energy. Biscuits prepared from pearled *bajra* flour were palatable and acceptable. Bran, usually a waste material, was successfully used for making multi-nutrient animal feed block.

Chemical and biochemical characteristics of tobacco-seed oil: Oil yield from seeds of tobacco, Siri (FCV), GT 7 (*bidi*), Manasi (*Jati* tobacco), Dharla (*Motihari* tobacco), HDBRG (burley type), Banket A1 (burley) and Abirami (chewing type) ranges from 32.79 to 38.14%. HDBRG yielded maximum oil (38.14%), followed by *bidi* tobacco variety GT 7(37.70%). Saponification value of the oil varied from 186.3 to 208.6, and its iodine value (IV) from 134 to 182.2. Predominant fatty acids in the oil are palmitic, stearic, oleic, linoleic and linolenic acids. Oleic and linoleic acid content range from 9.22 to 13.60% and 72.49 to 79.07% respectively. The oil also contains 1.30% of omega-3-fatty acid, an essential fatty acid for human-beings. It has higher ratio of polyunsaturated to saturated fatty acids than sunflower and groundnut oils, and comes under class 1 of the nutrition classes of edible oils. Protein content of the de-oiled seed-cake varies from 27 to 32.12%. The oxidative deterioration of tobacco seed-oil is at par with sunflower oil.

Tobacco-seed crushed with oil expeller, followed by solvent extraction yielded maximum oil (44%). De-colourization of oil with 4% Fullers' earth gives light-golden yellow colour similar to sunflower oil.

Fruit crops: Mango peel was utilized for production of pectinases through microbial fermentation using *Aspergillus niger*. Extracellular pectinase was immobilized in calcium alginate beads through entrapment technique. Thermal stability of immobilized enzyme after heat inactivation at 60°C was observed higher than free enzyme over a longer time interval. Isoforms of pectinase, viz. polygalacturonase, pectin methyl esterase and pectin lyase, were identified from *Aspergillus niger* multiplied on pectin (extracted from mango peel) using gene-specific PCR.

In grapes cultivar Cabernet Sauvignon, pruning time and bunch load affected wine parameters. Retaining 20 bunches/vine resulted in more TSS, anthocyanin and TTA in juice. Wine prepared from early pruned

vines had high pH, low TTA, more anthocyanin and alcohol and high colour intensity. Wine from late pruned vines with 30 bunch load was found to contain no sugar and high alcohol content. In raisins prepared from Tas-A-Ganesh, moisture content, colour intensity and phenol content were significantly affected by pre-treatment of bunches with ascorbic acid prior to dipping. Minimum colour intensity and moisture content were obtained in raisins prepared from bunches pre-treated with ascorbic acid at 300 ppm.

Maturity indices revealed that fruits of cultivar Bhagawa may be harvested around 180 days after anthesis when TSS : acid ratio reaches 32.31 but fruits of cultivar Ganesh can be harvested by 154 days. Further, post-harvest dipping of fruits of Bhagawa in different lac formulations increased the shelf-life to 23.3 days under SH 2–100%, followed by SH 1–50% (22.7 days) compared to the control (16.7 days).

Antioxidant capacity in mulberry was higher in genotype with dark fruits, i.e. CIAH-M 1. One serving of fruit beverage (100 ml) prepared from CIAH-M1 contained 29.8 mg phenol, 12.6 mg flavonoids, while total antioxidant activities were observed to be 98 mMTE. Highest TSS (18–20°Brix), colour and size (>20 g) was obtained when litchi fruits were harvested during last week of May. Treatment with 2% citric acid + 500 ppm KMS dip (8–10 min) and kept at 15°C extended the shelf-life of litchi fruits by 16 days. Further, fruits packed in perforated LDPE bags and stored in CFB has <5% damaged fruits as compared to wooden box packaging (>15%). Cabinet drying after 2 days of sun drying at 45°C gave best quality litchi nuts.

Vegetable crops: Capsicum could be stored in fresh condition without shriveling, maintaining firmness for 7 days in high humidity and low-cost polyethylene tent with a weight loss of only 2.2% compared to 8% weight loss by 3 days itself in the open (25–30°C and 40–52% relative humidity).

Capsicum stored in low cost polythene tent

Green chilli powder has assumed special importance due to presence of high vitamin C (105 mg/100 g) and capsaicin content. To develop this product, the blanched green chilli pieces were osmotically diffused in sodium chloride solution for 2–3 h at 40–50°C, followed by drying at 50–60°C for 8–10 h to reduce the moisture content to less than 2%. The drying process retained 35–38% ascorbic acid, 90–94% chlorophyll content and 82-84% capsaicin content. The dried green chilli pieces were ground and the powder can be stored up to 8–10 months at room temperature (22–30°C) without loss of green colour, nutrients and sensory attributes.

Success story

Green algal extract (GAe)

Green algal extract (GAe), a nutraceutical provides a unique blend of 100% natural, bioactive anti-inflammatory ingredient. It was extracted from seaweeds with an ecofriendly green technology to combat joint pain and arthritic condition. These are natural alternatives to synthetic anti-inflammatory drugs for controlling arthritis. The existing allopathic medications used in the treatment of joint pain and arthritis produce several undesirable side-effects, especially when used for longer duration. GAe is a green alternative to these allopathic preparations. The active ingredients are chemically engineered to retain the anti-inflammatory properties for an extended shelf-life and stability packed in low moisture content. 'Naturecaps' CadalminGAe^{TM} meets the needs of end-users.

A probiotic drink of cucumber was prepared through lactic acid fermentation using salt (2%) and mustard seeds (0.5%). The ready-to-serve probiotic drink supplemented with capsicum flavour, had TSS 2.4, pH 3.6, acidity 0.2%, tannins 6 mg/100 ml, 10^6 counts/ml of *Lactobacillus* sp. with a high sensory acceptability.

Spices: Storing nutmeg at 100% vacuum or 100% N_2 was ideal for long-term storage without aflatoxin contamination, insect damage and loss in quality of the produce. Cryo-ground cinnamon powder showed advantage in oil and oleoresin contents compared to conventionally ground sample using pin mill.

Medicinal crops: A rapid and sensitive liquid chromatography/electro spray ionization tandem mass spectrometry (LC/ESI-MS/MS) method was developed for the identification and quantification of three withanolides, namely withaferin A, 12 deoxy withastramonolide and withanolide A, in the extracts of *ashwagandha*. A HPLC-ELSD method was developed for identification and quantification of major saponins in *shatavari* (*Asparagus racemosus*). Extraction of aerial parts of mamejo (*Enicostemma axillare*) with water and methanol at room temperature was found to give maximum yield of swertiamarin.

Tuber crops: In potato, resistant starch content in Kufri Chipsona 1 was 1 mg/100 mg before storage and it increased to 1.4 and 1.3, after 90 days of storage at 4 and 12°C respectively. Foliar spraying of growth retardants (Paclobutrazol and ethrel) 4 or 6 weeks before harvesting resulted in mild sprout suppression of tubers up to 90 days of storage in heaps.

Detection of detergent in milk: Synthetic milk is the latest entry in the list of adulterants of milk. Detergents are the essential ingredient of synthetic milk, and it is reported to be used for the adulteration of dairy milk from 5 to 10%. A new test for detection

of anionic detergent in milk (dye-detergent complex extraction method) was developed. The developed rapid colour based method is more sensitive and can provide the results in less than five minutes. The limit of detection of this method is 0.02% labolene in milk. The other common adulterants and preservatives do not interfere in the developed test. The test does not require use of any equipment and the cost of ingredient used for preparation of test reagent is very low.

Polyphenol extract (strawberry) fortified stirred *dahi*: The low calorie strawberry polyphenol (SBPP) fortified stirred *dahi* had a better flavour and appearance with comparable compositional and physico-chemical parameters (water-holding capacity and viscosity). The acidity of SBPP fortified stirred *dahi* was slightly higher. Antioxidant activity and total phenol content of developed product was significantly higher than control. Sensory analysis indicated that the product was acceptable up to 2 weeks when stored at 7–8°C, with no significant difference in the anti-oxidant activity and total phenolic content.

Miniaturized spore-based assay on biochip for aflatoxin M1 in milk : Biochip-based technology has superior quantum efficiency, signal capturing at a single photon level and minimal background noise. A miniaturized spore-based assay for detection of aflatoxin M1 in milk on functionalized gold chip, was developed. It requires minimal quantity of milk (25 µl) and other reagents (0.5 µl). The new assay had higher sensitivity (0.5 ppb).

Oat- and milk-based probiotic fermented products for type-II diabetes: Oat-based probiotic fermented milk product containing *Lactobacillus rhamnosus* (LGG) was formulated and its effect on type-II diabetes was studied *in vivo* using wistar rats. Type-II diabetic rats showed significant decrease in blood glucose level (36.46–45%), HBA1c, oxidative stress, cholesterol (8.04–13.58%) and triglycerides (18.66–30.38%) level during progression and induction study. Promising results were obtained in progression study. Expression of certain genes like GLUT-4, IRS-2, ppar-y increased and of TNF-α and IL-6 expression decreased during the study. Oat- and milk-based probiotic fermented products showed the synergistic effect of probiotics and oats especially in progression of type-II diabetes and can be considered as an important dietary defense weapon to fight type-II diabetes.

Traditional meat products in retortable pouches: The technologies for ready-to-eat (RTE) and shelf-stable traditional Indian meat varieties such as curries, *kheena*, soups in transparent and non-transparent flexible retortable pouches were developed with acceptable sensory attributes up to a period of 12 months.

Shelf-life of meat: Super-chilling and vacuum packaging technology for enhancing the quality and shelf-life of buffalo meat steaks was developed. This process improved the shelf-life of fresh buffalo meat steaks up to three months without freezing, thereby significantly reducing the drip loss, labour charges, storage and transportation cost, electricity and space requirement to meat processors and buffalo meat exporters.

Success story

CIFT-OPex (oyster peptide extract) developed

An edible oyster (*Crassostrea madrasensis)* peptide-based nutraceutical, OPex was developed. OPex is a 100% natural blend of oyster peptide and oyster protein concentrate that possesses several bioactivities like anti-inflammatory, anti-oxidant and anti-bacterial properties. Oyster peptide extract was prepared using enzymatic method and the same was found to possess antioxidant effect. Also the extract inhibited ascorbate-$Fe2^{+}$-induced *in vitro* lipid peroxidation in rat liver and hydrogen peroxide-induced *in vitro* lipid peroxidation in brain. It is postulated that the active antioxidant peptides preserve the glutathione peroxidase system, recognized for its potent antioxidant capabilities and protect cells from lipid peroxidation and deleterious membrane structure changes.

Functional restructured meat products: Restructured mutton chops extended with 5% pea hull flour (hydrated 1 : 1) and 5% boiled and mashed potato were formulated. The product had comparatively high cooked yield (87.02%) and very good appearance, flavour and overall acceptability. Incorporation of 1% tamarind seed powder or flaxseed flour and 0.1% gum tragacanth or 0.5% gum acacia significantly enhanced the binding strength and texture of extended restructured mutton chops. The products remained shelf-stable at refrigerated temperature (4±1°C) for 15 days with sensory ratings between good and very good. *Bael* powder at 1% and *mousambi* peel powder at 0.5% were optimum for fortification of restructured buffalo meat steaks. The fortified products had a refrigerated shelf-life of 20 days with sensory ratings ranging between good and very good.

Products from spent animal's meat: Shelf-stable ready-to-cook meat rings from meat of spent hens containing 10% rice flour were found to be the most acceptable. No marked changes in the quality of product were observed up to 45^{th} day of storage at room temperature. Dry pet food was developed by incorporation of different buffalo offal. The food was prepared with incorporation of offal meals, soya meals and cereal flours by baking at 150°C for one hour. All the variants were fairly acceptable.

Slaughtering and meat processing equipment: Model plan of abattoir suitable for slaughtering 50–100 small ruminants—sheep and goat— under prevailing Indian conditions was designed. Dispositions of various components of abattoir were made to produce wholesome meat. Equipment such as restrainer, stunner and overhead rails were designed to carry out the slaughtering in humane manner and dressing operations in hygienic way. This model is suitable for medium scale entrepreneurs.

Processing of fabric: A protease enzyme-based finishing process was developed which improved the

handle/softness of tweed fabric from Chokla wool to the accepted level. It significantly reduced the fibre shedding property of Angora–Bharat Merino shawls.

Walnut husk and pomegranate rind extracts have anti-moth properties and addition of mordents during dyeing increased the moth resistance properties of the dyed materials.

Drug residues and environmental pollutants: Drug residues in meat and milk were analysed in respect to enrofloxacin. Meat and milk samples of yak were collected from Arunachal Pradesh. A total of 17.4% of collected yak meat showed an average of 4.06 ng/g concentration of enrofloxacin and 21.74% samples were below limit of quantification (LOQ). Average concentration of enrofloxacin in yak milk was 0.871 µg/ml with a range of 0.514–1.442 µg/ml.

Arsenic concentration was determined in urine, feces and wool in yak. The result revealed that arsenic concentration in wool was comparable to cattle hair of contaminated zone of West Bengal, India ,whereas arsenic concentration in urine and feces of yak were very low.

Trawl to harvest myctophids in the Arabian sea: Myctophids which get harvested as a bycatch along deep sea shrimp trawlers are generally discarded because of its low sale value. The newly developed post-harvest utilization and value-addition indicated that judiciously utilized myctophids can form a significant source of fish protein and contribute to the nutritional security of the people. A 49.5 m midwater trawl was developed for sustainable harvesting of myctophids off southwest coast of India in Arabian Sea.

Product development from myctophid: Battered and breaded products were prepared from the myctophid, *Diaphus watasei*, a deep sea resource. The product is acceptable even after 12 months of storage. Specialty products, viz. momo and rolls, were prepared from the cooked mince of *Diaphus watasei* and were rated high on sensory evaluation.

Collagen peptides: Collagen, a group of naturally occurring proteins found in vertebrate animals including fish, has a wide variety of applications in pharmaceutical, cosmetic, and photography industries. Fish-scale collagen peptides were prepared from scales of rohu (*Labeo rohita*) and catla (*Catla catla*). Specific peptides from each hydrolysate were selected and submitted to database. According to online databases, these peptides are present in human, bovine, fish and rat. Acid soluble collagen, pepsin digestible collagen and insoluble collagen were isolated from tuna and rohu skin. Yield of acid soluble collagen from tuna skin was the highest (14%).

Utilization of chromatophores: The chromatophores from squid skins were isolated, and used as natural pigment in lipsticks. Five shades (SQ1, SQ2, SQ3, SQ4 and SQ5) were developed using this pigment and they were screened for consumer acceptance. The new product was found acceptable, and it also met the national quality standards laid down for such category of products.

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12. Agricultural Human Resource Development

Quality human resource development is crucial for addressing the challenges in sustaining agricultural productivity in diversified agro-ecological regions. To address the challenges of agricultural growth and enhancing the benchmark quality standards of higher agricultural education across the State Agricultural Universities (55 SAUs), Deemed-to-be Universities (5 DUs), Central Universities (4 CUs with agricultural faculties), and Central Agricultural University (1) the Education Division of ICAR is playing a pivotal role by providing logistics and catalytic financial support for infrastructure development including domains of governance, development of uniform course curricula and capacity building. This has been possible through the XI Plan scheme of "Development and Strengthening of Higher Agricultural Education in India" through various sub-schemes and programmes.

During this year, three new agricultural universities namely Kamadhenu Veterinary University, Raipur, (Chhattisgarh), Tamil Nadu Fisheries University, Nagappatinam (TN), and University of Agricultural and Horticultural Sciences, Shimoga have been established by respective State Governments.

Infrastructural Development

The development grant through financial support helped in strengthening the infrastructure which included students' hostels, laboratories, smart class rooms, computer and internet facilities, instructional farms, state of art equipments and instruments, educational museums, educational technology cells, sports and recreational facilities etc.in the agricultural universities. In the XI Plan the construction of 89 girls' hostels, 46 boys' hostels, 35 international hostels, 37 educational museums and 45 examinations halls in 52 agricultural universities was supported. Most of these facilities have been completed and made functional enhancing the overall infrastructure in the campuses. Financial assistance of ₹ 545.43 crores was provided in the financial year 2011–12 for infrastructural development and strengthening of Agricultural Universities including civil works, student amenities for counselling and placement, faculty amenities, Best Teacher Awards, catalytic support for faculty exchange, Guest and Adjunct faculty, personality development, tutorials for SC/ST students and support to Deans for meeting expenditure under education technology and examination cells in addition to HRD, experiential learning and niche area of excellence.

Special and Institutional Grants

Special grant was provided to Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharashtra, Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Srinagar (₹ 100 crore), Kerala Veterinary and Animal Sciences University (KVASU), Kerala (₹ 100 crore) and Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Jammu, during the financial year 2011–12. The union budget 2012–13 also had the provision of institutional grants of ₹ 100 crore each for ANG Ranga Agricultural University, Hyderabad and Kerala Agricultural University, Thrissur and ₹ 50 crore each for CCS Haryana Agricultural University, Hisar, Orissa University of Agriculture and Technology , Bhubaneshwar and University of Agricultural Sciences, Dharwad.

Library Strengthening: Financial support of ₹ 57.16 crore was also extended for strengthening and modernization of libraries including networking for online access to literature, which ensured equity and availability of quality learning resources both in the main campuses and off-campus colleges. This has benefitted students and teachers for planning the research and preparation of teaching material by consulting the relevant learning resources and reference books.

- Demand-based additional new journals not covered under CeRA were procured, book bank for the benefit of the SC, ST and BC students were developed, special text-book collections built up at each campus, similarly separate competitive examination cells were established with the latest

A view of the new amenities created out of ICAR grant at Junagadh Agricultural University, Junagadh

collections for the aspirants of ICAR, ASRB, ARS, ICAR-JRF/NET, UPSC, APPSC, GMAT, TOEFL and bank examinations etc.

- **Digital Library**: The digital library infrastructure facilities viz. computers with latest configuration, Touch Screens for providing OPAC, internet facility, UPS etc. were strengthened in existing libraries and new ones were established to utilize the electronic information like CeRA, CAB Abstracts, *Krishiprabha*, EBSCO, Indiastat etc for the improvement of academic and research programmes. The e-Library infrastructure facility was also updated and strengthened with the latest versions of computer systems, online UPS, servers for utilization of electronic information resources and internet facility. Some libraries have also added e-Books (for example CRCnetBase e-Books on Agriculture and allied subjects) which can be accessed through I.P. and User ID password and act as virtual library for the teachers, scientists and students to browse important agricultural content. A separate e-Resource Training Centre to organize user awareness cum training programmes on e-Resource in Agriculture regularly and for offering Library and Information Science Course has been established at ANGRAU, Hyderabad.

Organization of AGRI-SPORTS

The XIII ICAR Sports Meet was hosted during 16–19 February 2012 at Dr PDKV, Akola (Maharashtra), in which, 41 agricultural universities participated in seven different sport categories and 1673 participants comprising 1,169 male and 361 female students and 143 team officials took part. The university also brought out daily bulletins and a colourful souvenir. PAU Ludhiana won the overall championship in athletics both in men and women categories. The University of Bangalore was declared as the overall champion.

Niche Area of Excellence (NAE): With an objective of achieving educational excellence in teaching, research, consultancy and other services, support to 51 Niche Area of Excellence have been provided, out of which 28 centres accomplished the task as on March 31, 2012. A grant of ₹ 26.66 crore provided during the financial year 2011–12, enabled creation of excellence in the chosen niche areas. Some of the significant achievements are:

- Development of the diagnostic kits and assays for quick and sensitive detection of the viral pathogens, and augmentation of immune response to vaccines by using new approaches. Efforts have also been made for augmentation of immune response through use of calcium phosphate and Poly L glycolide (PLG) nanoparticles based vaccine delivery. Capacity building of stake holders was done by organizing training programmes in emerging areas like molecular techniques for disease diagnosis and to address the problem confronting poultry sector. A repository of poultry viruses has been established and also in terms of development of an array of avian diagnostic assays for the benefit of farmers. A patent has been filed for chicken infectious anaemia virus antibody detection kit.
- Work was done on Isolation, characterization, production and dissemination of bio-agents at SVBPUAT, Meerut. A number of entomopathogenic fungi such as *Beauveria bassiana*, metarhizium, *Nomuraea* and *Verticillium* were successfully screened against legume pod borer. Rearing of the test insects on artificial diet was done successfully. A new species of entomopathogenic nematode *Steinernema asiaticum* has been identified. In addition, a number of predatory coccinellid beetles, pentatomid bugs and predatory syrphid flies have been recorded. Around 17 species of white grubs were collected from soils of different locations of the State.

The virulent strains of *B. bassiana* and NPV have been transferred to 7 agribusiness companies for their mass multiplication and dissemination in the field.

- Work at IVRI centre resulted in development of 15 processes and technologies for immune prophylactics and 11 types of innovations on immune-diagnostics against different infectious diseases of livestock and poultry in addition to submission of 143 gene accessions in GenBank. Identification, documentation and utilization of indigenous technological knowledge for diseases control, study of the mechanisms and amelioration of drug resistance developed in infectious agents and the host resistance to various diseases as well as a success story on PPR diagnostics and vaccine technologies are some of the major achievements.
- Implementation of newly designed P.G. Programmes, establishment of national and International linkages and training to about 160 researchers was done by Water Technology Centre at ANGRAU. This Centre popularised drip irrigation and fertigation for crops and evolved alternative cropping strategies for improving water productivity.
- SKRAU, Bikaner made efforts to demonstrate and highlight positive benefits of micro-irrigation and fertigation in realizing higher yields from high value crops in arid regions of Rajasthan, besides substantial savings in water and fertilizer use. Similarly, use of specific bio-regulators has led to high yield and savings in use of irrigation water. Also, the student community and other stake holders were benefitted through their involvement.
- Support by the niche area on Hi-tech horticulture including aromatic and medicinal plants, helped in organising trainings for youths/farmers at MPUAT, Udaipur. This centre also extended the facilities for experiential learning programme-

one on Hi-tech Horticulture and another on post harvest handling of horticultural crops. An innovative method of providing employment to unemployed agriculture graduates through nursery raising was designed and found very successful. The students raised more than 8 lakh saplings of different fruit crops, which were sold by the centre to the fruit growers of the region leading to resource generation.

- Work was done on key areas of plant microbe interactions and microbial molecular biology. About 20 postgraduate students from various life sciences degrees/B. Tech. (Biotech) have been trained in various molecular biology tools and worked with various aspects of the programme. Linkages were established at the intra-institutional and inter-institutional levels.

(A) Infected and ToLCV symptoms on non transgenic tomato Pusa Ruby; (B) White flies on T3 transgenic Pusa Ruby

- Niche area of excellence in medicinal and aromatic plants at JNKVV, Jabalpur contributed significantly in higher education (PG programme), research and extension activities for promoting medicinal and aromatic plants cultivation in the state of Madhya Pradesh, as a result, a large number of cultivators generated interest and started cultivation of medicinal plants.

Entrepreneurship Development

Experiential Learning is aimed at promoting entrepreneurship, knowledge and marketing skills through meaningful hands on experience and working in project mode, through end-to-end approach in product development. Some of the achievements are:

- Ten experiential learning centres for entrepreneurship among the students were established at MAU Parbhani. The students' expertise as master trainers emerged out for commercial exploration suitable for small scale and cluster mode of operation.
- Entrepreneurial skills were developed among students in Sabour by organizing different training programmes on processing and preservation of fruits and vegetables, preparation of value added products etc. Trainings were organized that benefitted the farmers and students. Ten students prepared entrepreneurship projects and submitted for funding to financial institutions.
- Experiential learning units at NAU, Navsari were established in post harvest technology (mango, tomato, and banana), onion dehydration plant, tissue culture lab, protected cultivation unit (vegetable and floriculture), bio fertilizer and biopesticide, bio-control unit and food quality testing unit. Among them, the bio-fertilizer production unit is a huge success in the region, leading to substantial resource generation.

Rural Agricultural Work Experience (RAWE)

RAWE programmes in the undergraduate curricula provide real life experience to students. This includes precisely prescribed programmes of work in farms as well as KVK's instructional plants, State farmers communication centres, industrial attachments etc. for a period of one semester with provision for adequate supervision, reporting and examination at the end. The scheme is supported jointly by ICAR and State Governments in sharing the stipend in the ratio of 75 : 25. In the XI Plan period about 27,600 students benefitted from RAWE.

At the national workshop on RAWE held on 19–20 May, 2012 at UAS, Bangalore, the new concept of student READY (Rural Entrepreneurship and Awareness Development Yojana) combining both RAWE and Experiential Learning courses together during the final year (VII and VIII semesters) was accepted. It would provide hands on experience and rural awareness to the students to become effective professionals and entrepreneurs.

National Information System on Agricultural Education Network in India (NISAGENET)

The web portal http://www.iasri.res.in/Nisagenet/ is being maintained at the central server of IASRI, New Delhi as a regular ongoing activity of the Agricultural Education Division of the ICAR. With the active participation of SAUs, DUs and other organizations engaged in agricultural education, the NISAGENET has become a single Window Information Delivery System. Its operational architecture has been modified to three tier web architecture and has enabling direct entry/ updation of data from the respective university/college(s) using the authenticated user Id and password. The database contains information on academic data of the universities, infrastructural facilities, budget provision, manpower employed, faculty and R&D activities. Moreover, it has an exhaustive Query/Reports system to provide information at country, state, university and college levels as well. To meet the requirements of the users, recently, the module on dynamic and selective reporting has been strengthened and scope widened.

The HRD data with regard to students admitted/passed and faculty/administrative manpower has been uploaded and validated for the year 2009–10 and 2010–11 by the respective AUs/colleges. For validation of the existing data in NISAGENET, Appraisal-cum-Data Validation Workshop for the Nodal Officers was organized at SKUAST Jammu, Jammu, (J&K) during 12–13 September, 2012.

Manpower Development

All-India Entrance Examination for Admission to UG and PG: The 17th Undergraduate Examination for degree programmes for admission to 15% seats in agriculture and allied subjects other than veterinary sciences including the award of National Talent Scholarships (NTS) was conducted on 14 April 2012. The examination attracted 57,627 applicants out of which 51,939 candidates appeared and a record number of 1,875 candidates were finally recommended for admission in 54 AUs through counseling. All the candidates who joined a university outside their State of domicile were awarded NTS of ₹ 1,000 per month. The examination for PG was conducted on 15 April 2012 for admission to 25% seats in PG programmes at 62 Universities, including award of ICAR Junior Research Fellowships (JRF). A total of 18,693 candidates appeared in the examination out of 20,896 applicants, and 2,404 candidates were recommended for admissions. In all, 472 students were awarded JRF in 20 major subject groups.

All-India Competitive Examination for ICAR Senior Research Fellowship for Ph.D: A total of 189 Senior Research Fellowships were awarded and 592 candidates were declared qualified for Ph.D. admission without fellowship in 13 major subject groups and 56 sub-subjects.

Globalization of agricultural education: About 250 candidates from 34 countries like Afghanistan, Bangladesh, Bhutan, Cambodia, Congo, Egypt, Eritrea, Ethiopia, Fiji, Guyana, Ghana, Indonesia, Iraq, Iran, Kenya, Mauritius, Maldives, Mozambique, Mongolia, Morocco, Myanmar, Namibia, Nepal, Niger, Nigeria, Rwanda, South Africa, Sudan, Sri Lanka, Syria, Turkmenistan, Vietnam, Uganada and Zimbabwe, exercised their preference to join various agricultural universities under various fellowships or as self-financed candidates.

Capacity Building of Faculty

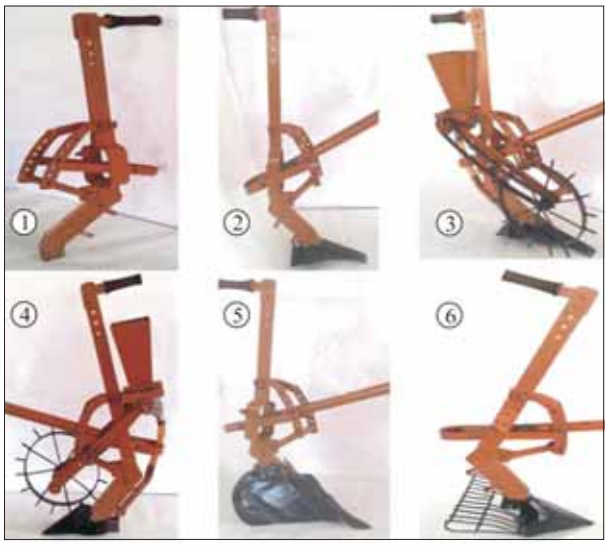
Summer/Winter Schools and Short Courses: Summer and Winter Schools and Short Courses of 10 to 21 days duration (40 SWS of 21days and 23 Short Courses for 10 days) were conducted at ICAR Institutes and State Agricultural Universities in key areas of agriculture and allied sciences like Application of remote sensing and GIS, Advances in Micro-irrigation and Fertigation, Farmers Empowerment and Entrepreneurship Development, Functional Genomics, Molecular Biology, Integrated Disease Management, Climate Change, Bio-fuels, Agri-business and Market Intelligence, Education Technology, etc.

Centers of Advanced Faculty Training: The 31 Centers of Advanced Faculty Training provided training to 966 scientists/faculty members from the National Agricultural Research System through 36 training programs in cutting edge areas of agricultural and allied sciences.

Promotion of Excellence and HRD

ICAR National Professor Scheme: For promoting excellence and creating a culture of basic research at national level, ten positions of National Professors have been created. Major achievements of ongoing ICAR National Professorial scheme comprised:

- *Designs for single factor and multi-factor experiments and their applications in Agricultural Systems Research:* A research level book entitled "Combinatorics in Sample Surveys vis-à-vis Controlled Selection" has been published. The book demonstrated the use of combinatorial properties of experimental designs in exercising control over sample selection from a finite population, besides the calibration approach based estimators when there is a negative correlation between the study and the auxiliary variable. The theoretical expressions for bias, variance and variance estimator of the proposed estimator are also developed. A web resource entitled "Sample Survey Resources Server" has been initiated and made available at www.iasri.res.in/ssrs/. Design resources server has been further strengthened by adding A- and D-efficient row-column designs in a given parametric range with two rows for 2-colour micro array experiments.
- *Development of technologies for subsoil structure modification, deep placement of fertilizers (P & K) and micro-nutrients and controlled field traffic for different cropping systems of Indo-Gangetic Plains:* An innovative gadget named Pant-ICAR Animal Drawn Six-in-One Tillage Outfit / Assembly was designed and developed, is being patented for soil cultivation especially in hilly regions. The outfit is embodied with different components alternately for performing six different farm operations such as ploughing without soil inversion, deep placement of fertilizers at 15 cm depth, sowing of cereals and pulses, furrow and ridge formation, interculture operation and potato digging. The outfit is light in weight and could be operated with medium size draft animals. The cost of the complete set



Pant-ICAR Animal Drawn Six-in-One Tillage Outfit / Assembly

is about ₹ 6,000/-. The KVKs of GBPUA&T, Pantnagar are being provided with at least one unit of outfit for field evaluation.

- *Plant-Need Based Nitrogen Management in Rice and Wheat:* Three different techniques, the Leaf Colour Chart (LCC), the chlorophyll meter (SPAD meter) and optical sensors (patented units) have been tested for their effectiveness in a series of field trials. Both the LCC and the SPAD meter have been found to be very useful in identifying the critical stages when the leaves start exhibiting the 'needs syndrome' and the fertilization at that stage ensures proper grain yields. The former (LCC) is inexpensive and easy to use and even semi-literate farmers can easily learn to use them.
- *Assessment, prediction and enhancement of biotic carbon sequestration in agricultural soils:* Impact of long-term application of organic amendments and fertilizer nitrogen (N) on carbon sequestration and its distribution among various physical pools of soil organic matter was studied post11-years of rice–wheat cropping. The studies showed that the application of farmyard manure and rice straw increased soil organic carbon pool by 34% over sole application of fertilizer N. Organic amendments had also a major influence on distribution of organic carbon among different soil organic matter pools.
- *Broadening the genetic base of Indian mustard* (*Brassica juncea*) *through alien introgressions and germplasm enhancement:* Developed and validated the concept of resynthesizing digenomic *B. juncea* from related digenomics. Morphological and molecular assessment of a large number of such derived juncea genotypes helped in establishing their potential as a new and distinct germplasm resource of tremendous breeding value for germplasm enhancement in mustard. Demonstrated the heterotic potential of derived *juncea* genotypes in crosses with natural *B. juncea*. Developed determinate mustard (Samar) for the first time in the world. It is expected to set in motion crop architectural transformation in mustard and enhance productivity through improved harvest index and better resource mobilization to developing sinks.

Determinate mustard genotype(Samar)

- *Allele mining for agronomically important genes in wild rice germplasm and stress tolerant landraces of rice growing in the hot spots:* 160 accessions of wild rice and 23 landraces of rice were collected from different districts of Eastern Uttar Pradesh and Southern Bihar from the Ganga and Son river plains along with full passport data. These accessions were grown in IARI fields during *kharif* season of 2011 and 2012 and basic morphological data were recorded. Phylogenetic analysis of these wild rice accessions was done using SSR DNA markers that clustered them into three main groups.
- *Design, construction and validation of DNA chips for virus identification and differentiation:* DNA chip for detecting animal viruses specific to Indian livestock now contains probes for 175 viruses and 146 virus genera. The chip, besides, identifying many common virus infections from clinical samples also identified a mix infection of BHV 1 and BVD 2 in cattle, which was subsequently confirmed by RT-PCR. A DNA chip for screening animal, fish and bird viruses in 8X60K has been developed and is under clinical testing. This chip contains unique probes for 826 viruses and 149 virus genera.
- *Changing consumption pattern in India: Opportunities for diversification towards high value commodities through production and marketing linkages:* Analyzed the pace and pattern of diversification of agriculture across states considering data for 30 years. There has been a consistent and significant growth (4% per annum) of high value commodities (HVCs) such as horticulture, livestock and fisheries resulting in improved income for farmers. Punjab, Haryana and UP were identified as low diversifying states while the North-Eastern states, Kerala and Gujarat were among the high diversifying states. Adequate policy support for marketing and value addition through both public and private investments holds key to sustain the shift towards HVCs. The introduction of e-tender system in the regulated markets of Karnataka was found to improve efficiency of marketing through reduced manipulations in price bidding and increased competition.

ICAR National Fellow Scheme: With an objective to provide support and develop strong centers of research and education around outstanding scientists, 25 ICAR National Fellow positions have been provided in National Agriculture Research System. Highlights of the ongoing projects are:

- *Improvement of strain of Chaetomium globosum, a potential antagonist of fungal plant pathogens for enhanced bioefficacy and developing molecular markers for its identification:* A Hsp22 gene of 630 bp from *C. globosum* (Cg 1) was

cloned and sequenced that showed 603bp open reading frame encoding 200 amino-acids. BlastX analysis revealed that the gene codes for a protein homologous to the previously characterized Hsp22.4 gene from *C. globosum* (AAR36902.1, XP 001229241.1) and shared 95% identity in amino acid sequence This gene was further cloned into pET28a(+) expression vector and transformed *E. coli* BL21 cells were induced by IPTG, and the expressed protein of 39 kDa was analyzed by SDS-PAGE. The IPTG induced transformants displayed significantly greater resistance to NaCl and Na_2CO_3 stresses. In addition, another gene responsible for the production of xylanase (1000 bp) has been cloned and sequenced from *C. globosum* (Cg2).

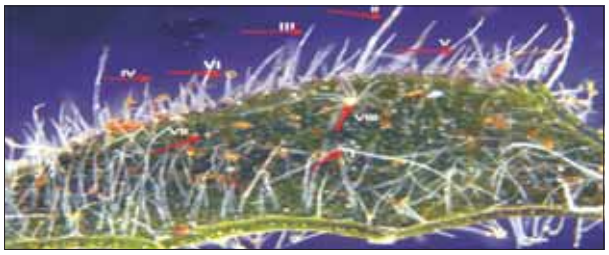
- *Decontamination of pesticide residues from edible commodities:* Use of saponin could decontaminate imidacloprid from okra up to 99% when used as a combination of 3 reagents. A transition metal catalyst along with hydrogen peroxide degraded organophosphorus (OP) pesticides to the extent of 92–100%. Degradation was however restricted to 60–70% for organochlorine (OC) and a new pesticide pyridalyl.
- *Assessment of sustainability of treated/developed watersheds in rainfed agro-eco-sub-regions of Peninsular India using GIS and remote sensing:* Based on an intensive study of eight watersheds, monitoring indicators that could help Project Implementing Agencies to monitor their project for sustainable development include—status of fodder availability (3.5%), total crop production trend (7.8%), gross agricultural income (7.8%), state of S& WC structures (17.9%), adoption of soil moisture conservation measures (17.9%) and practicing farm OM recycling (13.4%). Critical evaluation indicators that help in assessing sustainability of a given watershed project were—soil organic carbon content (13.4%), availability of credit facility for farmers (15.9%), presence of other gainful employment options for farm hands (13.4%), adequate availability of fodder (12.2%), state of soil fertility (12.4%) and Crop Diversity Index (13.6%). Both sets of indicators essentially signify aspects that are critical for sustainability of rainfed agriculture.
- *Development of ELISA based immunodiagnostics for Classical Swine Fever:* RT-PCR using primers specific to the E2 gene segment of classical swine fever virus (CSFV) was carried out to compare the results of the double antibody sandwich ELISA for detection of CSFV. All the forty-nine CSFV antigen positive samples in the ELISA were confirmed by the RT-PCR. Cloning of the E2 gene segment of the RT-PCR positive CSFV isolates has been completed and twenty cloned DNA products were sequenced. IgG level in the colostrum of sows after CSF vaccination was higher in the sows that were vaccinated within second month of pregnancy. A significant increase of CSFV specific antibody level was observed in the serum samples of piglets given zinc sulphate @ 150 ppm for 60 days from one month of age and CSF vaccine at 56 days of age.
- *Assessing soil quality key indicators for development of soil quality index using latest approaches under predominant management practices in rainfed agroecology:* The key soil quality indicators that emerged for Alfisol soils at Bengaluru Dryland Centre were: pH, available N, available P, available K, available S, Organic C, Mean Weight Diameter (MWD) and labile Carbon. Highest carbon stock was recorded in minimum tillage + 100% organic N (9.01 Mg/ha) followed by reduced tillage + 100% organic N (8.24 Mg/ha). Reduced and minimum tillage recorded 23.5 % and 27.2% higher carbon stock, respectively compared to conventional tillage. In groundnut–finger-millet rotation, Maize Residue (MR) @ 5 t/ha + 50% N, P_2O_5, K_2O recorded highest carbon stock (9.28 Mg/ha) followed by MR @ 5 t/ha + 100% N, P_2O_5, K_2O (8.90 Mg/ha), the increase over control being 36.6% and 31.1% respectively. FYM @ 10 t/ha + 100% N, P_2O_5, K_2O was found superior in finger-millet mono-cropping system.
- *Evolution of textile articles through processing of wool with silk waste and cotton to create entrepreneurial skills in rural women:* Rambouillet wool, eri and muga silk and regenerated cellulosic lyocell fibers were made into hand and ring spun eco-friendly pure and blended yarns (30 : 70, 50 : 50, 70 : 30 and 100 : 00). Yarn count, twist per inch, strength and elongation and yarn evenness of hand and ring spun pure and blended yarns were tested to estimate the yarn quality. Best selected blended yarns were chosen on the basis of physical properties. The pure yarns as well as best selected blended yarns dyed with acid, and reactive, direct and natural dyes. Fair to excellent colorfastness properties were observed in case of perspiration, rubbing, washing and light fastness tests with wide range of colours from natural dyes. Forward linkages have been made with the support of government agencies for income generation from textile entrepreneurial activities.
- *Identification and quantification of phosphatase hydrolysable organic P sources for plant nutrition and refinement of a non-destructive technique for phosphatase estimation:* Three organisms viz. *Aspergillus flavus* TFR1 (JN194185), *Aspergillus terreus* TFR2 (JN194186) and *Aspergillus oryzae* TFR9 (JQ 675296) were developed that can successfully synthesize nano-phosphorus from calcium phosphate with a particle size between 8 and 40 nm. The synthesized nano particle was encapsulated by oleic acid to form nano-phosphorus fertilizer. The developed nano-P

fertilizer was tested as foliar spray @ 16 litre/ha with a concentration of 40 ppm on 2 weeks old plants of arid crops like pearl millet and clusterbean under field condition. The nano-P fertilizer improved P use efficiency by 43% in pearl millet and 57% in cluster-bean. Additional 24% and 57% improvement of grain yield was noticed in pearl millet and cluster-bean, respectively.

- *Nanotechnology in aquaculture: An alternative approach for fish health management and water remediation:* Synthesized Silver nanoparticles showed strong antibacterial activity against a wide range of Gram positive and Gram negative bacterial pathogens of fish. Iron oxide nanoparticles as feed additives increased growth, haematological parameters and innate immune responses with no toxic side effects. Iron oxide nanoparticles exhibited potential for reducing ammonia and nitrate level of hatchery waters. Surface modified Poly-å-caprolactone microspheres and inorganic calcium phosphate nanoparticles acted as immunoadjuvants through parenteral immunization in fish with no toxic side effects (unlike oil adjuvants) using different protein antigens.
- *Development of soy and multigrain based nutritionally balanced functional foods for children:* To assess the nutritional status, 150 children of Bhopal district were surveyed for data on 24 h dietary recall, food frequency, socio-economic parameters, and anthropometry. As per the survey the children received only 50-55% of the recommended amounts of energy, protein and fat and 68% of iron. Height and weight of the children showed that they suffered from mild to moderate malnutrition as per the Gomez and Waterloo classification showing the urgent need for supplementation in the diets. Sixteen combinations consisting of corn, wheat, malted *ragi*, sprouted green gram, roasted peanuts, soy protein isolate, and papaya etc were chosen from 1450 feasible combinations using construction of composite index based on Principal Component Analysis (PCA). The protein content of the mixes was around 17.5 g/100 g, fat content around 5/100 g. Phenolics content was 100–125 mg/100 g equivalent of Gallic acid and antioxidant capacity was 5.6 to 9% radical scavenging activity. These mixes are now further being incorporated into products like porridges, biscuits, etc. as supplementary foods for children.
- *Precision nutrient management using GIS-based spatial variability mapping under Upper and Middle Gangetic Plain Zones of India:* The work on assessment of spatial variability in soil fertility status in the Western Plain Zone (WPZ) was taken up. Farmers participatory survey indicated that fertilizer use was skewed towards N (68–71%), whereas nutrients like K, S and micronutrients were generally neglected indicating highly imbalanced fertilizer management practices of the region that may not sustain high productivity of the crops in the long run. Highest K recycling through irrigation water under cropping systems was noticed under sugarcane–ratoon–wheat (112 kg K/ha), followed by rice–wheat system (79 kg K/ha). Marked variability in macro- and micro-nutrients status of soils across the districts and cropping systems was revealed. Different fertility parameters were classified into low, medium and high categories using the user defined ranges to develop homogenous fertility zones for the precision fertilizer recommendations for use by the farmers and policy makers.
- *Development and evaluation of neuraminidase DIVA marker vaccines against highly pathogenic H5N1 avian influenza viruses in chickens:* Antigenic and genetic analysis of highly pathogenic H5N1 viruses from Indian outbreaks from 2006 to 2010 was carried out for selection of hemagglutinin (HA) gene donor vaccine candidate. On the basis of 3-D antigenic cartography, A/chicken/West Bengal/80995/2008 H5N1 virus was found to be the best fit as the HA gene donor virus. For development of reverse genetics based non-pathogenic H5 vaccine strain, the basic amino acid cleavage site RRRKKR*GLF (major genetic character responsible for highly pathogenic nature of H5N1 viruses) in the HA gene of the selected H5N1 strain was modified to IETR*GLF by site directed mutagenesis. Using the mutated HA gene in the reverse genetics system, a recombinant H5N2 virus was generated from cloned gene segments of influenza virus as a non-pathogenic vaccine candidate for developing DIVA marker vaccine against H5N1 in poultry.
- *Development of commercially viable process technologies for weaning food based on underutilized crops of Uttarakhand:* A Popper/Puffing device costing ₹1,200 with a capacity of 1 kg/h for popping the grains of undervalued crops has been developed. Developed process technology for finger-millet, black soybean, horse-gram based multipurpose composite flour using optimized parameters of pretreatment methods like soaking, germination, blanching and malting. These optimized pretreatments could reduce anti-nutrients and thus improve the bioavailability of nutrients. A nutri-enriched bread has been prepared using optimized flour blend that contains 1.9% fat, 13.4% protein, 1.5% fibre and 301.5 Kcal energy, besides better sensory scores.
- *Functional Genomics, Epigenetics and Gene Silencing Technology for improving productivity in poultry:* Day old broiler birds showed higher expression of calmodulin, calreticulin, collagen, troponin C, troponin slow type protein, sarcolipin, myoglobin, cardiac related protein and myelin

genes than those of corresponding layer birds while myostatin, IGF-1 and GHR had higher expression in layer than broiler birds. At 6 weeks age, all thirteen genes had higher expression in layer birds than broilers. The ORF of chicken myostatin gene was characterized and its expression was found to be lowest during sixth week followed by fourth, seventh and second week, and day old. A total of nine haplotypes in promoter and six haplotypes in coding region of myostatin were observed in control broiler line where h1 haplotype was the most predominant one. Haplotype combinations showed significant effect ($P<0.05$) on body weights at 2 and 7 weeks of age. At 2 weeks age, h1h3 haplogroup recorded highest body weight (150.9g), whereas at 7 weeks, h1h6 haplogroup exhibited 28.16% higher body weight than h1h2.

- *Studies on phyto-semiochemicals involved in Insect-Plant interactions of major horticulture pests: Deciphering chemical cues*- Glandular and non-glandular trichomes (Type I–VIII) were observed in wild and cultivated Solanum species. Stellar trichomes (Type VIII) were found to be abundant in *S. melongena, S. indicum* and *S. gilo*. Types I–VII trichomes were also present in *S. mammosum* and *S. viarum*). The bioassays revealed the neonate larval mortality due to entrapment, repellency and feeding indicating the potential trichome based antixenosis and antibiosis. Host cues isolated from mango, viz. γ-Octalactone, 1-Octen-3-ol and ethyl tiglate were identified as potential ovipositional attractants. Ethyl tiglate was found to be most attractive with ovipositional index (OI) of 0.7 on natural substrate, while, γ-Octalactone was the most preferred ovipositional cue for *B. dorsalis* on artificial substrate with OI of 0.92.



S. viarum leaf covered with multiple trichome types, including the type I-VIII, the types VI & VII are glandular trichomes

- *Development of transgenic goat using Sperm-Mediated Gene transfer (SMGT) method and its use as a bioreactor for producing novel proteins of therapeutic importance:* Promoter region (app 2 kb upstream) of uroplakin gene has been cloned and characterized for making a vector cassette to drive the expression of the transgene in the target organ (urinary bladder). Cloning of a bigger upstream region app 8–10 kb is in progress. Electroporation parameters for transfection of testes/sperm has been optimized and being validated using *in vitro* fertilization. Isolation and *in vitro* culturing of urothelilal cells has been optimized.
- *Whole genome wide SNPs based assessment of genetic relationship of Indian native cattle adapted to different agroclimatic condition:* To discover the genome wide SNPs and unravel whole genome based population structure of Indian cattle, a total of 23 individuals representing 7 native cattle breeds viz. Amritmahal, Gir, Ongole, Red Kandhari, Sahiwal, Tharparkar and Leh adapted to different agroclimatic regions and two exotic Holstein and Jersey cattle breeds were genotyped using 770 K high density bovine SNP chip. The population structure analysis through multidimensional scaling plot revealed grouping of Indian cattle breeds in one cluster and widely separated from Bos taurine cattle. The native cattle from Leh and Laddakh region were genetically distinct from rest of the Indian cattle. This study represents a first approach to assess population structure of Indian native cattle breeds using the high density SNP chip and re-establishes the genetic distinctness of Indian cattle from Bos taurine cattle.
- *Comprehensive screening of target, non-target and unknown emerging organic contaminants in fruits and vegetables by GC-MS and LC-MS:* An integrated method of analysis was developed for the residue analysis of pesticides and plant growth regulators in fresh fruits and vegetables with special emphasis on semi-polar to polar compounds based on a generic method of sample preparation using methanol as extraction solvent. A GC-MS/MS method was also established for simultaneous analysis of 375 pesticides. More than 500 samples of 5 different vegetable commodities from different districts of Karnataka, Maharashtra, Tamil Nadu and Gujarat were screened for pesticide residues using GC-ToF and LC-MS/MS. The results with respect to different agro-climatic and horticultural practices were compared. Furthermore, precise, accurate and sensitive methods based on LC-MS/MS and UPLC with fluorescence detection have also been developed for multi-mycotoxins and aflatoxin analysis, respectively in plant matrices. The above analytical methods support holistic risk assessments related to food contamination at 10 ppb and lower residue levels.
- *Development of sensitive and specific diagnostic assays for detection of Trypanosoma evansi infection in animals using modern molecular tools:* Bloodstream forms of *Trypanosoma evansi* have been cultivated in axenic system using Iscove's modified DMEM-based HMI-9 medium supplemented with bathocuproine disulphonic acid, 1-cysteine, hypoxanthine, 2-mercaptoethanol, pyruvate, thymidine and heat

inactivated horse serum. The HMI-9 medium yielded best results in terms of adaptation, survivability and multiplication of trypanosomes. Phylogenetic analysis of the invariant surface glycoprotein gene sequences showed heterogeneity among four *Trypanosma evansi* Indian isolates of different geographical area.

- *Development of novel immunopotentiator molecules from fish host and pathogens for broad spectrum disease control in freshwater aquaculture:* The anti-microbial peptide genes (apolipoprotein M, apolipoprotein A1, hepcidin, mitochondrial anti-viral signaling peptide) partial sequence information were generated in rohu, *Labeo rohita*.. The expression level of the genes in various tissues and different developmental stages of rohu were studied. Further, the expression pattern of these genes was also measured after experimental infection of rohu with *Aeromonas hydrophila* and the potential role played by these molecules in bacterial pathogenesis determined.
- *Environmentally sustainable termite control: integrative and inclusive approach of frontier and indigenous technologies:* Effect of agronomic practices like tillage and crop residues in control of termite infestation was investigated with integration of termiticides, seed-treatments, and other biological options like botanicals (garlic-based products), entomo-pathogenic-fungi (*Beauveria bassiana* and *Metarhizium anisopliae*). A termite species *Heterotermes indicola* (Wasmann) identified from Delhi region. The seed-treatment with double dose of Chlorpyriphos 20% EC, and Fipronil 5% SC (@ 9 & 6 ml/kg seeds) was found to be detrimental to the wheat seedlings.

Emeritus Scientist Scheme

The ICAR continued to operate Emeritus Scientist Scheme as a structural method of utilizing Skill Bank of the outstanding superannuated professionals of NARS. Some of the major findings of the projects under this scheme are:

- Installation of light traps for mass trapping of adult insects with two deep ploughings before planting followed by soil application of talc based formulations of *Bacillus cereus* or *Metarhizium anisoplae* pellets (half at planting and half at earthing up time) + 2–3 foliar sprays of Jatropha and mycojaal (cattle urine extracts) were found viable alternative to chemical control against potato insect pest complex in Shimla hills.
- Microbilogically bioscoured cotton yarn in hank form dyed with natural indigo and fabrics made in handloom sector were converted to readymade jean pants of different sizes. The process adopted is least polluting and suitable for handloom sector.
- Release of exotic parasitoid *Acerophagus papayae* reduced the mealybug damage from grade 5 (>80% damage) to 1 (less than 5% damage) in Gulbarga and from 4 (>50% damage) to 1 in Bengaluru within four months.
- Atmosphere modified with cow dung cake smoke controls storage pests (insects and microbes) effectively.
- Out of 388 working germplasm of cotton in CICR Nagpur, 100 working germplasm has been characterized individuality using 28 STMS markers.
- A major shift towards the culture of the American Whiteleg shrimp (*Litopenaeus vannamei*) in the states of Andhra Pradesh, Tamil Nadu, Gujarat and Odisha was observed in over production of cultured shrimp and decline in prices. Most of the *Penaeus monodon* hatcheries and farms were converted into *L. vannamei* hatcheries and farms in these states.
- *Helicoverpa armigera* can be effectively controlled by mass trapping of male moths (male annihilation technique-MAT) through installation of pheromone traps @ 40 and 50 traps per hectare in tomato and pigeon pea, respectively. MAT was demonstrated and implemented on wide-area in guava, cucurbits and mango for the management of fruit flies; chickpea for management of *H. armigera*; and brinjal for the management of fruit and shoot borer (*Leucinodes orbonalis*).
- A high level of genetic diversity was observed among *Corchorus olitorius,* which could be used for the jute improvement programme.
- Adjuvants identified *in vitro* that enhance the immune system in birds.
- A line, having better Zn availability, was found in the pearl millet hybrid samples tested compared to check, while 32 lines were having better Fe content.
- Cowpea can be incorporated in rice–wheat cropping system in Tarai area of Uttar Pradesh and Hills of Uttarakhand.
- Using available data from known sources, current available catch and gap in present and required catch of tuna has been done.

Quality assurance and reforms

Accreditation: Quality assurance in higher agricultural education was pursued through accreditation of agricultural universities, their constituent colleges and programmes. Five universities, viz. Animal and Fisheries Sciences University, Bidar; Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, University of Agricultural Sciences, Raichur, Uttar Banga Krishi Viswavidyalaya and CSK Himachal Pradesh Krishi Viswavidyalaya, Palampur were visited by the concerned Peer Review Teams for validation of Self Study Report (SSR). The SSRs of 7 SAUs seeking accreditation have been received.

India-Africa Fellowships: India is offering 75 fellowships each year for a period of four years to the

nationals of African continent for pursuing Master's and Ph.D. programmes in Agriculture in Indian AUs to support the Agricultural human resource development in Africa through formal education of African scientists/ faculty and students. During the current year, a total of 132 (88 Master's and 44 Ph.D.) candidates, against the available slots, from 16 African countries, viz. Benin, Botswana, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mozambique, Nigeria, Rwanda, Somalia, South Sudan, Sudan, Tanzania, and Uganda, have been recommended to 24 Indian AUs. During 2010–11 and 2011–12, a total of 91 candidates including 60 for Master's and 31 for Ph.D programmes were admitted in different subjects.

India-Afghanistan Fellowships: To strengthen and expedite the process of human resource development in Afghanistan, India is offering 115 fellowships every year for pursuing Master's and Ph.D programmes in Indian AUs, to faculty members and students. In the current year, a total of 193 candidates have been recommended for admission in 35 Indian AUs for pursuing Bachelor's, Master's and Ph.D. programmes.

ICAR International Fellowships: With an objective to develop competent human resource and showcasing the strengths of Indian ICAR-AUs system, ICAR International Fellowships were introduced in 2009–10, for pursuing Ph.D. programme at the Indian agricultural universities (AUs) and overseas universities for overseas and Indian candidates, respectively.

A total of 15 candidates were selected during 2011–12, of which 13 candidates have joined their programmes in various overseas universities.

For the year 2012–13, 14 candidates have been selected for pursuing their Ph.D programme.

ASEAN-India Working Group: The second meeting of the ASEAN-India Working Group on Agriculture and Forestry (AIWGAF) was held on 6–8 March, 2012 in Plembang, South Sumatra, Indonesia. During the meeting, it was agreed to hold a conference of Heads of Educational and Research Institutions in India, Workshop on Climate Change adaptation and mitigation in agriculture was organized during 22–25 August, 2012 in New Delhi.

ASEAN-India meeting of Agriculture Minister and Senior Officers: The meeting was held at NASC Complex, New Delhi on 17–19 October, 2012. An Agri-Expo was also organized on this occasion. Shri Sharad Pawar, Hon'ble Minister of Agriculture, Government of India, inaugurated the meeting. The first issue of newsletter entitled "ASEAN India Newsletter" was also launched on 17 October 2012.

Policy for Higher Agricultural Education and guidelines for establishing new CAU: The Committee constituted to develop 'Policy for Higher Agricultural Education and Guidelines for Establishing the New Central Agricultural University' in the country held consultations with various stakeholders, during the year and the contents finalized.

Liaisoning with other departments and academic institutions: Liaisoning with MHRD, AICTE, UGC, NCERT, CBSE, IAUA etc. was maintained to improve the quality of higher education in the country, in general and of agricultural education in particular through synergies and exchange of information.

National Academy of Agricultural Research Management

National Academy of Agricultural Research Management (NAARM) continued to focus its activities in areas of capacity building, research, policy support and post graduate education.

Capacity building: The Academy organized 45 programmes, which included 3 foundation courses for Agricultural Research Service (FOCARS) and 42 other senior-level training programme in the areas like information and knowledge management, personal effectiveness, discipline competencies, business orientation and building linkages.

The Academy developed a scheme to institutionalize an integrated competency framework for capacity building for research excellence and leadership succession across NARS to address future challenges. It includes a new model of Foundation Course for ARS probationers (FOCARS), Executive Development programme for newly-recruited Directors and Management Development Programme in Leadership for aspiring research managers (a Pre-RMP programme),

Second ASEAN-India Ministerial Meeting on Agriculture & Forestry and Agri Expo was organized at NASC Complex, New Delhi

besides the refresher course for lateral entrants to the ARS.

Research: The research projects of the Academy are operative in five thematic areas viz. Agricultural science and technology policy, accelerating agricultural innovations through ICTs and institutional change, Organization and management for strengthening agricultural research, Agri-marketing and value chain management, and Governance and institutional arrangements attracting funding by NAIP, DST and other agencies. The research by faculty of NAARM led to nearly 100 publications in peer reviewed national and international journals, book chapters and other publications and presentations.

Policy Support: Eleven workshops, conferences and seminars conducted at the Academy provided a platform for dialogue on several issues of concern for national and international policy in agriculture that included workshops on Leadership Effectiveness and Performance Enhancement in NARS, Public Private Partnership in Agriculture, Policy and Prioritization, Monitoring and Evaluation (PME) Support to Consortia-based Research Projects in Agriculture, Annual Conference of Indian Society of Agricultural Marketing, Policy Workshop on Training Transfer at NARS, etc. These workshops provided platform for 400 professionals from public and private institutions of NARS to deliberate and recommend pragmatic policy strategies.

Education: All students (20) of the outgoing batch of Post Graduate Diploma in Management (Agriculture) got placements in mid-level management positions in private sector companies relating to retail, input, commodity exchange, services (logistics and collateral management) and finance. The selection process of students for PGDMA included an all India test conducted jointly with MANAGE, Hyderabad and NIAM, Jaipur (Joint Entrance Test for Agribusiness Management or JETABM) followed by group discussions and personal interviews.

NAARM successfully organized a one-year Post Graduate Diploma in Technology Management in Agriculture (PGDTMA) in Open Distance Learning (ODL) mode in collaboration with University of Hyderabad.

Other activities

Agribusiness Knowledge Centre (AKC): The AKC is a Public Private Partnership (PPP) initiative between NAARM and Gyantech Information Systems Private Limited (GISPL), Hyderabad to primarily 'Value Chain' farmers, academia, research and industry through exchange of knowledge among them. AKC has established space for private sector to function at NAARM. AKC successfully conducted National Mega Meet on Technology Commercialization with participation from ICAR institutes, private companies and grass root innovators wherein it identified five technologies for further commercialization. AKC has entered MoU with 'efreshindia' (www.efreshindia.com) for providing content for crop management and good agricultural practices in four identified regions of Andhra Pradesh.

Linkages: The Academy continued its linkages with its traditional partners – institutes of ICAR, SAUs and the CGIAR institutions. In addition, new linkages have been developed with a wide range of international institutions including universities, agribusiness, industry and NGOs in areas related to technology management, post graduate education and capacity building.

NAARM Collaborates with APTDC: Andhra Pradesh Technology Development and Promotion Centre (APTDC) and Confederation of Indian Industry (CII) in association with International Crop Research Institute for Semi-Arid Tropics (ICRISAT) organized AP-TEC 2012, a conference and exposition focusing on Technologies for Modern Agriculture with NAARM as knowledge partner.

National Stakeholders' Consultation Meet was organized by NAARM to plan and prioritize the XII Plan programme.

Reorganization of NAARM: NAARM has been restructured into six functional divisions, i.e. Human Resources Management; Information and Communication Management; Research Systems Management; Agribusiness Management; Education Systems Management; and Extension Systems Management in tune with its new vision and mandate. Accordingly, its cadre strength has also been increased to 62 from the present strength of 43. Efforts are underway to fill the vacant positions by recruitment and transfer.

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Vice-chancellors Conference

The annual conference of vice-chancellors of the Agricultural Universities and interactive meet between ICAR senior officers and Directors was organized during 15–17 February, 2012 in New Delhi. A dialogue between CGIAR and AU system was also organized on 15 February, 2012 for understanding the areas of cooperation and exchange. The first prize was given to KAU, Thrissur and second prize to CAU, Imphal in recognition of output in ICAR JRF examination. The GBPUA&T, Pantnagar and Dr PDKV, Akola jointly bagged the third prize.

Annual conference of vice-chancellors of the Agricultural Universities and interactive meet between ICAR senior officers and Directors was inaugurated by Shri Sharad Pawar, Union Minister of Agriculture and Food Processing Industries

13. Agricultural Economics, Marketing and Statistics

India has moved from an era of chronic food shortages during 1960s to food self-sufficiency and even food exports from 1990s. The agriculture sector grew at an average rate of 3.3% during the XI Five Year Plan and the targeted growth rate is 4 % in the XII Five Year Plan. Demand for food and agriculture commodities in India is rising at a much higher rate than the growth in population of the country. Rising per caput income and urbanization are leading to dietary transition primarily from food with low price calorie food like cereals towards high price calorie food like livestock products and towards processed and ready-to-eat products. The adoption of new technologies by farmers in the country has resulted in manifold increase in the farm productivity and production. In spite of high growth in demand due to increase in population and per caput income, and shrinking natural resources, public agricultural research enabled production of food to grow faster than demand. This is mainly attributable to improvements in agricultural productivity achieved through technological change enabled by investments in agricultural R&D.

To attain close to 4% growth in agriculture, favourable interplay of policies and technologies is required. These include unambiguous assessment of resources, assurance of stable and remunerative prices to producers, hike in 'investment in agriculture' and 'investments for agriculture', greater involvement of private business in agriculture, supply of quality seed and planting material at reasonable prices, timely and adequate availability of various inputs, push to diversification, strong support to R&D and technology dissemination, providing means (resources as well as policies) to mitigate the climatic challenges, increase in power supply to agriculture, and competitive market environment.

Market integration and price transmission: The case of rice and wheat in India

The analyses focused on impact of world food crisis of 2007–08 on consumers and transmission of world food prices to the retail level. Price transmission to the farmers or farm gate level is important, because only through this transmission, a possible supply response to increase the supply of these cereals can be expected. The long-run elasticity of price transmission from international to wholesale and retail prices of wheat is higher than that to the farm gate prices. The farm gate prices responded differently during rising and falling phases of international prices. Interestingly, the short-run shocks in international prices did not significantly influence domestic prices at any level of wheat supply chain. There is lack of congruence between international and domestic prices of rice and wheat. The rise in domestic prices during the crisis period was observed but was considerably lower than that in global prices.

During 2007–09, the movements in global prices and domestic prices of rice and wheat were almost in contrast to each other. During the five-year period ending 2008–09 or 2009–10, the coefficient of variation in international price was two-to-three times the domestic prices of rice and wheat. On the contrary, the coefficient of correlation between monthly international and domestic prices of rice and wheat have been found, generally, quite low and insignificant, both during pre-crisis (1996–2007) and crisis (2007–2011) periods. The main factors that impeded the transmission of abnormal increase in global prices to Indian markets were timely and effective government intervention in rice and wheat markets, and almost complete insulation of domestic fertilizer prices from increase in international crude oils and fertilizer prices. The paddy and wheat growers in India received considerably higher prices during 2006–08 and it continued during 2008-09, owing to the mix of domestic policies, including hike in MSPs. The farm harvest prices of wheat registered an annual increase of 14 to 22% and that of rice increased by 7 to 20% continuously during 2006–07 to 2008–09. There was a considerable hike in MSPs during 2007 and 2008 as part of food security package of the Government. The crux of findings is that high global prices have impacted farm gate prices in India, not directly but through their influence on the decision of the government related to the levels of fixation of guaranteed support prices.

Commodity outlook models for major grains and oilseeds

The Indian economy is undergoing a rapid transformation due to greater integration with the global economy hence a comprehensive agricultural policy has an important role to play. Timely and reliable information on the likely demand, production, trade and prices of important agricultural commodities in the country is required. Commodity outlook models help generating advance information on medium- and long-term projections on the above-mentioned economic variables. Apart from generating outlook, these models are capable of undertaking sensitivity analysis and simulations under alternative policy and technological scenarios.

Grain outlook model: A grain outlook model was developed that incorporates a system of simultaneous equations for effectively depicting the linkages between various economic variables corresponding to the food balance sheet of major foodgrains in India. This model specifically focuses on rice, wheat and maize, along with their interrelations with other complementary and substitute crops. Technically, the model utilises the time series information for undertaking projections, but simultaneously derives equilibrium values of the

Baseline equilibrium projections for wheat, rice and maize at all-India level (base year 2010–11)

Variable	Wheat			Rice			Maize		
	2015–16	2020–21	2025–26	2015–16	2020–21	2025–26	2015–16	2020–21	2025–26
Area ('000 ha)	29,365	29,755	30,187	42,774	42,945	43,156	9,103	9,078	9,010
Yield (tonnes/ha)	3.07	3.23	3.40	2.33	2.46	2.60	2.50	2.65	2.79
Production ('000 tonnes)	90,136	96,042	102,586	99,820	105,762	112,267	22,758	24,025	25,093
Food and other use ('000 tonnes)	87,483	93,476	100,085	95,911	102,007	108,350	10,389	11,122	11,662
Feed use ('000 tonnes)	2,579	2,495	2,425	0	0	0	9,530	10,283	10,688
Total use ('000 tonnes)	90,063	95,971	102,510	95,911	102,007	108,350	19,918	21,405	22,350
Ending stocks ('000 tonnes)	18,911	18,911	18,911	18,452	18,037	17,990	640	631	634
Net trade ('000 tonnes)	73	71	76	3,917	3,905	3,917	2,823	2620	2,745

variables based on the linkages established through a set of equations that cut across commodity as well as spatial dimensions. The projections on major variables for the three primary crops are presented in tabular form.

Oilseeds outlook model: It was developed for rapeseed/mustard, groundnut and soybean, as the primary commodities. Presently, the oilseeds outlook model has the year 2010 as the base-year for projections and can generate outlooks till the year 2025. As in grains outlook model, provisions were made to regularly update base-year and also to extend the period of forecasting.

In future, it is targeted to integrate both grains and oilseeds models dynamically so that each model takes inputs from the other model and gets converged simultaneously.

Historical and spatial trends in Indian agriculture: Growth analysis at national and state levels

Indian agriculture has witnessed wide variations in growth performance during last six decades after Independence. To find the effects of major changes in technologies and policies on the sector and to understand the broad trends in growth, a comprehensive growth analysis was undertaken by dividing the overall period into six phases, viz. pre-green revolution period (1960–61 to 1968–69); early green revolution period (1968–69 to 1975–76); period of wider technology dissemination (1975–76 to 1988–89); period of diversification (1988–89 to 1995–96); post-reform period (1995–96 to 2004–05); and period of recovery (2004–05 to 2010–11).

The green revolution period was the golden period for Indian agriculture that witnessed tremendous growth in both agricultural output and input use. During the period of wider dissemination of technology the spread of green revolution technologies across regions aided in maintaining the growth tempo realised during the previous period. The subsequent period witnessed the growth becoming broad-based with faster diversification of production towards horticultural and cash crops. However, the post-reforms period experienced a visible deceleration of growth as both public and private investments suffered a setback during this period, and the result was sluggish performance of the sector as a whole. Moreover, the use of primary inputs in the sector also slowed down due to which the yield levels of most of the crops suffered a deceleration. The retardation of growth continued up to the year 2004–05 after which a sharp recovery was realized that can be attributed to a conscious hike in public and private investments and substantial improvement in trade in favour of agricultural sector.

The study has concluded that, more than a matter of chance or as a brief spell of improvement, the recovery can be considered as the result of a significant alteration in strategy that put considerable focus on the agriculture sector, be it a rapid expansion of agricultural credit, reinvigorated growth in the distribution of quality seeds or substantial outlay of public and private investments in the sector. However, the future growth in the sector depends a lot on the manner in which the resources are

Growth rates of GDP (2004-05 prices) of various sub-sectors in India during different phases of growth (%/year)

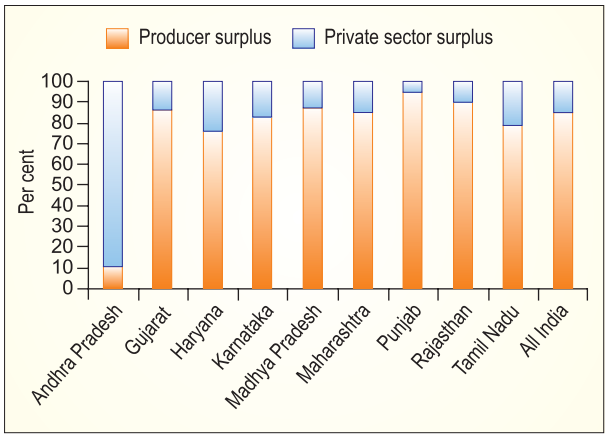
Sector	1960–61 to 1968–69	1968–69 to 1975–76	1975–76 to 1988–89	1988–89 to 1995–96	1995–96 to 2004–05	2004–05 to 2010–11
Agriculture and allied	1.03	1.98	2.42	3.24	2.35	3.31
Agriculture*	0.70	1.93	2.71	3.21	2.30	3.37
Forestry and logging	3.70	2.01	–1.77	0.74	2.05	2.25
Fishery	3.91	4.19	3.45	7.37	3.28	4.42
Non-agriculture	4.90	3.67	5.23	5.91	7.05	9.68
All sectors	3.19	2.99	4.25	5.14	5.95	8.57

*GDP agriculture includes crops and livestock.

put into productive use and the degree to which farmers are incentivised to continue with the farming profession.

Impact of technology and policy on cotton production in India

An empirical quantification of the impact of Bt cotton in India revealed an approximate welfare generation of Rs 220 billion, 85 % of it accruing to producers and the rest to the private sector seed companies and marketing firms. The distribution of the surpluses across the states varied widely depending upon the penetration of Bt technology, its agronomic performance and variations in pre-*Bt* cotton performance. The highest total surplus was recorded in Maharashtra followed by Gujarat. Andhra Pradesh and Punjab depicted contrasting performance in benefits accrual which may be attributed to differences in agronomic performances and the exogenous technology growth. While the lower reduction in insecticide usage combined with positive exogenous technology growth yielded a reduced producer benefit (in absolute terms and in comparison with the acreage) in Andhra Pradesh, the significant reduction in insecticide usage and lower exogenous production growth resulted in higher and more than proportionate benefit in Punjab.



Distribution of total surplus generated by *Bt* cotton across states

Agricultural growth and reduction in poverty

Study based on penal data of states at three points of time, viz 1983, 1993-94 and 2004-05, revealed significant depressing effect of all the three variables on rural poverty, the highest effect being exerted by per capita agriculture NSDP (net state domestic product). The significant negative coefficient of per capita AgNSDP suggested that the improvement in agricultural performance is associated with substantial reduction in rural poverty, indicating that benefits of growth in agriculture have trickled down to rural poor and the growth is inclusive. However, agricultural growth alone will not be sufficient to substantially reduce the incidence of rural poverty. Wages are the major source of rural households and improvement in wages would significantly reduce poverty of rural households. Therefore, the rural development programmes that have direct or indirect influence on living conditions of farming and landless labour households should be accorded a considerable importance to ensure inclusive growth. A significant negative relationship between poverty and literacy suggested that the education plays an instrumental role in rural poverty reduction, calling for greater investment on human resource development in the rural areas for inclusive growth.

Determinants for reduction in poverty of farming and agricultural labourers households

Exploratory variable	Dependent variable: Farmers' poverty (%)	
	Coefficient	Standard error
Agriculture NSDP per person (₹)	–0.976*	0.148
Rural literacy (%)	–0.315**	0.158
Rural wages (₹)	–0.198*	0.069
Constant	12.90	1.29
R^2	0.72	

*Significant at 1% level, **significant at 5% level. *Source:* Estimates based on data from NSSO and CSO, GoI.

Progress of Kisan Credit Cards

An analysis was undertaken to develop a clear picture on progress of Kisan Credit Cards (KCC). It was noted that once the distributional distortions are negated, the

State-wise revised estimates of progress in KCC Scheme, 2009

State	No. of KCCs (in millions)	Estimated actual cards (in millions)	% of household covered by KCCs
Andhra Pradesh	14.7	7.6	63
Asom	0.5	0.4	14
Bihar	3.3	2.9	20
Chhattisgarh	1.6	1.3	39
Gujarat	2.9	2.1	46
Haryana	2.4	1.2	72
Himachal Pradesh	0.4	0.3	35
Jammu and Kashmir	0.1	0.1	6
Jharkhand	1.1	1.0	–
Karnataka	5.3	4.7	63
Kerala	3.3	3.1	45
Madhya Pradesh	5.4	4.5	57
Maharashtra	8.2	7.4	54
Odisha	5.3	2.7	61
Punjab	2.3	0.8	79
Rajasthan	4.9	3.9	63
Tamil Nadu	5.9	5.3	64
Uttar Pradesh	15.9	7.9	35
Uttarakhand	0.6	0.3	32
West Bengal	3.2	2.8	40
India	93.7	61.7	48

coverage of KCCs reduced by one-third. Based on the estimated number of actual KCCs issued, the coverage of operational holdings gets reduced to 48% at the national level as against an absolute number of around 94 million reported at national level, with wide variation across states. On contrasting this poor coverage with the deadline to attain the full coverage by 2007–08, it calls for concerted efforts.

Female participation in agriculture in Eastern India during 1983–84 to 2009–10

The pattern of female participation in agriculture and allied sectors in different agro-ecological zones of India and its temporal variation in Eastern India were examined. Based on the information compiled from the employment schedule of NSSO data from 1983–84 to 2009–10, it was observed that female participation in agriculture is declining at the national level over the period of time; however, the rate of decline in Bihar, Jharkhand and Odisha was more than that noticed at national level. The same trend was observed in livestock and other allied activities as well.

Strengthening statistical computing for NARS: Indian NARS Statistical Computing portal for providing service oriented computing for the users of NARS by adding the modules of Completely Randomized Designs; Resolvable Block Designs; Augmented Block Designs; Row-Column Designs; Nested Block Designs; Split-Split Plot Designs; Split Factorial (Main A, Sub B´C) Designs, Strip Plot Designs; Response Surface Designs; Univariate Distribution Fitting; Tests of Significance; Correlation and Regression Analysis, was strengthened. The data can be analysed by uploading *.xls, *.xlsx, *.csv and *.txt files.

Experimental designs in presence of neighbour effects: In agricultural field experiments the treatments are assessed using small adjacent plots. Under such situations, the treatment applied to one experimental plot may affect the response on neighbouring plots besides the response of the experimental plot to which it is applied. This may be due to spread of treatments to adjacent plots causing neighbour effects, leading to substantial losses in efficiency. For precise comparison of treatment effects in presence of neighbour effects, neighbour balanced designs are useful. These designs ensure that no treatment is unduly disadvantaged by its neighbour(s). During experimentation, there may be possibility that some of the observations could become unavailable for analysis. The robustness of neighbour balanced complete block designs has been examined when specific observations are missing. The information matrix for direct treatment effects of the resultant design (one-sided neighbour effects) after missing of an observation from a block is derived and the efficiency of resulting design is investigated. The efficiencies are quite high indicating the designs are fairly robust against missing observations.

The methodology for estimating the direct and neighbour effects of treatments was derived. Series of row-column designs balanced for neighbour(s) were obtained and are found to be variance balanced for estimating direct and neighbour effects.

Analysis of experimental designs with *t*-family of error distributions: The analytical procedures were developed for the analysis of data generated from designs for one-way and two-way elimination of heterogeneity when the errors follow the *t*-family of symmetric distribution. For 2k factorial experiments when the errors follow the *t*-family of symmetric distribution, contrasts and sum of squares of contrasts for main effects and two

Trend in female participation in agriculture in Eastern India and at national level, 1983–84 to 2009–10

States	Female workers participation				Percentage points reduction during		
	1983–84	1994–95	2004–05	2009–10	1983 to 1994	1994 to 2005	2004–05 to 2009
Bihar	26.43	22.38	22.20	12.44	–4.05	–0.18	–9.76
Jharkhand	47.18	34.94	43.78	28.97	–12.25	8.84	–14.81
Odisha	34.84	36.41	38.29	32.07	1.57	1.88	–6.22
India	37.72	37.53	38.85	33.76	–0.19	1.33	–5.09

STATISTICS

Pigeon pea microsatellite database: *Pigeonpea microsatellite database* (*PipemicroDB*), based on chromosome as well as location-wise search of primers, is available at http://cabindb.iasri.res.in/pigeonpea.

It has an automated primer designing tool for pigeonpea genome. This is first database of pigeonpea marker in world with 123387 STRs extracted *in silico* from pigeonpea genome. It will help in selection of desirable traits, such as high yield, resistance to a particular disease and other traits, that will benefit the crop in long term. This tool enables researchers to select STRs at desired interval over selected chromosome. Further, one can use individual STRs of a targeted region over a chromosome to narrow down location of gene of interest or linked QTL. These markers will be of immense use in marker assisted selection which would help to overcome approximately 50% loss in pigeonpea productivity due to biotic and abiotic stress in India as well as many parts of the world. This will further pave way towards food security in terms of per capita protein requirement/availability to Indian population. This will also have a positive impact on Indian economy by decreasing import of pulses.

factor interactions have been worked out. For testing hypothesis of the main effects and two factor interaction effects, test statistics have been developed.

Robust block designs against missing data: Robustness of incomplete block designs against the non availability of data has been investigated in the literature in terms of average variance of all possible pairwise treatment comparisons in the design. A design that is robust on the basis of overall efficiency may not be robust when the efficiency is worked out on the basis of individual pair-wise treatment comparisons. Therefore, all the estimates of individual pair-wise treatment contrasts for the loss of any number of observation(s) in a block for balanced incomplete block design and variance balanced block designs were investigated. Designs that are robust on the basis of average variance but not on the basis of pair-wise treatment contrasts were also identified.

Efficient designs for drug testing in veterinary trials: In veterinary trials, neither a specific intervention treatment (treatment that has not been tested earlier) can be given continuously to animals, nor can these treatments be withdrawn after any period, for ethical reasons. Owing to treatment surrounding rule, only a limited number of intervention treatments and baseline can be compared at a time. A general method for constructing variance balanced alternating treatments design (ATD), suitable for making comparisons of two or more experimental conditions with each other or baseline was developed. Two series of row-column designs for comparing investigational products with an active control/placebo in veterinary trials were obtained. Further, designs for making comparisons of investigational products with more than one active control were also obtained. Two series of partially variance balanced symmetric factorial row-column designs were obtained.

Stochastic process modeling and forecasting: Threshold autoregressive (TAR) model is an important parametric family, which is capable of describing cyclical data. Self-exciting threshold autoregressive moving average model (SETARMA) was fitted. Real-coded genetic algorithm (RCGA) was employed to estimate the parameters of this model. As an illustration, Annual Mackerel catch data of Karnataka, India during the period 1961–2008 was considered. The SETARMA model generally performed better. Optimal out-of-sample forecasts up to three-steps ahead along with their forecast error variances were derived theoretically for fitted SETARMA model. The observed values were quite close to forecast values and estimated variances were near to theoretical values.

Software for survey data analysis (SSDA) 2.0: A web based software SSDA 2.0 was developed for survey data analysis for stratified multistage sampling design. Some of the important features of the software are: New user registration and editing user profile, individual data storage folder for imputation and analysis under name My Folder, Feedback, Help Manual, Extraction of NSSO Data, Calculation of Summary Statistics, Scrutiny and Editing of Outlier Data, Sample Selection, Imputation of Missing Data using mean zero and mean of neighboring unit methods, Sampling Weight Calculations and Estimates of Parameter. It has links such as contact us, upload file, download file, delete file, and download test data. The extraction program module takes the required text file as well as the meta-data defining the positions of relevant input variables.

Half-yearly progress monitoring system of the scientists in ICAR: A web based software was designed and developed to ensure more objective evaluation of the half-yearly performance of scientists for Half-Yearly Progress Monitoring (HYPM) of the Scientists in ICAR. The HYPM system was implemented from 1 April 2012 for online submission of proposed targets by the scientists for the first half year period (1 April to 30 September 2012). It is launched from IASRI server and made available at http://hypm.iasri.res.in. Various reports are generated for the proposed targets as submitted by the scientists and their achievements along with the comments of the Reporting/Reviewing Officers. These reports include target submission status reports with facility to view individual level proposed targets of the scientist and other options like manpower status, research projects, and salient research achievements of the institutes through the options under Report Module.

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14. Information, Communication and Publicity Services

The Directorate of Knowledge Management in Agriculture (DKMA) continued its mandated activities as nodal centre of ICAR for collection, storage, retrieval and dissemination of knowledge and information in agriculture and allied sciences. The endeavors include a wide range of publications in print and electronic format; maintenance of ICAR website with content development; publicity and public relation services; library services; trainings and workshops and participation and organization of exhibitions for showcasing ICAR technologies among stakeholders. Besides, DKMA also acts as a knowledge resource centre of ICAR with linkages across ICAR institutes, KVKs, scientific and educational institutions and international organizations in related fields. The DKMA coordinates network and connectivity infrastructure in the ICAR institutes through Agricultural Knowledge Management Units (AKMU) and National Knowledge Network and also maintains more than 400 internet nodes at ICAR Hq (KAB-I and KAB-II).

As a new initiative, a research journal in Hindi, *Krishika Shodh Patrika,* was launched to disseminate agricultural research further up to grassroot level. The journal was released by Bharat Ratna Dr A.P.J. Abdul Kalam, Former President of India, on the occasion of 84th Foundation Day of ICAR (16 July 2012).

Bharat Ratna Dr A.P.J. Abdul Kalam, Former President of India, releasing ICAR's new research journal in Hindi, *Krishika Shodh Patrika*

A half yearly periodical, *India-ASEAN News on Agriculture and Forestry*, was launched by the Union Minister of Agriculture and Food Processing Industries, Shri Sharad Pawar, at 2nd ASEAN-India Ministerial Meeting on Agriculture and Forestry (17–19 October 2012). The DKMA acted as the nodal point for organization of this international event which included ASEAN-India Agri-Expo.

The website of ICAR (www.icar.org.in) is bilingual (English and Hindi) and has come forth as a potent knowledge and information repository for a wide range of stakeholders that include researchers, students, policy planners, farmers, and civil societies. During the drought like conditions this year, specific weather-based agro-advisories and contingency plans were developed with the inputs of ICAR institutes and subject matter divisions on daily basis and posted on the website for wider dissemination. The advisories provided valuable and useful tips for farmers for taking necessary steps to mitigate the weather impact. As a follow up, on the late revival of monsoon, again advisories were hosted for the benefit of farmers. ICAR website recorded approximately 2 lakh visits per month accounting nearly 50% new visitors across the globe. During 2012-13, nearly 1,300 new pages were added and 1,500 pages were updated with the latest inputs. The website continued with its value added features such as news, success stories, career opportunities, photo gallery and administrative and financial notifications. The 'YouTube channel of ICAR' was initiated with more than 100 videos to start with that instantly attracted nearly 41,000 hits.

Union Minister of Agriculture and Food Processing Industries, Shri Sharad Pawar, launching the half yearly periodical, *India-ASEAN News on Agriculture and Forestry* at 2nd ASEAN-India Ministerial Meeting on Agriculture and Forestry

The ICAR website also hosts e-publishing platform of the Council that includes *The Indian Journal of Agricultural Sciences, The Indian Journal of Animal Sciences, Indian Farming* and *Indian Horticulture;* along with *ICAR Reporter, ICAR News, ICAR Mail, ICAR Chitthi* (Hindi) and *Agbiotech Digest.* The on-line availability in Open Access mode has enhanced visibility, improved impact factor, and readership across the world. The journals are being accessed from 182 countries globally, and from 85 cities within India with nearly 18,000 registered users of these journals. Besides, the platform also hosts 11 research journals of the related professional societies who have been trained by the DKMA for online processing and publishing of research articles. This online journal

portal has about 54,000 registered users. This activity has been undertaken under the NAIP sub-project on 'E- Publishing and Knowledge System in Agricultural Research.' With new additions during the year, the number of e-books and reports has gone up to 45 attracting nearly 7,000 visitors for the latest arrivals. Nearly 300 news items and success stories were published on the website including examination results, career opportunities and other related notifications.

The DKMA continued to publish twelve regular publications that include research journals, popular periodicals and in-house newsletters in which eight are in English and four in Hindi. Special efforts were made to develop these information products specific to cater the need of identified target audience such as researchers, students and farmers and agricultural community respectively. Review research papers were included as a regular feature in research journals and accent issues of popular periodicals were brought out on topical themes. In addition, nearly 50 titles were published in English and Hindi as technical books, monographs, textbooks, handbooks and technical bulletins. Two-half yearly issues of *Indian Agricultural Sciences* and *Animal Science* abstract journals were published and posted on ICAR website. The DKMA also provided expertise and consultancy to various constituents of ICAR for printing and publishing. DKMA coordinates and develops contents for publications related to some of the major events of the Council such as Annual General Meeting, ICAR Foundation Day and Award Ceremony and visits of dignitaries like H.E. President of India, Prime Minister of India and so on. During the year, the DKMA organized and participated in 10 exhibitions on the occasion of national and international events across the country. In addition this Directorate coordinated and facilitated participation of ICAR institutes in Agri-Expos at regional level. Revenue of nearly ₹65 lakh could be generated through the sale of publications and e-products (April–December 2012).

ICAR at Indian Science Congress 2013, Kolkata

As an effort to streamline connectivity issues and strengthening of communication within ICAR system, 1,040 uniform e-mail IDs were created for personnel of 17 ICAR institutes and ICAR (Hq), and the process for covering the entire ICAR system will be completed shortly. The ICAR institutes have been advised to implement uniformity guidelines for content management of their websites which resulted in more effective visibility of the ICAR system as a brand in the online scenario. As a designated national input centre for the AGRIS database of the FAO, DKMA indexed and submitted 1,120 inputs in WebAgris software to enable online search by users. Directorate provided training to scientist of ICAR institutes for preparing inputs in the desired software for AGRIS database. Similarly, trainings were imparted to scientists of ICAR institutes and ICAR registered societies for online processing of research articles. Work on implementation of KOHA software to improve management of library services was completed during the period and about 15,000 publications were bar-coded. Nearly 300 titles have been digitized under e-Granth project of the NAIP. The KVK-hub maintained at the ICAR headquarters organized twice a week interactive sessions of scientists and extension functionaries through e-enabled KVKs.

As Consortium Leader of the multi-centric (10 centres), NAIP project on Mobilizing Mass Media Support for sharing Agro-information, DKMA mobilized publication of nearly 600 news-clippings in national and regional media (Hindi, English, Punjabi, Malayalam, Tamil and Gujarati) on new agricultural technologies and major events at ICAR (Hq) and its institutes. The project also facilitated about 40 TV/Radio programmes at national and regional level and produced 25 video/audio capsules for wider dissemination. Publicity and public relation services were provided to the following major events organized by the Council: Dr M.S. Swaminathan Award for Leadership in Agriculture (25 January 2012), New Delhi; 2nd Global Agri-Business Incubation Conference (6 February 2012), New Delhi; Second International Conference & APCHNE-2012 (February 13–15), New Delhi; Conference of ICAR Directors and VCs of Agricultural Universities (17 February 2012), New Delhi; 'ICPBFS-2012' Use Bio-Technology Tools to Increase Agricultural Productivity (21 February 2012), New Delhi; 20th World Book Fair (27 February 2012), New Delhi; Pusa Krishi Vigyan Mela (1 March 2012), New Delhi; 83rd Annual General Meeting of ICAR Society (6 March 2012), New Delhi; Orientation Programme for African Students (19 March 2012), New Delhi; 4th Plant Genome Savior Community Awards (22 May 2012), New Delhi; 84th Foundation Day of ICAR & ICAR Award Ceremony (16 July 2012) New Delhi; Annual Review Meeting of ICAR Seed Project (25 July 2012), New Delhi; ICAR Knowledge Meet (21 August 2012), New Delhi; Expert Consultation on Trans-boundary Diseases in Agriculture (10 October 2012), New Delhi; 2nd ASEAN-India Ministerial Meeting on Agriculture & Forestry and ASEAN India Agri-Expo (17-19 October 2012), New Delhi; Symposium on Indo-ASEAN Export Potential of Agricultural Products (18 October 2012), New Delhi;

ILRI-ICAR partnership dialogue on livestock (7 November 2012), New Delhi; INSA Public lecture of Secretary, DARE and DG, ICAR on Indian Agriculture (19 November 2012), New Delhi; 7th National KVK Conference (20–22 November 2012), Ludhiana; The 3rd International Agronomy Congress (26 November 2012), New Delhi; ICAR-ICARDA Collaborative Program's Review Meeting (29 November 2012), New Delhi; 38th Foundation Day of ASRB (1 November 2012), New Delhi; Meeting of Administration and Finance Divisions of ICAR Institutes (22 November 2012), New Delhi; International Workshop on Cactus Crop (25 November 2011), New Delhi; Expert Consultation on Strengthening the Veterinary Profession in India (25 November 2011), New Delhi; ICAR-NAIP Interaction Meet with Scientists Trained Abroad in Frontier Areas of Agricultural Sciences (28 November 2011), New Delhi; Sixty Years of Fruitful Partnership between India and US (20 December 2012), New Delhi; International Conference on Statistics and Informatics in Agricultural Research. (18 December 2012), New Delhi; ASEAN-India Farmers Exchange Program, (19–30 December 2012)

DKMA has developed a strategy for the XII Plan period with enhanced focus on sharing of knowledge among various stakeholders through more effective usage of ICT and related frontier technologies. Print, electronic and web-mode of communications are being integrated to maximize the reach and impact of the information packages and products. Linkages are being created within NARES to develop a common platform for exchange and sharing of knowledge and information in synergistic mode so that the collective efforts may reach to the end users of agricultural technologies. ❑

15. Technology Assessment, Refinement and Transfer

In order to facilitate adoption of technologies developed by the National Agricultural Research System of the country, Krishi Vigyan Kendras (KVKs) have taken up a number of activities for assessment, refinement and demonstration of technologies/products under different agro-ecosystems. At present, 631 KVKs are functioning across the country under different host organizations like State/Central Agricultural Universities (428 KVKs), ICAR Institutes (51 KVKs), NGOs (99 KVKs), State Governments (35 KVKs), Public Sector Undertakings (3 KVKs) and Central/Deemed Universities and other organizations (14 KVKs). The activities of the KVKs include on-farm trials (OFTs) to identify location specificity of technologies in various farming systems; frontline demonstrations (FLDs) and training of extension personnel. Besides, the KVKs also contributed for the development of contingent plans for drought and flood situations, and implementation through technical back-up to the extension system. In order to show potentiality of technologies in terms of technological inputs, information and knowledge, KVKs have organized Technology week across the country.

Technology assessment and refinement

Assessment: KVKs laid out 20,015 trials to assess 2,323 technological interventions on the farmers' field at 3,625 locations in various crops under different thematic areas, namely cropping systems, capacity building, drought management, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated farming systems, integrated nutrient, pest, and disease management, processing and value-addition, resource conservation, seed/planting material production, storage techniques, varietal evaluation, and weed management. Major crops include paddy, wheat, maize, bengal gram, blackgram, greengram, pigeonpea, pea, groundnut, mustard, sesame, soybean, sugarcane, cotton, tomato, brinjal, okra, chillies, banana, mango, turmeric and coconut.

In livestock, 443 assessment trials on technological interventions were carried out at 621 locations covering 5,218 trials on disease management, drudgery reduction, feed and fodder management, integrated farming systems, nutrition management, processing and value-addition, production and management, and storage techniques related to animal enterprises. The major livestock enterprizes include dairy cows, buffaloes, sheep, goat, poultry birds, pigs and fisheries.

As many as 90 women-specific income-generation technologies related to technological empowerment of rural women were assessed at 163 locations, covering 1,428 trials. A total of 10 enterprizes were considered for assessing the technologies and the major ones include apiculture, lac, mushroom, vermicompost production and nutritional gardens.

Refinement: Refinement of 285 technological interventions was carried out in 327 locations by laying out 2,244 trials in the farmers' field under various thematic areas of crop production and protection. A total of 63 crops were considered for refinement of technologies and the major crops include paddy, wheat, mustard, groundnut, sugarcane, cotton, tomato, chillies, okra and mango.

Besides, 43 technological interventions at 68 locations were also refined through 461 trials on livestock, poultry and fisheries enterprises under the thematic areas of livestock production and protection. In addition, 5 women-specific income-generation technologies were also refined by conducting 62 trials at 8 locations. The major enterprises were mushroom, apiculture and nutrition gardens.

OFT on cono-weeder at KVK, Kota

Frontline demonstrations

Frontline demonstrations (FLDs) were conducted to demonstrate production potential of newly released crop varieties/production technologies in crops/ animal husbandry/ other agriculture-related enterprizes on the farmers' fields. These demonstrations were also utilized for organizing training and field days for the benefit of extension workers and farmers. During the year, 1.31 lakh demonstrations were organized, out of which 73,175 were on crops including cereals, millets, oilseeds, pulses, commercial crops, fibre crops, spices, medicinal crops, plantation crops, fodder crops, green-manure crops and horticultural crops, covering an area of 23,246 ha. In order to promote the hybrids, 5,909 demonstrations were organized covering an area of 2,082 ha in cereals, millets, oilseeds, pulses, fodder

crops, cotton and horticultural crops. In improving tools and farm implements, 4,710 demonstrations covering an area of 3,419 ha; 14,390 demonstrations on livestock enterprizes; and 5,991 demonstrations on other enterprizes including gender-specific technologies for women empowerment were organized. Besides, 26,218 demonstrations on climate-resilient technologies were also conducted by KVKs under NICRA project.

Cereals: A total of 24,238 demonstrations were conducted, covering an area of 8,492 ha in various cereals such as paddy, wheat, maize, sorghum, barley and oats. The highest increase in yield was recorded in sorghum (39.7% increase over farmers' practices), followed by 35.8% in maize and 29.5% in barley. Paddy and wheat demonstrations recorded an increased yield of 19.8 and 19%, respectively.

Millets: Demonstrations were also conducted on barnyard millet, finger millet, pearl millet and proso millet in 2,040 farmers' fields covering an area of 688 ha during the year, achieving an average increase of 29.40% yield over their local checks/farmers' practices.

Oilseeds: During the year, 11,644 demonstrations in 3,998 ha area were conducted on groundnut, sesame, soybean, sunflower, *toria*, linseed, mustard, castor, brown sarson, niger, rapeseed, safflower and *raya*. The increase in yield varied from 15.1 % in brown sarson to 89.8 % in linseed under improved technology demonstration compared to farmers' practices.

Pulses: Frontier technologies on pulse crops such as blackgram, chickpea or gram, cowpea, field pea, greengram, horse gram, lentil, pea, pigeonpea, rice bean and rajmash were demonstrated in 17,145 farmers' fields covering an area of 5,930 ha. The increase in yield was 39.3% in blackgram, 31.8% in chickpea, 23.4% in cowpea, 38.9% in field pea, 31.8% in greengram, 33% in horse gram, 34.7% in lentil, 48.6% in pea, 32.8 % in pigeonpea, 28.3 % in rajmash and 38.1% in rice bean demonstration plots compared to farmers' practices. These FLDs also included 5,372 demonstrations conducted to harness the pulse producivity in 137 districts.

Commercial crops: A total of 1,714 demonstrations were conducted in commercial crops like sugarcane (283), cotton (1,379), tobacco (29), betel leaf (10) and mulberry (13) in an area of 790.3 ha through KVKs in the country. The yield increase in FLDs was 12.7% in cotton, 15.3% in sugarcane, 20.6% in mulberry, and 27.5% in betel leaf as compared to local checks in respective crops.

Fibre crops: Frontline technology demonstrations were also conducted in jute and sunnhemp in 140 farmers' fields covering an area of 40.6 ha and achieved an average yield increase of 21.5% under demonstrations compared to farmers' practices.

Fodder crops: Demonstrations on fodder crops such as barseem, cowpea, lucerne, maize, napier, oat, pearl millet, sorghum and sudan grass were conducted in 2,241 farmers' fields covering an area of 402 ha. The fodder yield increase achieved under demonstrations ranged from 10.3% in *dhaincha* to 82.8% in Napier grass compared to their local checks.

Low-cost, labour-efficient and eco-friendly option for managing foot rot in black pepper

Foot rot disease causes severe economic loss in black pepper. KVK, Kannur (Kerala) attempted technology assessment and refinement by involving black pepper growers. The technological intervention trial conducted with the treatment option phyto-sanitation + application of *Trichoderma viride* enriched manure @ 5 kg/vine was found to be low-cost, labour efficient and eco-friendly. As the results were disseminated to the farmers through various extension agencies, the demand for *Trichoderma* increased. In order to meet the demand, KVK started producing and supplying *T. viride*.

During the period 2006-07 to 2011-12, 27.98 tonnes of *Trichoderma* worth ₹19.59 lakh was supplied to 3,544 farmers for its use in about 1,418 ha.

Low-cost, labour-efficient and eco-friendly option for managing foot rot in black pepper

Green-manure crops: In view of depleting soil fertility, frontline demonstrations were conducted on green-manure crops in 49 farmers' fields covering an area of 10.5 ha achieving an increase of 19.4% in yield of green-manure to improve the soil-fertility status.

Horticultural crops: Altogether, 13,988 demonstrations on horticultural crops comprising vegetables (9,637), fruits (1,635), flowers (380), spices and condiments (1,569), plantation crops (660) and medicinal crops (107) were conducted in 2,900 ha area in the country. The yield increase recorded under FLDs as compared to farmers' practice was in the order of 15.6% in medicinal crops, 27.4% in fruits, 32.7% in flowers, 35.1% in spices and condiments and 37.4% in vegetables over the farmers' practices.

Hybrids: In order to achieve higher harvest index in crops, KVKs conducted 5,909 demonstrations on hybrids covering an area of 2,082 ha in cereals, millets, oilseeds, pulses, fodder crops, cotton and horticultural crops. In maize, millets and paddy, 3,864 demonstrations were conducted by 160 KVKs to demonstrate the potential of various hybrids in 1,367 ha area achieving up to 167% increased yield in rice hybrid KRH 2 under SRI technology. A total of 588 demonstrations on hybrid cotton were conducted by 35 KVKs in 296 ha wherein the yield increase was highest in RCH 625 (35.9%) compared to local checks. Demonstrations

(405) on hybrids of castor, mustard and sunflower were conducted by 31 KVKs across the country covering an area of 154 ha and achieving yield increase as high as 82.8% in KBSH 1 sunflower compared to local checks. Demonstrations (156) were conducted on napier hybrids achieving enhanced yield up to 31.9% in napier Co 4 as compared to local checks. Similarly, 876 demonstrations were conducted on vegetable and fruit crops hybrids covering an area of 204.3 ha through 93 KVKs achieving yield increase as high as 114.3% in tomato hybrid Red Coral compared to local checks.

Farm mechanization: Demonstrations (4,710) were conducted on improved tools and farm implements including drudgery reduction technologies covering an area of 3,419 ha. Maximum (1,144) demonstrations were conducted on harvesting equipment and tools, followed by 988 on planting/sowing equipment, 762 on inter-tillage equipment, 556 on plant-protection equipment, 373 on weeders, 297 on post-harvesting and processing equipment and the rest on chaffers, threshers, vegetable preservators, coconut climbers, etc.

Demonstration of sugarcane bud chipper

Livestock, fisheries and other enterprizes: As many as 14,390 demonstrations were conducted covering 7,091 dairy animals, 1,856 sheep and goat, 145,973 poultry birds, 418 ducks, 818 pigs, 27 units of rabbits, 186 units of fisheries and 2 units of prawn cultivation. Besides, 5,991 demonstrations were also carried out on bee keeping (150 units), food processing (198 units), mushroom production (2,033 units), vermicompost production (423 units), household food security (100 units), nutrition gardens (279 units), sericulture rearing (12 units), value-addition (124 units) and women empowerment (74 units) through economic activities covering a total of 5,991 farmers in the country during the year.

Capacity building

During the year, 65,314 training programmes were organized under capacity building with the participation of 18.8 lakh farmers/farm-women, rural youth and extension personnel.

Role of KVKs in Disaster Management

A severe cyclonic storm *Thane* affected the coastal districts of Tamil Nadu especially Cuddalore, Villupuramand and Unioin Territory of Puducherry on 30 December, 2011. Agricultural scenario in all these districts was severely affected with damage to crops, livestock, fisheries and infrastructure.

Quick revival processes were initiated by KVKs of these three districts to stabilize. The cyclonic storm had affected the coastal districts of Tamil Nadu and Puducherry especially Cuddalore, Villupuram and Puducherry. The damage caused to the KVKs and to the farming community was assessed. Accordingly, ICAR had sanctioned an amount of ₹ 65 lakh to KVK Puducherry, ₹ 11 lakh to KVK Cuddalore and ₹ 6 lakh to KVK Villupuram for carrying out relief measures.

Following steps were suggested:

1. Contingent plan for cultivation of short-duration paddy varieties and cultivation of pulses/vegetables in paddy fallows.
2. Integrated farming system promoted as part of the contingency plan.
3. Production and supply of cashew grafts for replanting in cyclone affected areas and
4. Farmers advised about alternative crops like bamboo and alternate enterprises like poultry.

Farmers and farmwomen training: A total of 51,098 training courses were organized for the benefit of 15.47 lakh farmers and farm-women on various technologies to update their knowledge and skills. Most of these courses were on productivity enhancement of field crops (22%), horticulture crops (16%), empowerment of rural women and plant protection (13% each), livestock production and management (12%), soil health and fertility management (9%) farm machinery tools and implements and capacity building and group dynamics (5% each), production of input at site (4%), fisheries and agro-forestry (3% each). Of these 51,098 courses, 36% were conducted on-campus and 64% were off-campus courses. The participants included 4.03 lakh farm-women. Among the crop production technologies, about 26% of the training courses were on integrated crop production technologies, followed by resource-conservation technologies (8.8%) and weed management technologies (6.5%). Out of 8,092 training courses on horticulture, 3,762 were on vegetable crops, 2,473 on fruit crops, 511 on spice crops, 409 on ornamental crops, and 408 courses on medicinal and aromatic crops.

Rural youth training: During the year, 8,486 skill-oriented training courses were organized for 1.91 lakh rural youth, including 69,163 young women (36.17%). Majority of the courses were on integrated farming, mushroom production (7% each), value-addition, dairy farming (6% each), seed production (5%), vermi-culture, nursery management of horticulture crops, bee-keeping, protected cultivation of vegetables (4% each), repair and maintenance of farm machinery implements, sheep and goat rearing, poultry production, production of organic inputs and small-scale processing (3% each).

Extension personnel training: A total of 5,730 capacity building programmes were conducted for 1.42 lakh extension personnel, which included 34,563 (24.35%) women extension personnel. These courses were organized for extension functionaries working in government and non-governmental organizations related directly or indirectly with the development of agriculture sector. Training was imparted in frontier areas of agricultural technologies related to productivity enhancement in field crops, integrated pest management, integrated nutrient management, group dynamics and farmers' organization, management in farm animals, rejuvenation of old orchards, women and child care, livestock feed and fodder production, protected cultivation technology and capacity building for ICT applications.

Sponsored training: As many as 6,685 training courses were sponsored by different organizations, which were conducted for 2.83 lakh farmers and farmwomen, rural youth and in-services extension personnel. Most of the sponsored courses were on production of inputs at site, economic empowerment of women, processing and value-addition, methods of protective cultivation, farm machinery tools and implements, fisheries management, household nutritional security, animal nutrition management, animal disease management, drudgery reduction of women and fisheries nutrition.

Lac becomes lucky for tribals in Jharkhand

KVK, Ranchi demonstrated and promoted scientific lac cultivation among 500 farmers belonging to 22 tribal villages of Khunti district and Kuchru of Ranchi district. With the help of the Indian Institute of Natural Resin and Gum (IINRG), the KVK introduced cultivation of *kushmi lac* in *ber* plant which is first of its kind for the farmers of this locality. This enabled the tribal people of these villages to successfully produce lac and also able to find market for broodlac from their *palas* and ber tree. Each lac cultivator of Putadag village in Angara Block of Ranchi district earns ₹ 20,000–25,000/year. Shri Baleshwar Bedia, a lac cultivator of Putadag village earned up to ₹1 lakh/year. Lac cultivators are now able to produce their own brood lac by utilizing their own trees and have become model for other lac cultivators.

The KVK has formed a brood lac (lac seed) bank with farmers as members. This bank ensures timely supply of quality brood lac to the lac cultivators.

Lac cultivation in Ranchi district of Jharkhand

Extension programmes

Extension programmes are organized by KVKs to create awareness among farmers about improved technologies and to provide timely advisory to farmers. A total of 4.86 lakh extension programmes/activities were organized which attracted the participation of 170.16 lakh farmers and 2.61 lakh extension personnel. The KVKs also organized 1.30 lakh extension programmes through electronic and print media to have wider coverage in the districts. These included electronic media in the form of TV programmes, radio talks, CDs/DVDs, extension literature, newsletters, newspaper coverage, technical bulletins/reports/books, popular articles, leaflets, folders and books/booklets.

Method demonstration on CMS technology in black pepper at KVK, Uttara Kannada

Production of technological products

The technological products like seed and planting material of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish were produced at KVKs, which benefited 23.68 lakh farmers in the country.

Seeds: During the year, 1.74 lakh quintal seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fibre crops, were produced and provided to 2.54 lakh farmers.

Planting materials: In all, 206.59 lakh quality planting materials of elite species of commercial crops, vegetables, fruits, ornamental, medicinal and aromatic crops, plantation crops, spices, tuber crops, fodder and forest species were produced and provided to 1.60 lakh farmers.

Bio-products: Bio-products, namely, bio-agents, bio-pesticides, bio-fertilizers, vermicompost, mineral mixture etc., were produced and supplied to the extent of 2.41 lakh q and 6.18 lakh numbers benefiting 15.27 lakh farmers.

Livestock, poultry and fish fingerlings: Improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 2,706 farmers. Different strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 6,972 farmers.

Participatory seed production

KVK, Saharanpur (Uttar Pradesh) has been engaged in participatory seed-production programme of wheat and paddy since 2008. These farmers were trained on different aspects of seed production. A total of 531 q seed of wheat varieties HD 2851, DBW 17, HD 2894, PBW 590 and PBW 550 and 770 q seed of paddy varieties— Pusa Basmati 1401, Pusa Basmati 1460 and Pusa Basmati 1121 were produced and supplied to 457 and 525 farmers, respectively. The concept of supplying quality seed from farmer-to-farmer in the villages enhanced seed replacement rate, i.e. 52 % in wheat and 44.5% in paddy. Better quality seeds enabled the farmers to harvest up to 50.5 q/ha yield in wheat and 58 q/ha yield in paddy. Owing to availability of seed, the area coverage under high-yielding varieties of paddy and wheat was expanded. The paddy variety Pusa 1401 was grown in 7,278 ha followed by Pusa 1460 in 5,500 ha and Pusa 2511 in 4,550 ha. Similarly, wheat variety HD 2851 was grown in 15,550 ha followed by PBW 590 in 14,500 ha, PBW 550 in 12,800 ha, DBW 17 in 10,850 ha and HD 2894 in 4,800 ha.

Improved breeds of pigs were provided to 195 farmers. KVKs also enabled 201 farmers to establish rabbit-rearing units by providing 425 rabbits. A total of 117.46 lakh fish fingerlings were produced and supplied to 5,098 farmers.

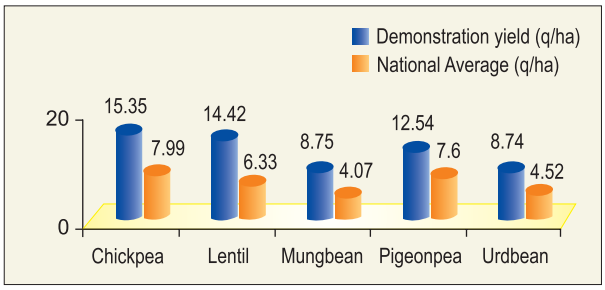
Soil, water and plant analysis: A total of 3.78 lakh samples (comprising 3.16 lakh samples of soil, 0.56 lakh of water, 0.03 lakh of plant, 0.002 lakh of leaf/petiole and 0.03 lakh of manure) were analyzed covering 3.33 lakh farmers belonging to 0.40 lakh villages and the revenue generated was ₹ 29.22 million.

Rainwater harvesting: Rainwater harvesting unit with micro-irrigation system was established in 118 KVKs. A total of 590 training courses and 424 demonstrations were conducted utilizing this facility and produced 7.63 lakh planting materials. Further, 53,900 farmers and 1,518 officials visited these units and got acquainted with the system.

Technology week: Technology week, under public-public and public-private partnership mode, was organized by 213 KVKs benefiting 8 lakh farmers, farm-women, extension personnel, rural youth and members of self-help group by organizing 5,553 extension activities such as seminars, skill demonstrations, film shows, field visits on results demonstrations, exhibitions and scientists-extension personnel-farmer interactive sessions.

Kisan Mobile Advisory: As a part of application of Information and Communication Technology in KVK system, Kisan Mobile Advisory (KMA) was initiated by the ICAR during 2010-11 to provide timely and need-based information to farming community. At present 310 KVKs are providing this service through various service providers. Information on weather, market, various farm operations, outbreak of pests and disease incidence and their control measures are given to the farmers through Short Message Service (SMS). During the year, about 1.47 lakh short text messages were sent to 11.14 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast, and pest and disease control. Some KVKs are also attempting Voice Mail Services to farmers.

Technology demonstration for harnessing pulses productivity: A national level programme on 'Technology Demonstration for Harnessing Pulses Productivity' was co-ordinated with participation of IIPR, Kanpur, Zonal Project Directorates namely, Zone II, IV, V, VI, VII and VIII and 137 KVKs in 11 States. The programme focused on development of district specific technology modules and capacity building of KVK functionaries, representatives of line departments and participating farmers. A total of 5,372 demonstrations in an area of 5307.69 ha were laid out on pigeonpea (1,358), chickpea (1,620), urdbean (768), mungbean (1,166) and lentil (460).



Comparison of demonstration yield and national average of major pulses

Transplanting technology revolutionized pigeonpea cultivation

Demonstrations on climate resilient technologies

National Initiative on Climate Resilient Agriculture (NICRA), a network project was launched in February 2011. Under the sub theme-Technology Demonstrations and Dissemination for Climate Resilient Agriculture, about one lakh farmers are being covered in 132 villages. In this component, an integrated package of proven technologies was demonstrated in one village in each district for adaptation and mitigation of the crop and livestock production system to climate variability based on the available technologies.

During the year, 100 KVKs carried out 9,478 demonstrations on natural resource management in an area of 6,675 ha, 12,741 demonstrations on crop production technologies in an area of 4,301 ha and 1,222 demonstrations on fodder and feed production in an area of 197 ha. About 48,413 animals/birds belonging to 7,893 farmers got benefited from the demonstrations related to livestock and fisheries. Capacity-building interventions benefited 37,435 farmers and the extension activities like exposure visits,

7th National Conference on KVK-2012 Organized

The 7th National Conference on KVK-2012 was organized with focus on "Integrating Technologies and Best Practices" at Punjab Agricultural University, Ludhiana from 20 to 22 November, 2012. About 1,300 delegates from across the country participated in the Conference. The deliberations were held during eight technical sessions, viz. (*i*) convergence and linkages between KVK-ATMA programmes - best successful cases of field extension; (*ii*) KVK's best practices and innovative approaches for out-scaling technologies; (*iii*) best practices and technologies for higher production, value-addition and improved livelihood; (*iv*) facilitating KVKs in management, administrative and financial matters; (*v*) Farm innovations and best practices developed by farmers; (*vi*) ICT mediated best practices in knowledge empowerment of farmers; (*vii*) integration of best practices and technologies under NICRA-project; and (*viii*) technological backstopping and harnessing synergy of working in partnership mode. A technology exhibition and innovative market place was also organized. Shri Sharad Pawar, Hon'ble Union Minister of Agriculture and Food Processing Industries, inaugurated the Conference as well as the exhibition. Two farm women were honoured as "Champion Female Farmers" for their excellence in agriculture. He also conferred KVKs with National and Zonal Best KVK awards for the year 2011.

The recommendations include development of technology delivery models for resource poor farmers based on principles of group dynamics; adoption of demand driven approach; functional convergence with programmes of National Mission on Agricultural Extension and Technology; harnessing the potential of ICTs; launching of farmers first programme through research-extension convergence; prioritizing and integrating technologies and best practices; and development of soft skills and competency of KVK staff.

ASEAN-INDIA Farmers' Exchange Programme

As part of a number of activities under ASEAN – India Commemorative Summit, the first leg of ASEAN-India Farmers' Exchange Programme was conducted in India during 19-30, December 2012. The farmers' delegation from nine ASEAN member states, namely Cambodia, Brunei Darussalam, Indonesia, Myanmar, Malaysia, Vietnam, Philippines, Lao PDR and Thailand, participated.

The delegation comprising 18 farmers and 9 officials from the ASEAN countries visited Indian Agricultural Research Institute, New Delhi; National Dairy Research Institute, Karnal; Central Soil and Water Conservation and Training Institute, Dehra Dun and Central Institute for Research on Goats, Makhdoom, Mathura. The delegation also visited the Punjab Agricultural University, Guru Angad Dev University of Veterinary and Animal Sciences, Ludhiana, KVKs, farmers' fields and agri-enterprises. Besides, the delegation also interacted with scientists, farmers, officers of different departments and ICAR.

field days, *krishimela* and method demonstrations benefited 2,944 farmers.

Demonstrations on cold-tolerant varieties showed 72% enhancement in yield, whereas demonstrations on crop diversification indicated 69.3% increase in yield over farmers' practice. Advancement of planting dates of *rabi* crops in areas with terminal heat stress resulted in 38% increase in yield over farmers' practice. Under the initiative, 14,703.50 quintals of fodder and feed was produced and emphasis was given on better utilization of the same through 160 demonstrations on improved fodder/feed storage methods. Under Institutional Interventions, 2,617 demonstrations were organized on mechanization through custom-hiring and ensured timely planting in an area of 2,567 ha. In all 26,218 demonstrations were conducted by KVKs under NICRA project.

Technological backstopping

The Directorates of Extension (DEs) of SAUs/CAU updated the technical knowhow of 6,136 staff members of KVKs by organizing 263 training programmes. The DEs also organized 210 workshops and meetings for effective implementation of KVK programmes. The officials of Directorates of Extension made 1,526 visits to the KVKs to review and monitor the activities of KVKs. These visits included participation in Scientific Advisory Committee meetings and Technology Weeks.

Besides, the Zonal Project Directorates arranged 85 training programmes for 2,609 KVK staff members on fodder production and grassland management, content designing and delivery for mainstream media, information and communication technologies for agricultural information management and networking, off-season vegetable production technologies etc.

Agricultural Technology Information Centre

Forty-four Agricultural Technology Information Centres (ATICs) in the country serve as single-window delivery system by providing technology solutions (information, services and products). As many as 7.2

Tomato cultivation becomes a farm-business in Himachal Pradesh

In the mountainous terrain of district Shimla of Himachal Pradesh, the farmers of Sub-Tehsil Nerwa, Tehsil Chopal were growing paddy, wheat and maize. The earnings were meagre and hence the standard of living was very poor. The KVK, Shimla attempted to mitigate the situation through crop diversification with tomato cultivation in Nerwa area of the district. The KVK trained farmers of the area in nursery production of tomato and tomato-cultivation technologies. Tomato varieties, namely Naveen 200 Plus, Himsona and Minakshi, were demonstratd for adoption in farmers' field conditions. From about 30 acres in the year 2000, tomato area spread to 200 acres in 2002 covering 600 farmers. During 2011–12, around 3,000 families were involved in tomato cultivation with a turnover of ₹ 200 million. With an expenditure of ₹ 1 lakh/acre, farmers are earning a gross income of ₹ 2.6 lakh/acre/crop.

In order to facilitate better price for their produce, KVK formed a group of 30 farmers of the locality, which has been registered in the name of *Shalu Valley Kisan Sangh*. The produce is sold by this group in local market of Nerwa and different markets of Dehra Dun (Uttarakhand), Saharanpur (Uttar Pradesh) and Delhi. At present, tomato cultivation has become an integral part of farmers of Nerwa area.

lakh farmers visited the ATICs during the year. Technological information was provided to 3.13 lakh farmers through print and electronic media, whereas technological products like seeds (88,076.74 q), seedlings/saplings (13.30 lakh), livestock (3.41 lakh), poultry birds (3.79 lakh) and bio-products (1,172.42 q) were provided to 2.60 lakh farmers. Technological services like soil and water testing, plant diagnostics, seed testing, animal health camp, different farm machinery equipments, etc. were provided to 4.08 lakh farmers.

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Area covered through seeds and planting material supplied by KVKs

Seeds and planting material of high-yielding varieties/ hybrids produced and supplied by the KVKs in the country have spread to large area as detailed below:

- **Cereals:** The estimated spread was maximum in paddy (212,302 ha) followed by wheat (24,909 ha), sorghum (8,624 ha), *ragi* (5,230 ha), barley (2,090 ha), maize (2,085 ha), *bajra* (1,973 ha) and barnyard millet (1,173 ha).
- **Oilseeds:** The area spread was maximum in rapeseed and mustard (49,082 ha) followed by soybean (9,630 ha), sesame (8,154 ha) and groundnut (2,884 ha).
- **Pulses:** The estimated spread was highest in greengram (10,655 ha) followed by pigeonpea (7,297), blackgram (4,898 ha) and chickpea (3,520 ha)
- **Vegetables:** The area spread was maximum in cabbage (10,680 ha) followed by brinjal (10,240 ha).
- **Planting materials:** The area spread was highest in mango (3,041 ha) followed by cashew (483 ha) and guava (477 ha).

16. Empowering Women in Agriculture

The Directorate of Research on Women in Agriculture (DRWA) has been engaged in research under different technology-based theme areas in farm women perspective in a network mode with research and development institutions and agricultural universities.

Migration pattern and gender: Considering the significance of migration in the life and livelihoods of rural people a study was conducted. Occupational profile of women labour migrants indicated that 92% were engaged as wage labourer in the infrastructure sector. Importantly an estimated 48% of women migrants moved back to their villages during the lean months (monsoon and autumn) that coincided with important agricultural seasons in their places of origin. Significantly, 67% of these women were engaged as agricultural labourers in rice and vegetable farming in their villages, whereas 25% were engaged in farming either on their own or leased–in land. About 12% possessed own land with an area of 1–2 acres. The reasons of migration included non-availability of job opportunities for most part of the year and low wages followed by natural calamities and debt burden.

Public private partnership for gender mainstreaming: Research on public private partnership (PPP) for gender mainstreaming in agriculture was undertaken at six network centres. PPP models from 22 States of India were collected and analyzed based on the impact of models on gender mainstreaming in agriculture as per strengths and weaknesses of the models. Models in the areas of gender empowerment in crop production (DRWA, Bhubhaneshwer); empowering women vegetable growers for market linkage (Avinashilingam University for Women, Coimbatore); entrepreneurship development of farmwomen in mushroom production (KAU, Thrissur and MPUAT, Udaipur); promotion of biofertilizer through SHGs (AAU, Jorhat); and value-addition of fruits, vegetables and bead-string making (CCS HAU, Hisar) and were found suitable for scaling up.

Storage pest management: A study on storage pest management in pigeon pea (*Cajanus cajan*) was undertaken with resources, easily available with farmwomen, viz. begunia leaf powder, neem leaf powder and chilli powder at different doses along with neem oil as the standard check. Application of neem leaf powder @ 10 g/kg was effective and recorded minimum (17.3%) bored grain followed by begunia leaf powder (17.38%) and dry chilli powder (19%) in comparison to the control (27%). Maximum test weight was recorded in standard check (6.23 g) followed by neem leaf powder 5 g/kg (4.56 g) after six month of storage. Highest germination percentage was recorded in standard check (84%) closely followed by chilli powder applied @10 g/kg (72.49%). It was inferred that 10 g of *Capsicum annuum* powder; *Vitex negundo* and *Azadirachta indica* leaf powder was standard dose for the safe storage of pigeon pea up to six months and did not have any environmental or health hazard.

Women in horticulture: Knowledge and research gaps among women farmers were identified under the Network project on Assessment of gender issues–identification and refinement of selected women-specific technologies in horticultural crops being implemented at six centres. Interventions taken up to address the gaps were: (*i*) raising vegetable seedlings in portrays; (*ii*) planting on raised beds for better survival; (*iii*) seed replacement with high-yielding brinjal, bitter gourd, cucumber and pumpkin; (*iv*) cultivation of off-season and high-value vegetables under protected structures; and (*v*) proper staking/training of vegetables.

Vegetable production with bamboo structures – a women-specific technology in horticultural crops

Gender issues in livestock production: Action research was taken up under the project on enhancing livelihood of rural women through livestock production involving goats, pigs, backyard poultry and area-specific mineral mixture at five network centres. At Izatnagar the income from a unit of five adult female and one male goat was about ₹ 11,000 after one year and from rearing pigs was ₹ 7,000/animal. Use of revolving stool (*pirhi*) for milking animals reduced the drudgery and increased their efficiency of work. General lack of awareness about chaff cutter and feeding trough for feeding animals resulted in loss of animal feed. A model for sustainable poultry production is being tested in Jaypur village in Puri district involving women SHGs wherein the profits generated by rearing chicks are being ploughed back to purchase new lot of chicks. At Namakkal women farmers were initiated to take up azolla production for developing low cost feed for poultry and goat.

Gender gap in nutritional status: Gender gap in nutritional status of farm families was identified in

rice-based cropping systems in Odisha, Uttarakhand and Madhya Pradesh. Anthropometric measurements (body mass index) indicated highest gender gap in rice–rice cropping system (13.3%), followed by rice–millet (11.1%). Measurement of haemoglobin concentration revealed large gender gap in rice-rice cropping system which was mainly due to monocropping of rice, resulting in less food choice at household level.

Occupational health hazards of farmwomen: Lack of safety measures during the farm operation resulted in incidents/accidents such as trapping of cloth (5.4%), slipping (3.2%), falling of machine on body (2.7%) etc. The hazards faced by farm women in their daily activities were also due to lack of modern equipment/technology (41%), low wage (43.3%), monotonous work (40.8%), irregular hours (31.9%) and excess responsibilities (20.4%). Occupational health hazard and stress indices were developed to identify the extent of hazard and stress level faced by farm women while performing household, farm and animal rearing activities.

AICRP on Home Science: The All India Co-ordinated Research Project (AICRP) on Home Science is being implemented through nine state agricultural universities. This project focused on development of gender-specific database, development of training modules for farmwomen, technology interventions for drudgery reduction of women in agriculture, nutritional security and health promotion of farm families, promoting vocational skills amongst adolescent girls, value-addition to under-utilized natural fibre resources and empowerment of rural women for livelihood security.

Analysis of gender disaggregated data collected from 23,000 respondents of 11,500 families from 56 zones revealed that independent participation of male member was higher than female members in all the States except Uttarakhand, where participation of women was the highest (29.41%). Joint participation with female members was higher in Andhra Pradesh, Himachal Pradesh, Maharashtra and Rajasthan in seed selection, nursery raising, transplanting, weeding and harvesting. Complete access of resources to rural women over use of land was high in Himachal Pradesh (70%), Maharashtra (50%) and Uttarakhand (32%) but low in sale and purchase of land. More women respondents of Himachal Pradesh, Rajasthan and Karnataka had complete access to tools and implements than other states. Complete access to and control over storage and retention for household use for women was higher than other resources in Punjab (63%), Uttarakhand (55%), Andhra Pradesh (51%), Himachal Pradesh (31%), Rajasthan (30%) and Haryana (27%) than rest of the States. Control over improved seeds was visibly high in Uttarakhand (55%).

A comparison of the role profile indicated that highest independent participation of rural women was in homestead gardening (28.8%), followed by livestock-management activities (22.3%) and post- harvest management (11.4%). The responsibility profile showed that women shouldered major responsibility in livestock management (29.3%), followed by homestead gardening and post-harvest management activities. Rural women had complete access to resources related to livestock management (33.3%), followed by homestead (26.1%) in comparison to resources in other areas. Rural women's control over resources was also higher (28.3%) in livestock than other areas.

Rural women of Himachal Pradesh (77%) and Rajasthan (50%) were completely responsible for maintenance and lending of tools, which is higher over other states.

In Himachal Pradesh, number of women who had control over use of land resources was more than the male members of the family, because men stayed away from the villages for their livelihoods and attended farming operations seasonally. Women had higher responsibilities in backyard management including livestock with highest participation in Punjab, Himachal Pradesh, Rajasthan and Karnataka. Male members were generally considered as owners of cattle and women were associated with livestock as 'milk managers'. Decisions concerning feeding, excreta management, storage of fodder and dairying incomes were made by women.

Interstate comparison of participation in extension programmes indicated that women in Asom attended more trainings in livestock management, in Andhra Pradesh in homestead management, and in horticulture in Himachal Pradesh. Women's participation in farm-related trainings and awareness in Uttarakhand was the highest (87%). Women did not attend the training programmes due to shortage of time, lack of prior notice and relevance of training. In the adoption of technologies, the major constraints were lack of access to women-friendly technologies and region-specific inputs, and marketing.

Capacity building of farm women: Training modules on bee-keeping, value-addition to tomatoes, fruit preservation, vermi-compost, dairy management, mushroom cultivation and production of biofertilizer were developed for establishment of micro-enterprizes for economic empowerment of women.

For drudgery reduction of women in agriculture, improved agricultural tools/technologies, namely, fertilizer trolley, manual seed drill, mat nursery, vegetable plucker, vegetable bag, water bag, face protector, dung collector, fodder chopper, fodder collector, groundnut stripper, groundnut decorticator, groundnut stripping frame, long handle fork, manual maize sheller, mango harvester, potato picker and revolving stool, were field validated. Trainings/demonstrations were organized for capacity development of women in agriculture. Nutrition gardens were established in *rabi* and *kharif* seasons to improve the daily diet of rural families to reduce micro-nutrient deficiencies. For promotion of vocational skills among adolescent girls and young mothers, need-based skill-oriented training programmes were organized for their

capacity development benefiting adolescent girls/ mothers and anganwadi workers.

Value-addition and income-generating technologies were disseminated in the adopted villages for empowerment of women. Training programmes on dyeing with natural dyes, loin loom weaving, care of woollen garments, importance of protective clothing, handmade paper product, garment construction, children's garments, hand-made carry bags, files and covers making, *Grewia optiva* (*biul*) handicraft development, embroidery, photo-frames from waste newspaper and soft toy making were conducted for capacity building and skill upgradation of farmwomen. Significant gain in knowledge was observed after the training. Women initiated their own micro-enterprise unit at home scale taking job orders.

Protective garments were designed and developed to protect farm women from the health hazards during pesticide application. During pesticide application, the farm workers are exposed to pesticide vapours leading to various health hazards and it enter body via dermal absorption, inhalation and ingestion due to improper clothing. Hence farm workers suffer from short term

A farm woman wearing face protector; and (*inset)* campaigning and trainings to create awareness about functional features and advantages of protective clothing

health risks, i.e. headache (78%), eye irritation/itching (75%), nausea (58%), breathlessness (53%), loss of appetite (47%), dizziness (38%), skin allergy/ ailments (35%), vomiting (20%) and scorching (10%). Lectures, campaigns, video shows and trainings were conducted to create awareness about functional features and advantages of protective clothing among pesticide applicators.

Role of women in inland fishery: The impact of gender and its role in open water fisheries was assessed in two stretches of upper Hooghly estuary (Nawabganj and Tribeni). In Nawabganj stretch, fisherwomen performed grading of fish. It provided extra income of ₹60/day to the family as mixed fish catch sold at low price in comparison to graded fish. They were also involved in other income generating activities like stitching clothes, wage earning, livestock, nursing and cooking. Livelihood diversification of fisher women was observed with declining fish catch and increase in numbers of fishers in last decade. Highest diversification (29.13%) was observed for nursing followed by grading of fish (26.7%) and livestock rearing (14.56%).

Empowering ST women through transfer of composite carp culture technology: Composite carp culture technology was disseminated to a self-help group of 12 Santhal women in Boudh and Purulia, in Biharunder, the DST funded project.The group took lease of Panchayat tank '*Dhanga Bandh*' a seasonal pond having 1.75 ha water spread area. CIFA extended technical assistance, capacity building training and provided critical inputs. By stocking good quality fish

Empowering ST women through transfer of composite carp culture technology

seed and proper scientific care the SHG achieved three-times higher production than the pre-adoption production levels. Women SHG group member actively participated in all stages in composite carp culture including harvesting. Participation of tribal women in composite carp culture proved beneficial in achieving nutrition security and also socio- economic upliftment. ❑

17. Research for Tribal and Hill Regions

The ICAR through its institutes located in the North-west Himalayas, North-east Himalayas and Andaman and Nicobar Islands evolved technologies to meet the needs of tribal and hill farmers. These technologies are intended to improve the socio-economic status of target groups, and will help them acquire special skills through vocational training in traditional and non-traditional crops, agroforestry, apiculture, horticulture, animal husbandry, poultry and fisheries.

NORTH-WEST HIMALAYAS

Varietal developement

Vivek Maize Hybrid 39, VL Lahsun 2, VL Mandua

Variety/Hybrid	Adaptation region/ Agro-ecology	Duration	Salient feature
		Varieties/hybrids notified	
Vivek Maize Hybrid 39 	For commercial cultivation in Zone I (UA, HP, J and K and NEH region)	Extra-early (85–90 days)	Single-cross hybrid with yellow, semi-dent grain, gave 21.93% higher yield over the best check Vivek Maize Hybrid 17.
VL Lahsun 2	Zone I	190–195 days 	It showed higher bulb weight, less storage loss and high TSS (°Brix). It also possessed resistance against purple blotch and stemphylium blight in Zone I.
VL Mandua 347	Bihar, Gujarat, Jharkhand, Karnataka, Madhya Pradesh and Uttarakhand	Early duration (95–100 days)	VL Mandua 347, a cross between VR 708 × VL 149 surpassed the check variety VR 708 by 10% higher yield and showed moderately resistance to blast. It will be suitable for those areas where monsoon gets delayed or drought is a common phenomenon, higher hills.
		Varieties/hybrids released	
VL Tamatar Hybrid 1	Uttarakhand	60–75 days (first picking)	It showed 27.97% higher yield than the check hybrid DARLH 304 in State Varietal Trials and is suitable for both organic and inorganic conditions as well as for polyhouse cultivation.
VL Shimla Mirch Hybrid 1	Uttarakhand	65–70 days (first picking)	It is suitable for both organic and inorganic conditions as well as for polyhouse cultivation.
VL Cherry Tamatar 1	Uttarakhand	70–75 days (first picking) 	An indeterminate, open-pollinated variety, can be grown both under polyhouse and open-field conditions. Fruits small, attractive, red with oval shape; better in nutritive traits (Vitamin C and TSS), good taste and being table type, it can fetch high price to the growers.
VL Shimla Mirch 3 	Uttarakhand	70–80 days (first picking)	An open-pollinated variety, can be grown under both organic and inorganic conditions especially during summer-rainy season in hills. Fruits are uniform, attractive dark green, medium size (60–70 g), blocky, 3–4 lobes with bright smooth surface. It is also suitable for polyhouse cultivation.
VL Tamatar 5	Uttarakhand	70–80 days (first picking)	A semi-indeterminate, open-pollinated variety, can be grown both under polyhouse and open-field conditions especially during summer-rainy season in the hills. It is suitable for both organic and inorganic conditions.

UA, Uttarakhand; HP, Himachal Pradesh; J and K, Jammu and Kashmir; NEH, north-eastern hills

347, VL Tamatar Hybrid 1, VL Shimla Mirch Hybrid 1, VL Cherry Tamatar 1, VL Shimla Mirch 3 and VL Tamatar 5 were notified/released for various agro-climatic regions of country.

Development of VL *Syahi Hal*

Hill farmers generally use the locally available traditional wooden plough. VL *Syahi hal* was developed as an alternative to the traditional plough. This plough can be used for ploughing as well as levelling fields. The weight was also kept within 11–14 kg to make it convenient for handling.

VL *Syahi Hal*

Colocasia (taro)-based cropping system

In hills of Almora, potato consumed the highest total input energy (25,084 MJ/ha), and in colocasia-based relay intercropping the consumption was least (5,108 MJ/ha) by coriander. Colocasia–coriander–tomato showed higher energy ratio (30.4), human energy profitability (2,813.4) and energy profitability (29.43) with the highest system biomass. The total energy output of the crop production systems followed the order: colocasia–wheat–okra (1,362,928 MJ/ha), colocasia–coriander–tomato (1,249,136 MJ/ha) and colocasia-gardenpea–frenchbean (839,299 MJ/ha). The colocasia–coriander–tomato and colocasia–onion–frenchbean cropping systems were more suitable in the North-Western Himalayas for higher energy-use efficiency and energy productivity respectively.

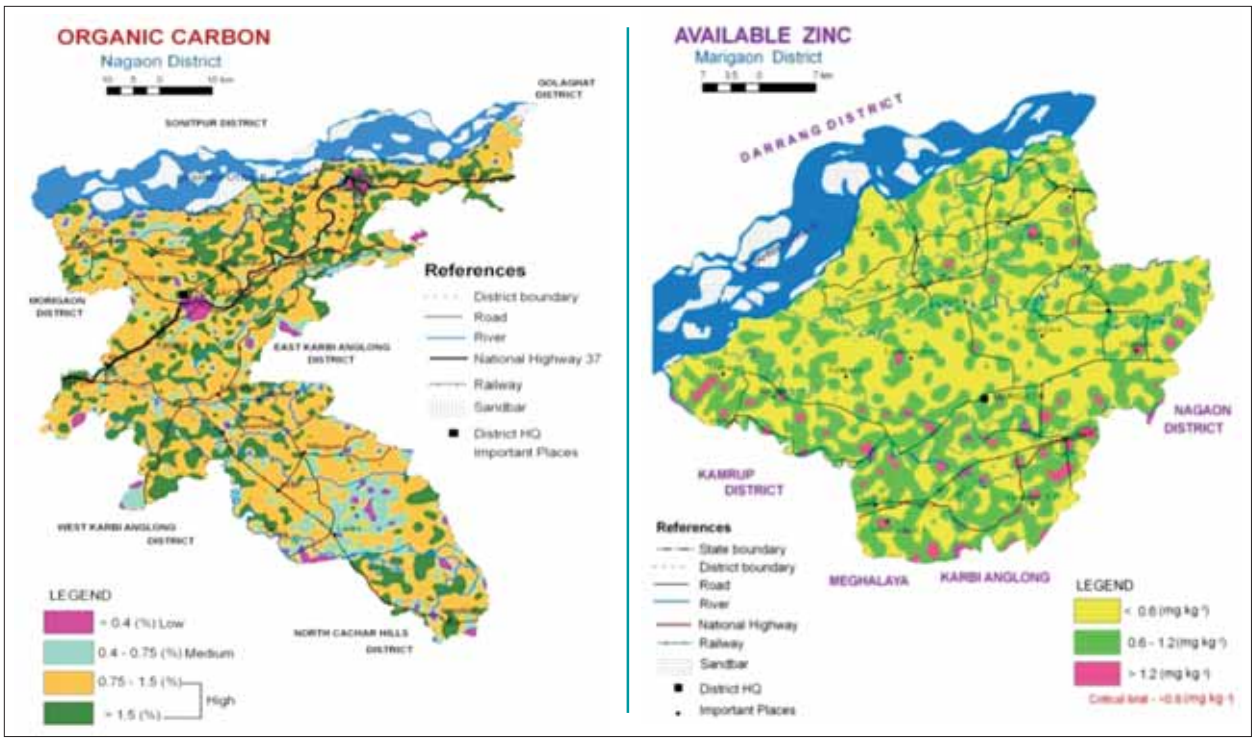
Effect of PSB strains on pea

Carrier-based formulation of eight cold-tolerant P-solubilizing bacterial strains were tested for P uptake in pea variety VL 47 under pot condition. *Pseudomonas fragi* strain CS11RH1 and *Pseudomonas poae* strain PB2RP1(2), and *Pseudomonas* sp CS11RP1 improved the number of seed in pea plants by 10.1% and 7.7% respectively. Maximum P uptake was recorded by *Pseudomonas poae* NS12RH2(1) (47.3%), *Pseudomonas poae* CS11RP1 (44.2%) and *Pseudomonas fragi* CS11RH4 (40.6%), respectively, over uninoculated control. Rockphosphate application combined with bacterial inoculation improved the P uptake by 17.6 to 27.3%.

NORTH-EAST HIMALAYAS

Soil fertility mapping

Geo-referenced soil fertility mapping of macro- and micro-nutrients for the 13 priority districts of Asom state (1 : 50,000 scale) was carried out. These maps can be utilized for optimization of nutrient supply for better crop production and for regularizing supply of nutrients during crop season.



Organic carbon map of Nagaon district of Asom (*left*); and available zinc map of Marigaon district of Asom (*right*)

Varietal improvement

RCM 13, a pre-released short-duration rice culture: RCM 13 line, having a short-duration character, was developed at Manipur centre. The line takes 75 days to reach 50% flowering and matures in about 95–105 days. The genotype was also found suitable as contingent variety for pre-*kharif*/early *kharif*/main *kharif* condition and different cropping systems in the region. It is the first evolved culture having low amylose content (11.7%).

Akhanphou rice: Akhanphou, a popular local rice cultivar of Manipur, was found highly resistant to leaf blast under uniform blast nursery continuously for two seasons. Besides, the genotype possessed four major blast-resistant genes (*Pita/Pita2*, *Pi40*, *Pi54* and *Pi2*), and also showed tolerance to low phosphorus conditions.

Taro: RCMC 5, a very high-yielding clone of taro (*Colocasia esculenta*) developed at Manipur centre, showed a potential yield of 28.31 tonnes/ha and moderate resistance to *Phytophthora* leaf blight.

King chilli: Genetic diversity study of 22 king chilli landraces of Manipur, one landrace of Nagaland and two capsicum varieties using 38 microsatellite markers showed 9 distinct groups. The Manipur accessions were found different from Nagaland accession. The Nagaland accession showed similarity with those collected from Ukhrul district, Manipur (RCMKC 7 and RCMKC 9) bordering Nagaland. The accessions collected from Chatrik village of Ukhrul (bordering Myanmar) and Thingkeu village of Churachandpur (bordering Mizoram) were also found different from other Manipur accessions. Among the Manipur accessions, RCMKC 7 (collected from Ramva, Ukhrul) was different from rest of the group.

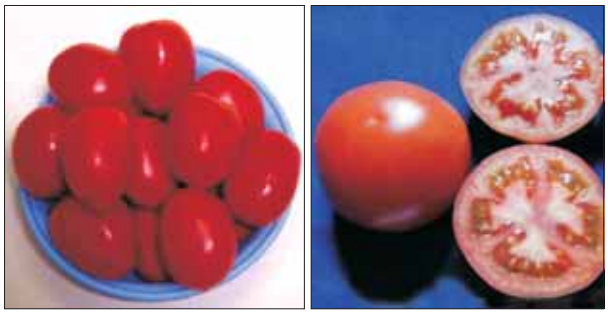
Identification of candidate genes for aluminium-toxicity tolerance

In order to improve aluminium toxicity tolerance in rice, differential expression of six candidate genes under aluminium toxicity stress was studied through semi-quantitative PCR. Two candidate genes *IPS1* and *CAX2* were identified for improving aluminium toxicity tolerance.

Temperature-tolerant rice and maize and moisture-tolerant tomato for North-eastern hill ecosystem

Of the 600 rice genotypes tested at Umiam for heat tolerance, RCPL 1-136 genotype appeared most tolerant to high temperature (72% spikelet fertility on recovery) with tolerance for drought (RWC 48.6). Similarly, pollen-grains of nine genotypes of maize were exposed to heat stress at 45°C for different periods. RCM 17 genotype showed highest tolerance. However, one hour exposure at 45°C reduced pollen viability by 50% in almost all genotypes in Meghalaya.

Of the 38 genotypes of tomato collected and evaluated under poly-house condition at 20–30°C at three levels of moisture stress (90±2.3%, 80±2.3% and 70±2.3% moisture stress), Megha Tomato 3 variety performed best at low-moisture condition. Similarly, five tomato genotypes collected from Varanasi and five breeding lines



Manileima tomato hybrid found suitable under frost condition (*left*); and Kashi Hemant performed better under low light condition (*right)*

from Manipur were evaluated under three growing conditions, viz. natural field (exposure to frost), low-cost polyhouse (exposure to heat) and 50% agro shade net (exposure to low light intensity). Tomato variety Manileima was found suitable under frost condition, whereas Selection 9A has shown resistance to drought and high temperature. Under low light condition, Kashi Hemant performed better than other genotypes.

Unique traits of local pigs and poultry

Pigs: The performance of pig breeds, Ghoongroo/Duroc was evaluated under low input production system and demonstrated the technology for climate resilient production system. At Umiam, the unique traits of the indigenous pigs of the north-eastern region were identified. Phenotypic and morphometric traits of Bru pigs in Mizoram and their performance and the production system were evaluated. Blood samples from Bru pigs and Khasi local pigs were collected, and genomic DNA isolated for microsatellite genetic characterization and DNA repository of indigenous pigs.

Indigenous poultry: The indigenous chickens were of medium size, active and having multi-colour plumage. Majority of the birds are normally feathered; however, frizzled and naked neck types were also observed in many areas. The birds possess single comb, red ear lobe and white non-feathered shank.

Local poultry–Naked neck types were also observed in many areas

Thermal tolerance and reproductive competence of native fish species of NEH region

Thermal tolerance and rate of oxygen consumption, critical thermal maximum (CT*max*) and lethal thermal maximum (LT*max*) were studied in two potential ornamental fishes of the region—*Brachydanio rerio* and

Danio dangila. The results showed that *B. rerio* was more thermal tolerant, indicating better adaptation than *D. dangila*.

Animal production

Different freezing rates (20, 40 and 60°C/min) using programmable freezer, were tried to optimize the freezing of boar semen. Freezing rate of 40°C/min showed the maximum post thaw motility and viability of spermatozoa in boar semen. Significantly higher sperm plasma membrane integrity and mitochondrial membrane potential and lower DNA damage were recorded at 40°C/min freezing rate than that at 20°C/min and 60°C/min. The plasma membrane, mitochondrial and DNA damages were significantly higher during manual freezing than during programmable freezing.

ANDAMAN AND NICOBAR ISLANDS

Germplasm and crop improvement

CARI Brinjal 1, developed by repeated selection and purification cycles from the local collection, survived under wilt pathogen sick condition and gave better yield than other varieties under island conditions. It has been registered with the NBPGR, New Delhi.

Thirtythree accessions of *Morinda citrifolia*, one of *Eryngium foetidum*, two of *Amaranthus viridis*, seven each of *karanja* and *jatropha*, and 16 of tuber crops were collected and deposited in the NPBGR, New Delhi. Two new indigenous vegetables—*Mukia maderaspatana* and *Limnophila chinensis*—were identified, and 64 species of medicinal and 19 of speciality flowers were collected and maintained in the gene garden of the institute.

Indigenous vegetables having rich source of zinc and calcium (*Centella asiatica*), copper (*Sauropus androgynous*), iron (*Portulaca oleracea*) and magnesium (*Amaranthus viridis*), and underutilized fruit *Malpighia glabra* for polyphenol, anthocyanin, carotenoids, tannin and ascorbic acid were identified. *Morinda citrifolia* accession TRA1 was the richest source of polyphenol, flavonoids and ascorbic acid, while TRA2 had higher tannin and anthocyanin.

Water and nutrient management in capsicum through drip system

Under protected cultivation, application of 50% recommended dose of fertilizers (RDF) as vermicompost + 50% RDF as water-soluble fertilizer through fertigation + vermiwash spray was found highly profitable and economically viable to get more of yield of Indra variety of capsicum under island ecosystem.

Organics in managing acid soils of Andaman

A field experiment was conducted with maize consisting of seven treatments, viz. poultry manure, vermicompost, coconut husk compost, coconut husk compost + lime, gliricidia, lime and control. Significant enhancement was observed in root volume, grain yield, stover and biological yield owing to poultry manure followed by vermicompost and gliricidia treatments. The yield increase in these treatments was mainly owing to increased availability of nutrients such as nitrogen and phosphorus besides improvement in soil reaction. Though lime application has improved the soil pH to 6.69, the yield parameters were lesser than the organic amendments due to limited availability of major nutrients such as N and P.

Production technology including protection

Cauliflower varieties, viz. Mareet F_1, Shobha F_1, White Marble, White Shot and White Taj, performed well in heavy rainy season under rainshelters.

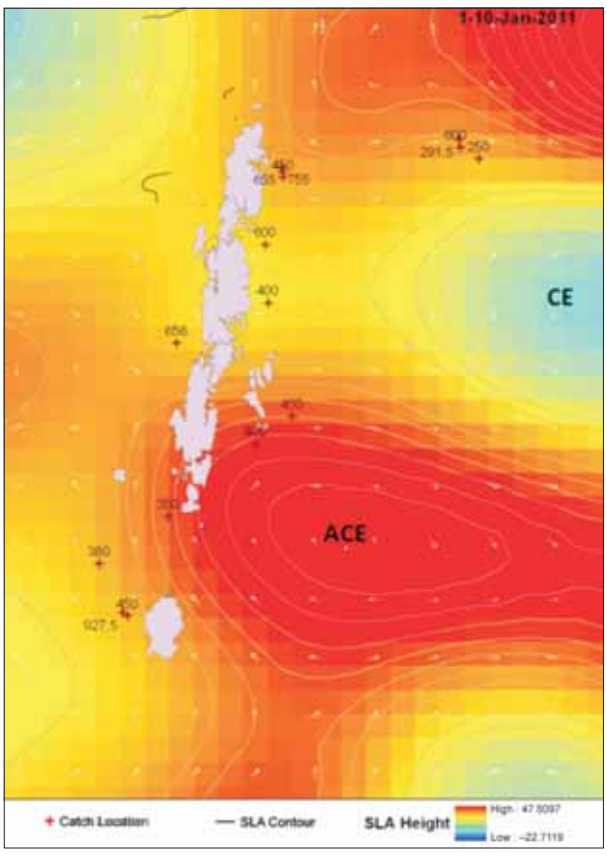
The lowest bacterial wilt incidence (20%) was reported in tomato grown on cocopith : vermicompost : lime (1 : 1 : 0.01) compared to 56.7% in control pots.

Deepika, an improved dual-purpose Nicobari fowl produced by crossing White Nicobari and Vanaraja, showed higher adult body weight and annual egg production with better survivability.

Two herbal products, namely Gromune (Tonic) and Morical feed supplement, were prepared from the fruits of *Morinda citrifolia*. Feeding Gromune @ 15 ml/bird improved immunity, and Morical @ 4% in feed supplement enhanced 24% egg production in Japanese quail.

Potential fishing zone advisories for Andaman

Andaman receives rainfall for almost 250 days in a year and due to non-availability of cloud-free satellite data, the PFZ advisories for this region have been grossly



Altimeter derived eddy map. ACE, Anti-cyclonic eddy; CE, Cyclonic eddy

Capacity Building of Tribal Farmers

Under tribal sub-plan project for improving livelihood of tribal farmers of Jharkhand, Manipur, Asom and Rajasthan by enhancing rapeseed-mustard production through capacity building of the stakeholders, 120 farmers were trained at the DRMR, Bharatpur, and more than 2,500 farmers were benefited through farmer participatory on-farm demonstrations, exposure visits and supply of simple tools for agricultural operations, etc. A mini workshop of the programme coordinators from cooperating centres was organized at the ICAR Krishi Bhavan, New Delhi, on 19 March and at the DRMR, Bharatpur, on 20 March 2012.

discontinuous. Hence a study was designed to explore methods to augment Chlorophyll-a and SST-based operational PFZ advisories with AltiKa-based satellite altimetry data.

The mesoscale features, particularly eddies, in the fishing areas around the A&N islands were characterized. Overlay of fish catch positions on altimeter-derived eddy maps indicated significant catches in areas (*i*) between anti-cyclonic and cyclonic eddies where divergence followed by enhanced primary productivity occurs; (*ii*) between two anti-cyclonic circulations where divergence and upwelling occur and (*iii*) around the boundary/ periphery of anti-cyclonic eddies which are productive. The analyses of data showed that such mesoscale eddies are very common in the vicinity of A & N islands and need to be targeted for increased catches of pelagic fishes.

Optical characterization of coral reef diversity

The coral reefs in Andaman were monitored to study the coral recovery and reef fish diversity after the 2010 mass bleaching phenomena. All the sites showed significant increase (11%) in live coral cover. The study showed that the abundance of Chaetodontids and Pomacentrids decreased with decrease in coral cover while that of Acanthurids and Scarids, which are predominantly algal grazers, increased.

Underwater radiometer survey was carried out at North Bay and in the Mahatma Gandhi Marine National Park (Tarmugili and Chester Island) and a total of 62 spectral signatures covering different life forms of live and dead corals, rubble and sand were obtained. The analysis of the data indicated the potential of using satellite data for differentiation of live forms of corals.

Economic valuation of mangroves in A & N islands

Total economic value of the A & N mangroves was worked out to be more than ₹ 12,000 crore per annum on

Success story

Improving living standards of tribal farmers through technological interventions

The Tribal Sub Plan scheme was implemented in the fields of 96 tribal farmers of Macharam, Jangamreddy palle, Chitlamkunta, Petanchenu and Maddimadugu in Amrabad Mandal of Mahabubnagar district in Andhra Pradesh. To improve living conditions of the tribal farmers through interventions of improved oilseeds technologies, especially in castor a non-edible and high-value crop, besides creating agricultural related assets, a scheme was initiated. The farmers were trained in improved production technologies of *rabi* castor including cropping systems for sustainable production.

Seeds of castor hybrids, DCH 519 and DCH 177, were given to farmers for growing in *rabi*. At different stages of crops, they were trained to apply fertilizers, weedicides and pesticides. Besides, 55 sprinkler sets and 125 secateurs were supplied. To alleviate the problem for transporting agricultural produce, assistance was given of three bullock carts. Farmers could earn on an average ₹ 8,000/0.4 ha despite severe drought. It indicates scope for higher economic returns under good years.

TRIBAL SUB PLAN PROGRAMME

Jute and allied fibres

Under the programme, major emphasis was given to bring more area under cultivation of sisal and ramie in tribal areas of the country to uplift their socio-economic conditions. The TSP activities comprised generation and distribution of planting materials, crop area expansion, and transfer of technology, human resource development, public awareness generation and literature development.

Ramie: Planting materials of ramie, rhizome, plantlets and stem-cuttings for 10 ha generated at Ramie Research Station, Sorbhog, Asom, was supplied to Assam Ramie Fibre Cultivation Cooperative Ltd. About 25 ha area of the research farm was exclusively under use for generation of planting materials for the TSP. Tribal areas of Lakhimpur, Dhemaji and Sonitpur districts of Asom were selected for expanding ramie cultivation.

Ramie nurseries were established at four tribal villages. Ten ha area covering 51 farmers was brought under ramie plantation. Stem-cuttings as a low-priced and alternative planting material to ramie rhizome was popularized among the farmers, and about 50% of the covered area was planted with stem-cuttings. Among the trained farmers, group leaders were identified for effective implementation of tribal support programme in those districts. In total 80 farmers were trained.

Sisal: Under TSP, Sisal Research Station, Bamra, Odisha, generated 51,328 sisal-suckers that were distributed among the tribal farmers of Jharsuguda and Sambalpur districts of western Odisha. With the continued meetings and awareness programmes with the tribal farmers at the research centre and also at the tribal villages, tribal farmers of Jharsuguda and Sambalpur were encouraged for sisal plantation. As a result, 11.55 ha of land covering 28 tribal farmers were brought under sisal cultivation. The improved production technologies of sisal were demonstrated to farmers.

current prices and per household harvest was more than ₹ 65,000 annually from the mangroves. Economic value of mangroves was found to be more than ₹ 2 lakh/ha/annum.

Impact assessment of technological interventions in Andaman

The impact assessment revealed that composite fish culture with CRM was promising both in South and North and Middle Andaman districts. In 30% cases the farmers have resorted to adoption of the technology even after *Tsunami* 2004 in South Andaman. An average harvest of 2.5 to 3 tonnes/ha/year against 0.07–0.08 was obtained. Many farmers, through the sale of the fish, i.e. 1.5 to 2 tonnes/year, could earn an income of ₹ 1.85 to 2 lakh against 0.45 lakh. The technology has helped the farmers getting regular income and nutritional supplements. The horizontal spread of the technology was to the tune of 20 ha in N&M Andaman. Broad bed and furrow system (BBFS) was adopted by the farmers in the villages of South Andaman. Farmers could earn an additional income of ₹ 20,000 to 25,000/year against ₹ 800–1,000 from rice crop alone from an area of 0.2 ha. In addition to that, employment generation of 90 to 120 man-days took place under these technologies. Major constraints observed were lack of labour, marketing, storage facilities and non-availability of essential inputs in time.

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18. Organization and Management

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December, 1973. Subjects allocated to the DARE as per the Government of India (Allocation of Business) Rules are specified in Appendix 1 of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India in the DARE functions as the Director General of the ICAR. The Financial Advisor of the DARE is the Financial Advisor of the ICAR. Generally single-file system is followed between DARE and ICAR.

The Department has Central Agricultural University (CAU), Imphal, and Bundelkhand under its administrative control. The CAU, Imphal has its jurisdiction over the North-Eastern States: Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim and Tripura, and is wholly financed by the Government of India.

DARE has 17 Group A, 16 Group B, 11 Group C, and 6 Group D posts. The recruitment to the post in the Group A, B, C is being made centrally, either through the Department of Personnel and Training or through the Department of Agriculture and Co-operation, depending on the level of the post. 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 Class. Presently, DARE has 5 Scheduled Castes and 1 Scheduled Tribes employee.

A detailed break up of the posts and names of the important functionaries is given in Appendix II . The financial requirement (Grant No. 2) includes budget estimates (BE) and revised estimates (RE) of DARE,CAU and ICAR (Plan and Non-Plan) 2011–12 respectively and BE for 2012–13 (Plan and Non-Plan) . The detailed break up of these financial figures is given in Appendix III.

ICAR

The Indian Council of Agricultural Research is an autonomous organization under the Department of Agricultural Research and Education, Ministry of Agriculture, Government of India. Formerly known as Imperial Council of Agricultural Research, established on 16 July 1929 as a Registered Society under the Societies Registration Act 1860, on the recommendations of the Royal Commission of Agriculture, and has been 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 Bhavan I and II, and NASC Complex, New Delhi.

The Union Minister of Agriculture is the President of the ICAR. The Principal Executive Officer of the ICAR is the Director General, who also acts as Secretary to the Government of India in the Department of Agricultural Research and Education.The General Body of the ICAR Society is the supreme authority of the ICAR, and the Union Minister of Agriculture, Government of India, heads it. Its members are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the Senior Officers of the various state governments, representatives of Parliament, industry, educational institutes, scientific 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, ICAR who also acts as Secretary, DARE. It consists of eminent agricultural scientists, educationists, legislators and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committee, Policy and Planning Committee, several Scientific Panels, and Publications Committee. In the scientific matters, the Director General is assisted by eight Deputy Directors General, one each for (*i*) Crop Science, (*ii*) Horticulture, (*iii*) Natural Resource Management, (*iv*) Agricultural Engineering, (*v*) Animal Science, (*vi*) Fisheries, (*vii*) Agricultural Education and (*viii*) Agricultural Extension. Besides one National Director (NAIP) and one National Co-ordinator who looks after the Secretariat of National Basic Strategic and Frontier Application Research in Agriculture (NFBSFARA) also assist Director General, ICAR.

The Deputy Directors General are responsible for the Institutes, National Research Centres, and the fundings of Projects Directorates in their respective fields. The National Director (NAIP) is responsible for all the research projects running under Components I to IV of NAIP. The NAIP supported a number of policy and institutional changes and financing investments in 185 sub-projects under four components. Besides, three sub-projects under Component-3 were funded by additional financing grant from the Global Environment Facility Trust Fund of the World Bank. In view of the progress shown and the lag in implementation of phase I, NAIP has been granted extension till 30 June 2014.

The ICAR recruits scientists and to such other posts and services as may be specified by the President, ICAR from time to time through competitive examination/ direct recruitment by selection etc. through its independent recruitment body, Agricultural Scientists' Recruitment Board,established on 1 November 1973. The ASRB is accountable to the President of the ICAR Society. The ICAR received funds from the Government of India and from the proceeds of the Agricultural

Produces. The Senior Officers post at the ICAR (Hqrs) is listed in Appendix 3 of the ICAR. The Research set up of the ICAR includes 51 Institutes (Appendix 4), 6 National Bureaux (Appendix 5), 35 Project Directorates and Zonal Project Directorates (Appendix 6), 17 National Research Centres (Appendix 7), and 78 All-India Co-ordianted Research Projects and Network Projects (Appendix 8).

The 'Directorate of Knowledge Management in Agriculture'(DKMA) works as communication arm of the ICAR responsible for delivery of information/ knowledge generated by the network of the ICAR and its institutions.The DKMA addressed its mandate through Publications and Information, AKMU and Public Relations units. The E-Publishing Knowledge System in Agricultural Research, a project under NAIP increased visibility of ICAR literature in 182 countries and there is enhancement in the number of foreign authors for the research journals.

The ICAR promotes research, education and extension education in 55 State Agricultural Universities, 5 Deemed Universities, and 4 Central Universities with Agricultural facility by giving financial assistance in different forms; and DARE promotes 1 Central Agricultural University for the North-Eastern Hills Region (Appendix 9).

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

IP Protection and Grant of Titles

Patents: Twenty research institutes filled 50 patent applications, taking the cumulative patent applications number to 716 filed by 58 institutes. Applications covered a range of technology areas, viz. crops and horticulture, dairy and veterinary sciences, fisheries and farm implements and machinery.

Eight national patent applications were granted in 2012 and two applications granted by United States Patent and Trademark Office (USPTO), viz. 'An Artificially Synthesized Peptide' (in collaboration with DBT) and 'A Process for the Production of Organic Formulation of Bio-Pesticide *Pseudomonas fluorescens*'. The cumulative total of granted patents increased to 137.

Copyrights, Design and Trademarks: Three copyrights were filed by IASRI, New Delhi for Monograph Hadamard Matrices; Monograph α-designs; and Expert System for Maize Crop (Maize AGRIdaksh). One application for Design registration was submitted by IVRI, Izatnagar for IVRI Foetal Extractor. Trademarks were also registered to ensure the quality of goods and services provided by ICAR institutes. Accordingly, trademark "CRIJAF SEED" was filed by CRIJAF, Kolkata; "DRR" (word & logo) by DRR, Hyderabad; "SHATPADA" by NBAII, Bengaluru and "CARIUTTAM" by Central Avian Research Institute, Izatnagar.

Plant Varieties: As the Protection of Plant Varieties and Farmers' Rights Authority notified new genera, applications for 45 varieties (38 extant and 7 new) were filed at the Plant Variety Registry. The cumulative total of applications filed by ICAR for plant variety registration rose to 876 application (784 extant and 92 new varieties) which included cereals (wheat, rice, maize, sorghum, pearlmillet) 502; oilseeds (sesame, groundnut, castor, sunflower, soybean, linseed, Indian mustard) 30; pulses (pigeonpea, lentil, chickpea, mung bean/green gram, pea, kidney bean, *urd* bean/black gram) 174; commercial crops (jute, cotton, sugarcane) 128; horticultural crops (chrysanthemum, ginger, turmeric, black pepper, small cardamom, potato, cauliflower, cabbage, brinjal, tomato) 42. The cumulative total of varieties granted registration rose to 326. These included grant of registration certificates to 128 (3 New and 125 Extant) varieties: comprising wheat (07); rice (23); maize (13); sorghum (8); pearlmillet (5); pigeonpea (13); lentil (1); chickpea (44); jute (7); cotton (5); and sesame (2).

Capacity Building for Strengthening IP

For training and capacity building in soft skills to understand and appreciate the nuances of IPR and technology commercialization, scientists/staff were encouraged to attend programmes that enhance their capabilities to take appropriate strategic and management decisions about the protection and exploitation of institutional intellectual property; and accordingly more than 172 persons from 30 institutes participated in different programmes at reputed national and international organizations, including ASSOCHAM India, New Delhi; FICCI, Hyderabad; Thomson Reuters, New Delhi and Mumbai; Michigan State University, USA; PPV&FR Authority, New Delhi; Indian Institute of Management, Ahmedabad; Indian Institute of Management, Indore; Indian Law Institute, New Delhi; Society for Technology Management (STEM), Pune; NIIPM, Nagpur etc.

Further, to strengthen the IP and enhancing the technology management capabilities Seminars/Lectures/ Trainings/Workshops were organized by 11 ICAR institutes; these were attended by 1361 researchers, practitioners and farmers.

Outreach activities

With the objective of making research demand-driven by getting closer to the client and generating ability to respond to changing environmental and client needs with greater alacrity, ICAR and Confederation of Indian Industry (CII) jointly organized four Regional Meets in partnership with the State Agriculture Universities. These Meets were held at Ahmedabad, Coimbatore, Hisar and Agartala in cooperation with Anand Agriculture University, Anand; Tamil Nadu Agriculture University, Coimbatore; CCS Haryana Agriculture University, Hisar; and Central Agriculture University, Imphal respectively. Besides, the Institute Technology Management Units (ITMUs) also organized commodity/region specific programmes to promote commercialization of successful research results and encourage partnerships with diverse stakeholders. These included: Tuber Crops Research

Subject Area	Technology Applied for Patenting
Crops and Horticulture	
Bio-formulations	Process for Improved Yield of *Trichoderma biomass;* Samfungin: Novel fungicide; Wettable Powder Formulation of *Paecilomyces lilacinus*; Organic Fertilizer of Banana Pseudostem; Production of Coir Pith Cake; Extraction of Bio-pesticide; Multi-nutrient Organic Manure; Compost-Gypsum Blocks
Biotechnological Processes	Production of Antibodies for ELISA-based Diagnosis; Genetic Engineering of Male Sterility and Transgene Containment in Plants; Anti Cancer activity of cyclic dipeptide isolated from novel bacteria
Crop Production/Protection	Production Process of High quality white pepper; Decontamination of Pesticide Residues; Light Trap for Managing Insects; Insect Parasitoid and Predator Collection Device
Veterinary and Dairy	
Animal Health Diagnostics	Bio-Marker-based Detection of Bovine Sub-clinical Mastitis; Kits for Parentage Verification; Solid State Bioreactor; Bio-formulations for Carbendazim Tolerance; Antibodies Detection Kit, Primers, Method for Sex Determination in Chicks
Animal Based Value Added Products	Herbal Meat Product; Use of Goat Milk Fat in Meat Products; Process for Aurvedic *Paneer*, Flavoured Milk and Whey Drink; AJAS Goat Milk Based Products; RTE Salty Crisp Milk Product; RTC Milk Chips; Production of Xylo-oligosaccharides from finger millet straw
Fisheries	
Fish Products and Processes	Medicated Feed Mix; Nutra-pharmaceutical feed mix for fungal treatment in aquatic animal; Extruded fish product; Fish enriched noodles; Fiber Glass Sheathed Rubber Wood Canoe; Seafood Self-Heating Pack; Fish Gravy Powder; Concentrates from Seaweeds; Feed for Improved Growth in Fish; RTE Thermal Processed Smoked Tu; Insulation Fish Bags; Taurine Extraction From Fish Head
Testing Kits/Diagnostics Methods	*In Vitro* Culture of Glochidia Larvae; Extraction of Caroteinoprotein; Production of High Purity Glucosamine Hydrochloride; kit for Identification of White Spot Disease; Collagen-chitosan Tissue Regeneration Membrane; Fish De-scaling Machine; Development of Fish Gel; Depuration System for Bivalves
Farm Implements and Machinery	
Farm Implements and Machinery	Machine for Peeling Litchi and Scooping Out the Pulp; Guar Dehulling Machine; Banana Fibre Spining System; Fineness Tester of Jute and Allied Fibers; Water Application Device-LEWA; Design of Device to Assess Leaching of Chemicals; Straw Reaper; Combine Harvester; Palm Climbing Device; Potting Machine for Nursery; Sugarcane Bud Chipping Machine; Jute Ribboning Machine; Auto-cleavable microencapsulation system
Nano-technological Processes	Slow release Nano-Formulations; Nano-copper based formulation; Nano-induced Bacterial Polysaccharid; Ohmic Heating System for Food Products; Production of Nanocellulose
Post Harvest Products and Processes	Candy of Banana Pseudostem; Enzymatic Pretreatment to Cottonseed kernel; Integrated Grading System of Jute; Dietary Fiber rich Biscuits; Fiber Extraction from Mango Processing Waste; High Protein Carotene Rich Pasta.

Patent Number	Technology/ Innovation
IN250709 (A01N 1/02)	A kit for diagnosis of *Brucellosis*
IN250779 (C07K 14/475)	A process for producing a bio-pesticide composition containing *Trichoderma harzianum* and *Pseudomonas fluorescens*
IN250880 (A23L 1/00)	Method of determining maturity of intact mango in tree
IN251022 (A01M1/20)	A manually operated low cost handy cryo-freezer for gamete cryopreservation
IN251836 (A01N 65/00)	A multiplant manual ribboning device for extraction of green ribbon from a bundle of jute or mesta plant operable in one cycle
IN252072 (D04H)	Male-specific protein of Indian major carp, *Labeo rohita* (ham.)—a key for sex differentiation and brood stock management
IN252363 (C12Q1/00)	An insect handling device
IN254341 (C12P 19/34)	Process enabling simultaneous detection of transgenes namely Human Serum Albumin (HAS) and Bar Genes in transgenic wheat
US8216843 (C07K, C12N)	An artificially synthesized peptide
US20080286853 (A01N, C12N)	A process for the production of organic formulation of bio-pesticide *Pseudomonas fluorescens*

Some Technologies Commercialized by the ICAR Institutes

Crops and Horticulture

Plant variety: Wheat: HI 1544; Rice: Ajay (CRHR-7), CR Dhan 701 (CRHR-32), Rajalaxmi (CRHR-5); Maize: Vivek QPM 9, VL Babycorn-1; Chilli: MSH 206, Arka Meghana; Chrysanthemum: Pusa Anmol; *Cymbidium* hybrids; Tomato: Arka Rakshak; Ginger: IISR Varada; Nutmeg: IISR Viswashree; Ajmer Coriander-1; Ajmer Fenugreek 1, 2; Ajmer Fennel 1.

Bio-formulations: Arka fermented Coco peat, Bio-bactericide composition B5, DOR Bt-1 formulation, PCR-based detection kit in pomegranate, Rapid detection of Bt-Cry toxin, Bio-pesticides (e.g. *Paecilomyces lilacinus, Pochonia chlamydosporia*)

Biotechnological products: *Bacillus thuringiensis* Cry2Aagene, Okra SSR markers

Crop protection devices: Insect rearing cage, UV chamber for *Corcyra* Eggs, Egg cleaning device, Pheromone trap, *Helicoverpa* oviposition cage; Insect handling device, Light trap

Post-harvest products and processes: Banana flower, stem in pickle, juice/RTS and fibre products; Candy from fruits; Coconut chips,; Nutraceutical concentrates; PUSA Bajra puff; Pusa fruit drink; Pusa nutri cookies; Insulated ventilated freight containers for Horticulture train; Automatic machine for scooping out the pulp of custard apple; Lac-based fruit coating formulation

Dairy and Veterinary Sciences:

Animal breeds and production technologies: Poultry breeds: Vanaraja and Gramapriya; Production technologies of CARIBRO Dhanraja, CARIBRO Vishal, CARI Pearl, quail; CARI Priya

Animal Health, Diagnostics and Vaccines: PPR vaccine, Vero-cell based sheep pox and goat vaccine, Classical swine fever cell culture vaccine, Cotton strain-19 vaccine, ELISA Blue tongue antibody detection kit, Area specific mineral mixture

Value added products: Technology for emulsion based chicken, meat and pork products

Industry Interface (CTCRI, Trivandrum); Research-Industry Interactive Meet (DSR, Mau); Interface Meeting–Sugar industry (IISR, Lucknow); Public-Private Interface (VPKAS, Almora); Agri-business Meet (CIFA, Bhubaneshwar); ICAR Industry Day (NRC Yak, Dirang); Farm Innovators Day (CSWCRTI, Dehra Dun); Manufacturers Meet (IARI, New Delhi), ICAR Industry Day (NRC Agroforestry, Jhansi); Industry Interface (DOR, Hyderabad) and Interface meetings for commercialization of technologies (CMFRI, Kochi).

A 'Knowledge Meet' was organized to deliberate on research needs to meet the new challenges and to envision the opportunities to be harnessed from the technological revolution happening globally. The Meet was inaugurated by Prof. Abhijit Sen, Member (Agriculture), Planning Commission and addressed by senior officials from associated Government of India Departments and International organizations. The delegates representing Directors of ICAR Institutes and Vice Chancellors of State/Central Agriculture Universities deliberated to

collectively develop a road map for the long-term so as to orient the proposals for XII Plan.

Technology Transfer/Commercialization

The technologies generated at the ICAR institutes are being transferred/commercialized through Memoranda of Understandings, licensing agreements, and consultancies/contract research/contract service to farmers, NGOs, government organizations and private organizations (including seed/veterinary/processing/pesticides companies). Thus, about 165 such partnerships were developed by the 20 research institutes with around 118 public and private organizations.

ADMINISTRATION

Recruitment

By direct recruitment and promotion following posts were filled up during 2011-12: one in the grade of Under-Secretary, nine in Senior Administrative Officer, seven in Administrative Officer (by promotion) and 25 direct recruitment vacancies in the grade of Administrative Officer and Finance & Accounts Officer, two in Director (Finance)/Comptroller, 25 in Section Officer, two in Principal Private Secretary, three in Private Secretary, one in Legal Adviser, eight in Deputy Director (OL), 51 in Assistant, two in Personal Assistant, 28 in UDC, and one in LDC have been filled by direct recruitment and promotion.

Financial upgradation granted under MACP scheme

During 2011–12, large number of eligible officers and staff of ICAR (Headquarters and Institutes) were granted financial upgradation under MACP Scheme abide by the Government of India (Department of Personnel and Training).

Staff welfare fund scheme

(i) As per the recommendations of the Managing Committee of ICAR Headquarters' Welfare Fund financial assistance of ₹ 25,000 was extended to the family of one deceased employee of the ICAR (Headquarters).

(ii) 48 Scholarships (₹ 2,500 each) were awarded to the meritorious wards of the Councils' employees under Staff Welfare Fund Scheme.

(iii) Wards of two employees of ICAR (Headquarters) who died in harness have been appointed on compassionate ground.

FINANCE

The Plan and Non-Plan allocation (R.E.) to DARE/ICAR for 2011–12 were ₹ 2,850 crore and ₹ 2,157.60 crore respectively. An internal resource of ₹ 137.89 crore (including interest on loans and advances, income from revolving fund schemes, recovery of loans and advances and interest on short-term deposits) was generated. The Plan and Non-Plan allocations (B.E.) for 2012–13 are ₹ 3,220 crore and ₹ 2,172 crore respectively. The details of financial outlay–demand no. 2 of DARE are given in Appendix III.

PROGRESSIVE USE OF *RAJBHASHA*

DARE

The Department of Agricultural Research and Education has an Official Language Section for the compliance and implementation of the Official Language Policy of the Government of India. It consists of one post each of Assistant Director (Official Language), Junior Hindi Translator and Hindi Typist. Besides the Hindi translation of the Budget, compilation and preparation of the Annual Report of the Department etc. also take place. The functioning of this section also includes holding Hindi workshops, meetings, reports, organizing Hindi *Pakhwada* to encourage the employees for doing their official work in Hindi.

His Excellency President of India, Shri Pranab Mukherjee, conferring 'Indira Gandhi *Rajbhasha Puraskar'* for 2010-11 to Department of Agricultural Research and Education (DARE)

ICAR

- During 2012–13 three Institutes/Centres of the Council were notified in the Gazzette of the Government of India thus raising the total number of notified Institution to 121 under rule 10(4) of the Official Language Rule 1976.
- Joint Official Language Implementation Committee of the DARE and the ICAR working under the Chairmanship of the Secretary DARE/Secretary, ICAR met four times during 2012–13. Similarly, Official Language Implementation Committee constituted at mostly Institutes/Centres convened its meetings.
- Proceedings of the Official Language Implementation Committee meetings held by the Institutes etc. as well as the quarterly progress reports regarding the use of Official Language *Rajbhasha* received from various institutes at the ICAR (Headquarters) were reviewed and proper measures were suggested to overcome the shortcomings found therein.

- Rosters have been maintained for imparting training in Hindi, Hindi typing and Hindi stenography and officials were accordingly deputed for training during the year. This year, only one typist was nominated for Hindi typing.
- This year "*Hindi Chetna Mass*" was celebrated at ICAR (Headquarters) and many programmes were organized for staff to promote the progressive use of Hindi in official business. A Message of Hon'ble Union Minister of Agriculture was issued on this occasion. The DG, ICAR also issued an appeal requesting the officers/staff to do their maximum official work in Hindi. Hindi Day/Week/Month was also organized in different Institutes/Centres of ICAR.
- Four Hindi Workshops were also organized for various categories of officers/staff.
- During 2011–12 cash awards were given away to 10 officials at headquarters for doing their maximum official work in Hindi.
- Evaluation is being done to give away prizes to institutes for the *Rajarshri Tandon Rajbhasha Purskar* for 2011and *Ganesh Shankar Vidyarthi Utkrist Hindi Krishi Partika Purskar*.
- 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 Headquarters as well as its institutes 31 offices were inspected during 2012, and suggessions were given to improve the shortcomings. Second Sub-Committee of the Parliamentary Official Language Committee inspected 13 Institutes/Centres of the Council during this year.
- *Krishika*, biannual research journal in Hindi was started during 2012–13.
- The Council and its institutes are organizing regular training programmes for farmers in Hindi and in other regional languages and remarkable progress has been made at Krishi Vigyan Kendras situated in Hindi speaking region in the use of Hindi and in the other regional languages in their day to day official work.
- Besides all the material regarding Parliament, Annual Plan Report, Review of demands for grants, General Body, Standing Finance Committee, Parliamentary Standing Committee on Agriculture, AGM of ICAR Society and many other meetings were prepared bilingually. The drafts of speeches of Hon'ble Union Agriculture Minister and other higher officials of ICAR were prepared originally in Hindi also.

TECHNICAL COORDINATION

The Council provided the financial support to 56 journals for publication, 35 societies/association/ universities for holding National Seminars/Symposia/ Conferences and 22 societies/association/universities for holding International Seminars/Symposia/Conferences. Annual grant to NAAS, Indian Science Congress and IAUA were also released. Fifty queries from VIPs, nine queries under RTI Act, 51 Parliament Questions were replied. Annual Report of DARE 2011–12 and Account Report were placed before the Parliament.

The ICAR Directors' Conference 2012 was held from 17 to 18 February, 2012 under the chairmanship of Dr S. Ayyappan (Secretary, DARE and DG, ICAR). Besides interface of the ICAR Directors and the Vice Chancellors of Agricultural Universities was inaugurated by the Hon'ble Union Minister of Agriculture and Food Processing Industries, Shri Sharad Pawar who felicitated Dr K.L. Chaddha (a renowned Horticulturist) and Dr V.P. Singh (Ex-Scientist, IARI, New Delhi) for having been conferred with the prestigious Padma Shri award and said that it is a matter of great pride and honour for ICAR. After the inaugural session.

This Unit organized ICAR Regional Committees (RC) No. I–II and IV–VIII Meetings, such as RC I at CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur, from 8 to 9 June 2012; RC II NAARM, Hyderabad from 19 to 20 July 2012; RC IV at A.N. Sinha Institute of Social Studies, Patna from 21 to 22 September 2012; RC V at IARI, New Delhi from 14 to 15 December 2012; RC VI at CAZRI, Jodhpur from 16 to 17 November 2012; RC VII at International Centre, Goa from 9 to 10 November 2012; and RC VIII at TNAU, Coimbatore from 15 to 16 June 2012 respectively.

FOUNDATION DAY AND AWARDS CEREMONY

H.E. (Former) 14th President of India, Dr A.P.J. Abdul Kalam, delivered the 'Foundation Day Lecture and appreciated efforts of the ICAR on 16 July 2012. The ICAR Award-2011 function was also held on same day as part of Foundation Day. The Chief Guest of the function, Shri Sharad Pawar (Hon'ble Union Minister of Agriculture & Food Processing Industries and President, ICAR Society) gave away the awards and said that the recognition through Awards should lead to enhanced zeal

Bharat Ratna Dr A.P.J. Abdul Kalam, fourteenth President of India inaugurated 84th Foundation Day of the ICAR

and creative work by the Awardees. Shri Harish Rawat, Union Minister of State for Agriculture & Food Processing Industries and Parliamentary Affairs; and Dr Charan Das Mahant, Union Minister of State for Agriculture & Food Processing Industries graced the occasion.

Eightythree awardees under sixteen categories were conferred awards. These comprise three Institutions, one AICRP, nine KVKs, nine Farmers, one Journalist, four Teachers and 56 scientists. Among 56 scientists there were 5 women scientists. The awardees gave a presentation of their achievements on 14 July 2012 before a panel of experts.

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19. Partnership and Linkages

The International Cooperation 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 & Cooperation as the Nodal Department. In addition, Ministry of Science and Technology has developed Programme of cooperation with various countries and international organizations in which ICAR/DARE is the participating agency in the field of agricultural research. The Joint Commissions/Working Groups constituted by the Ministry of External Affairs and the Ministry of Commerce have the component of agriculture/agricultural research in which DARE participates directly or through the Department of Agriculture and Cooperation. The Department organizes visits of foreign nationals on request. The Department also receives proposals for customized training courses for foreign nationals.

Work Plan

The Work Plans between ICAR-IWMI and ICAR-IRRI were signed during 2012-13.

Collaborative Projects

Followings are the Collaborative Projects:

- Collaborative research projects or Workshops in the field of Biotechnology under Indo-Australian Biotechnology Fund (IABF)- Round 6 which is a joint initiative between the Government of India through the DBT and the Department of Innovation, Industry, Science & Research (DIISR), Government of Australia, submitted by the Central Marine Fisheries Research Institute, Kochi

Dr S. Ayyappan, Secretary (DARE) and DG (ICAR) inaugurated a Review Meeting on ICAR-ICARDA collaborative programme on 29 November 2012

- Participation of CSSRI in the University of Melbourne sponsored AusAid–Public Sector Linkage Programme (PSLP) funded capacity building programme 'Safer and more sustainable disposal of domestic sewage effluent in India using agroforestry systems' submitted by Dr R.K. Yadav (Principal Scientist, CSSRI, Karnal).
- Collaborative project on 'Global Yield Gap and Water Productivity' received from Dr Kenneth G. Cassman (Prof. of Agronomy and Chair, Independent Science and Partnership Council of the CGIAR, University of Nebraska, Lincoln) with ICAR.
- Participation of Directorate of Water Management, Bhubaneshwar in the New Indigo project on 'Reuse options for marginal quality water in urban and peri-urban agriculture and allied services in the gambit of WHO guidelines'.
- Project proposal on 'Genotypic interaction of chickpea (*Cicer arietinum* L.) with *Mesorizobium* sp. for enhanced nitrogen-fixation and other symbiotic benefits'—submitted by Dr K Swarnalakshmi (Senior Scientist, Division of Microbiology, IARI, New Delhi) for funding by International Foundation for Science under first IFS Research Grant.
- Project on 'Using Rainwater Harvesting for Resilient Local Groundwater Management in the Presence of Saline Aquifers', received from In-charge PME, IARI, New Delhi. The project is being submitted to DST under Australia-India Strategic Research Fund (AISRF). The project implementing agencies are: Water Technology Centre, IARI, New Delhi; University of Western Sydney, Australia; and MPUAT, Udaipur.
- Permission for involvement of Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora for promotion of the technologies in International Fund for Agricultural Development Project on 'Integrated Livelihood Support Project (ILSP)' to be run by Uttarakhand *Parvatiya Aajeevika Sanvardhan* Company, Dehra Dun (Uttarakhand)/ Uttarakhand Livelihood Project for Hill People.
- Project proposal on 'Building partnership for conservation, restoration and sustainable management of Aravalli Eco-region, Western India' received from the Director, CAZRI, Jodhpur. The project proposal is submitted by UNESCO Delhi Office to the German agency (German Federal Ministry for the Environment) for funding. The project implementing partners are National Institute of Ecology (NGO), New Delhi, University of Delhi and CAZRI and the

partner institution for embedding in the target region are Man and Biosphere National Committee, Ministry of Environment & Forest, Government of India, State Forest Department, Government of Rajasthan and School of Environmental Science, Jawahar Lal Nehru University.

- Collaborative project on 'New knowledge and innovation food design leading to sustainable development of the agro-food sector and decreased poverty' received from the Director of Research & Dean, Faculty of PG Studies, Anand Agricultural University(AAU), Anand. The project partners are AAU, Anand, SASNET fermented Foods (a Swedish-Indian network) and Hildur Functional Foods Pvt. Ltd (Swedish Indian joint venture SME). The project is to be funded by Food Technology, Engineering and nutritious/ Faculty of Engineering, Lund, Sweden under Swedish International Development Cooperation Agency (SIDA).
- Collaborative research project on 'Genetic analyses of Asia seabass populations in Indian peninsular waters using polymorphic DNA markers' in collaboration with the National Bureau of Fish Genetic Resources, Lucknow, and Temasek Life Sciences Laboratory, Singapore which is a non-profit organization undertaking cutting edge research in molecular biology and genetics utilizing a broad range of model organisms and is affiliated to the National University of Singapore and Nanyang Technological University.
- Collaborative research project on 'Precision Farming for Enhancing the Livelihood Security of Farmers' received from the Director Research, Tamil Nadu Agriculture University (TNAU), Coimbatore. The project is to be collaborated between TNAU and Nova Scotia Agricultural College, Canada. It has been indicated that as a member of the Shastri Indo-Canadian Institute, Nova Scotia Agricultural College (NSAC) was awarded ₹3 lakhs by Shastri-Indo-Canadian Institute, New Delhi to carry out a joint/ collaborative research project with Tamil Nadu Agriculture University.
- Proposal relates to issue a letter of intent for partnership in the INNO-ASIA project Phase-II by Central Soil and Water Conservation Research and Training Institute, Dehra Dun. The Project proposal is being submitted to BMBF (German Federal Ministry of Education and Research) by professor flugel of Friedrich Schiller University, Jena.
- Approval of the project on 'Crop plants which remove their own major biotic constraints' submitted by Dr G.T. Gujar (Head, Division of Entomology) and Dr Pritam Kalia (Head, Division of Vegetable Science, IARI, New Delhi) for funding by DST.
- Collaborative project on 'A Global Census of Rumen Microbial Diversity' funded by New Zealand Ministry for Agriculture and Forestry under RMG (Rumen Microbial Genomics) network between AgResearch, New Zealand and NDRI, Karnal submitted by Dr Rameshwar Singh (the then Head, Dairy Microbiology Division, NDRI Karnal).
- Collaborative project on 'Genetic Engineering of stay green trait for development of drought tolerant wheat' submitted by Dr Ajay Arora (Principal Scientist, IARI, New Delhi) for funding by Department of Science & Technology (DST), Government of India under Indo-Czech Programme of Cooperation in Science & Technology. The project partners are IARI, New Delhi and Institute of Experimental Botany, Academy of Science of the Czech Republic, Laboratory of Stress Physiology, Czech Republic.

Fund released to CG Institutes

- India is donor member to CGIAR. In 2012-13 we have contributed ₹ 105,753,000 under Plan Head of ICAR Funding and we have also contributed to ₹ 37,500,000 under Non-Plan Head of DARE Funding through Contribution Arrangement.

Major Events

- A Workshop on 'Climate Change, Adaptation and Mitigation in Agriculture in the ASEAN Region and India' was organized in New Delhi from 23 to 24 August 2012.

Second Meeting of Agricultural Experts Working group on 'Agro-Products and Food Security of BRICS Countries' held on 27 August 2012

- A Meeting of Experts on 'Agro-Products and Food Security of BRICS Countries (Brazil, Russia, India, China and South Africa)'/Second Meeting of Agriculture Experts Working Group was organized at NASC Complex Pusa, New Delhi from 27 to 28 August 2012.
- The Second ASEAN-India Ministerial Meeting on 'Agriculture and Forestry and the ASEAN - India Agriculture Expo' was held from 17 to 19 October 2012 at NASC Complex, Pusa, New Delhi.

Agri-Innovate India

Agri-Innovate India Limited, a Government of India Company, established by the Department of Agricultural Research and Education (DARE) aims to work on the strengths of DARE and Indian Council of Agricultural Research and promote the development and spread of Research and Development outcomes through IPR protection, commercialization and forging partnerships both in the country and outside for the public benefit. During 2012–13, the statutory requirements in respect to registrations, enrollments, etc. have been completed. The process for scouting and screening of the available technologies eligible for commercialization has been initiated. Organizational structure of the company is framed and the recruitment process has been started. As the recruitment of the desired professionals is completed, the company shall start its commercial activities.

Central Agricultural University

North-Eastern Hills Region: The Central Agricultural University, Imphal had been trying to impart agricultural education to students from North-Eastern Hills Region through seven constituent colleges. During 2012–13, total 240 students were admitted to eight undergraduate degree programmes. One hundred seventy students took admission to Master's Degree Programmes and 12 students were admitted to Ph.D. programme. University has 902 students on its roll. 196 students completed Bachelor's degree and 73 students were awarded Masters Degree during 2012–13. The performance of students at All India Post-Graduate Entrance Examination of ICAR made CAU proud of its students. 125 students got admission to different post-graduate programme in various SAUs and National Institutes all over the country. Forty-two students were admitted to National Institutes like IARI, IVRI, CIFE, NDRI, FRI and IIT.

Twentyfive students from CAU were selected for the award of JRF on the basis of which CAU is adjudged at 4th position amongst SAUs in India. Directorate of Research is operating 22 AICRP centres, 5 NAIP projects, 1 Centre of Excellence, 1 Mega Seed Project and 66 *ad-hoc* projects. The efforts were made to spread the CAU– R-1 variety by undertaking seed production programme on farmers' field. More than 100 tonnes of truthful label seed has been produced. A new project on biotechnological research on fishes with an outlay of ₹ 10.5 crores has been approved by DBT for College of Fisheries for five years. New varieties of rice, viz. CAU-R3 and CAU-R4 for different agro-ecological situations have been recommended. Technology for processing of pineapple juice to pineapple powder has been developed and is being fine tuned. Dissemination of scientific information to the stakeholders is being carried out through extension wings of Colleges and three KVKs by the Directorate of Extension Education. Major thrust area of activity being increase in the area of second crop in *rabi* after the harvest of rice. Based on the technology developed by CAU with participation of farmers, a large-scale demonstration of mustard over an area of 1,000 ha with 'zero tillage' has been taken up to show the feasibility to farmers in valley districts under tribal sub-plan in collaboration with NRC for Rapeseed Mustard, Bharatpur.

Bundelkhand: The Department of Agricultural Research and Education has proposed to the establishment of Central Agricultural Unversity for Bundelkhand Region, which covers 13 districts, i.e. 7 districts (Jhansi, Jalaun, Lalitpur, Banda, Chitrakoot, Hamirpur and Mahoba) of Uttar Pradesh; and 6 districts (Sagar, Damoh,Tikamgarh, Panna, Chatarpur and Datia) of Madhya Pradesh.

A Bill on 'The Rani Lakshmi Bai Agricultural University Bill, 2012' has already been introduced on 22 May 2012 in the Rajya Sabha for the purpose.

Consultancies

- Dr V. Venkatasubramanian [ADG (AE), ICAR, New Delhi] had Consultancy proposal for preparation of Country Paper/Study Report of India on 'National Agricultural Extension Systems in SAARC Countries-An Analysis of the System Diversity' for SAARC Agriculture Centre, Bangladesh.
- Delegation of Pan African University of Life and Earth Sciences, Ibadab, Nigeria visited Indian Agricultural Research Institute, University of Delhi, Delhi; National Dairy Research Institute and Directorate of Wheat Research, both in Karnal; and Punjab Agricultural University, Ludhiana from 7 to 11 May 2012.
- Dr S.S. Raju (Principal Scientist, National Centre for Agricultural Economics and Policy Research, Pusa, New Delhi) is assigned report writing pertaining to for Consultancy on 'Assessment of Diversity of Veterinary Services (Public and Private Sector) in India' for SAARC Agriculture Centre, BARC Complex, Bangladesh as a Focal point Expert at home station.
- Professor Ramesh Chand (Director, National Centre for Agricultural Economics and Policy Research, Pusa, New Delhi) is assigned report writing pertaining to International Trade, Regional Integration and Food Security in South Asia for Commonwealth Secretariat, London as a Focal Point Expert at home station.
- Dr Ramesh Chand [Director (NCAP)] visited Bangaladesh from 3 to 4 September 2012 to attend sixth meeting of the Governing Board of SAARC Agriculture Centre, Dhaka, Bangladesh.
- Dr U.C. Sud (Head, Division of Sample Survey, Indian Agricultural Statistics Research Institute, New Delhi) visited Bangladesh from 14 to 23 October 2012 for providing Consultancy Services to Bangladesh Bureau of Statistics, Bangladesh in identifying and implementing a harmonized

Crop-Cutting Experiments/Methodology under the FAO-TCP (the Bangladesh Project) Project as a TCDC Consultant to Bangladesh for 80 days.

- Dr (Mrs) R. Manimekalai (Senior Scientist, Central Plantation Crop Research Institute, Kasaragod) visited Sri Lanka from 23 to 29 July 2012 as a FAO-TCDC Consultant.
- Dr P.M. Jacab (Head, Central Plantation Crop Research Institute Regional Station, Kayamgulam) visited Sri Lanka from 23 to 29 July 2012 as a FAO-TCDC Consultant.
- Dr P. Routray (Senior Scientist, CIFA, Bhubaneshwar) visited Bangaladesh from 7 to 26 August 2012 under FAO-TCPF Project as a FAO-TCSC Expert/Consultant.
- Dr (Mrs) Kavita Gupta (Senior Scientist, Plant Quarantine Division, National Bureau of Plant Genetic Resources, New Delhi) is assigned report writing pertaining to re-writing of the APAARI publication, '*Biosafety Regulations of Asia-Pacific Countries*' at home station.
- Dr R.K. Jain [Project Coordinator (Nematodes) AICRP on 'Plant Parasitic Nematodes with Integrated Approach for their Control', Division of Nematology, IARI, New Delhi] visited Republic of Afghanistan from 2 to 5 September, 2012.
- Dr P.S. Birthal (Principal Scientist, National Centre for Agricultural Economics and Policy Research, Pusa, New Delhi) is assigned report writing on 'Patterns and sources of growth in Indian agriculture for IFFPPRI, Washington, USA at home station.
- Dr T. Srinivas (Senior Scientist, Central Tuber Crops Research Institute, Thiruvananthpuram) is assigned report writing for short-term Consultancy for seed marketing course for participants from Egypt., Ehopia, Palestine, Pall, Sudan and Yamen at Cario at home station.
- Professor Ramesh Chand(Director), Dr P. Ramasundram (Principal Scientist), Dr (Smt) Usha Rani Ahuja (Principal Scientist), Shri Sajesh V.K. (Scientist) and Shri Khyali Ram Choudhary (Technical Officer, NCAP, Pusa, New Delhi) is assigned consultancy project for CGIAR Independent Science-Partnership Council, FAO, Rome, Italy at home station.
- Dr Kaushik Banerjee (ICAR National Fellow , Senior Scientist, NRC on Grapes, Pune) visited San Jose, Costa Rica from 12 to 23 November 2012.
- Dr D.K. Ghosh (Senior Scientist, Virology, National Research Centre for Citrus, Nagpur) visited Kathmandu, Nepal from 23 November 2012 to 24 December 2012.

International Conferences/Workshops

- Eighth International Safflower Conference on 'Safflower Research and Development in the World: Status and Strategies' was held at Hyderabad under the Aegis of ICAR through Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Hyderabad from 19 to 23 January 2012.
- International Conference on 'Recent Perspective in Macro-Molecular Structures and Functions ' was held from 27 to 28 January 2012 at Central Agricultural Research Institute, Port Blair.
- Indo-US bilateral Workshop entitled 'Application of nutraceutic for livestock health and production' was held from 9 to 10 February 2012 at NIAN&P, Bengaluru.
- FAO-ICAR International Conference on 'Scientific Development and Technical Challenges in the progressive control of Foot-and-Mouth Disease in South Asia' was held from 13 to 15 February 2012 at NASC Complex, New Delhi.
- Global Conference on 'Women in Agriculture: Envisioning Research, Extension and Policy' was held from 13 to 15 March 2012 at NASC Complex, New Delhi.
- International Workshop on'Strategies in value addition and safety aspects pertaining to Dairy and Food Industry' was held from 15 and 16 March, 2012 Madras Veterinary College, Chennai.
- Hosting 'X International Congress' and 'XXII International Grassland Congress in 2015' at New Delhi— jointly organized by Range Management Society of India and Indian Grassland & Fodder Research Institute, Jhansi.
- International Conference: Dialogue on Designer Rice for the future-2012 was held from 9 to 10 July 2012 at Hyderabad.
- International Conference on 'Plant-Protection for Global Food and Biosecurity' at Acharya NG Ranga Agricultural University Auditorium, Rajendranagar, Hyderabad was held from 26 to 29 August 2012.
- International Expert Consultation on 'Policy and Research needs to Manage Trans-Boundary Disease and Pests of Agricultural Importance', jointly organized by the ICAR and Asia-Pacific Association of Agricultural Research Institutions, was held from 10 to12 October 2012 with General Assembly Meeting was held from 10 October 2012 at NASC Complex, New Delhi.
- International Symposium on 'New Paradigms in Sugarcane Research' was held from 15 to 18 October 2012 at Sugarcane Breeding Institute, Coimbatore.
- Fifth International Symposium on 'Human Health Effects of Fruits and Vegetables Health 2012' was held from 6 to 10 November 2012 at University of Agricultural Sciences, Dharwad.
- International Conference on 'Mushroom Biology and Mushroom Products' was held from 19 to 22 November 2012 at NASC Complex, New Delhi.
- International Conference on 'Plant-Protection for Global Food and Biosecurity' was held at Acharya

N G Ranga Agricultural University Auditorium, Rajendranagar, Hyderabad from 28 to 30 November 2012.

VIP Delegations

- Hon'ble Tjekers Tweya, Deputy Minister of Trade and Industry, and accompanied delegation from the Republic of Namibia visited Central Institute of Agricultural Engineering, Regional Station, Coimbatore from 20 to 21 March 2012.
- His Excellency Mr Bui Ba Bong, Deputy Minister of Agriculture and Rural Development, Vietnam and accompanied delegation visited Indian Agricultural Research Institute and Indian Council of Agricultural Research, New Delhi on 29 March 2012 and Indian Institute of Horticultural Research, Bengaluru on 26 March 2012.
- His Excellency Mr Luis Mayol Bourchon (Minister of Agriculture, Chile) accompanied 9-member delegation to Indian Council of Agricultural Research/NBPGR and National Agriculture Science Museum, New Delhi on 4 May 2012.
- His Excellency Mr Jose Pacheco, Minister of Agriculture, Government of Republic of Mozambique visited IARI and National Agriculture Science Museum, New Delhi on 14 June 2012 and Directorate of Wheat Research and National Dairy Research Institute, Karnal on 15 June 2012.
- His Excellency Mr Nganon Djoumessi Emmannel (Minister of Economy Planning and Regional Development, Republic of Cameroon) met with DDG (Horticulture) from 12 to 16 September 2012.
- A 4-member Bangladeshi delegation led by their Agriculture Minister Her Excellency Begum Matia Chowdhury visited National Agriculture Science Museum/Indian Agricultural Research Institute, New Delhi; Central Soil Salinity Research Institute, Karnal and Central Rice Research Institute, Cuttack from 6 to 10 November 2012.

Scientists on deputation

- Dr Vikas V.K (Scientist, IARI, Regional Station, Willington) visited Mexico from 1 March to 31 May 2012 to attend the training programme on Basic Wheat Improvement Programme, 2012.
- Dr Jitendra Kumar Sundaray (Principal Scientist, KRC of CIBA, Kakdwip, West Bengal) visited Bangladesh from 25 March to 2 April 2012 for participation in the field visit and Workshop on 'Increasing the Resilience of Agriculture and Aquaculture Systems in coastal areas of Ganges Delta'.
- Dr Sarangi and Dr S. Mandal (Senior Scientists, CSSRI, Karnal) visited Bangladesh from 25 March to 2 April 2012 for participation in the 'CPWF G2 field visit and Review Planning Meeting and Ganges BDC Reflection Workshop'.
- Dr M.M. Pandey (DDG, Agric. Engg., ICAR) visited Addis Ababa, Ethiopia from 10 to 13 April 2012 for participation in the Regional Development Workshop.
- Dr R.P.S Verma (Principal Scientist of DWR, Karnal) visited China from 10 to 20 April 2012 to attend the XIth International Barley Symposium.
- Dr V. Ravindra Babu (Principal Scientist, DRR, Hyderabad) visited Dhaka, Bangladesh from 15 to 18 April 2012 to attend the Harvest Plus Rice Team Meeting.
- Dr K. K. Bandyopadhyay (Principal Scientist), Dr V. K. Sehgal (Senior Scientist) and Dr S. Naresh Kumar. (Senior Scientist, IARI, New Delhi) visited Colombo, Sri Lanka from 16 to 18 April 2012 for attending a Workshop on 'Seasonal Weather Forecast and Crop Yield Forecasting'.
- Dr (Mrs) S. Uma (Principal Scientist, NRC on Banana, Tiruchirappalli) visited Rome, Italy from 17 to 19 April 2012 for attending the Symposium on 'Review of Global Crop Diversity Trust Funded Project on Strategy for the Conservation and use of Plant Genetic Resources' .
- Dr Dibakar Mahanta (Scientist,VPKAS, Almora) and Dr J.V.N.S. Prasad (Senior Scientist, Agronomy, CRIDA, Hyderabad) visited Nairobi, Kenya from 23 to 27 April 2012 for attending the Carbon Footprint Assessment Training Workshop and Climate Change Research Planning Workshop.
- Dr Anurava Pattanayak (Principal Scientist , Plant Biotechnology, ICAR Research Complex for NEH Region, Meghalya) visited Thailand from 24 to 27 April 2012 for participation in the XI Review and Steering Committee Meeting of the Consortium for Unfavorable Rice Environments.
- Dr (Mrs) G. Padmaja (Principal Scientist and Head) and Dr M.S. Sanjeev (Senior Scientist, CTCRI, Thiruvanathapuram) visited Bangladesh from 29 April to 7 May 2012 to participate in the training programme on 'Post-harvest utilization and management of sweetpotato'.
- Dr T.M. Gajanana (Principal Scientist, Agricultural Economics, IIHR, Bengaluru) visited Bangkok and Chanthaburi, Thailand from 1 to 4 May 2012 for participation in the Regional Workshop.
- Dr S.K. Chaturvedi [Head (CI), IIPR, Kanpur] visited Addis Ababa, Ethiopia from 7 to 11 May 2012 to attend 2012 Annual 'Tropical Legumes-1 (LT-1)' project Meeting (TLM)'.
- Dr Shankar Lal Jat (Scientist, Agronomy, DMR, New Delhi) visited CIMMYT, Mexico from 21 May to 22 June 2012 for participation in advance course on 'Conservation Agriculture'.
- Shri Rajiv Mehrishi (Special Secretary, DARE & Secretary, ICAR) visited Mexico from 10 to

14 June 2012 to see the research facilities and laboratories being upgraded at CIMMYT, to bring such facilities for the BISA centres in India.

- Dr R. Sai Kumar (Director), Dr V.K. Yadav (Senior Scientist), Dr Ramesh Kumar (Senior Scientist) and Dr Avinash Singode (Scientist, all from DMR, New Delhi) visited Germany from 11 to 16 June 2012 for participation in Abiotic Stress Tolerant Maize for Asia project annual progress review and planning meeting and training course on Double Haploid breeding.
- Dr V.K. Sehgal (Senior Scientist, IARI, New Delhi) visited Ispra, Italy from 13 to 14 June 2012 for attending the Workshop on 'Crop yield estimation in tropical region: 'Concept, Applications and Challenges for Heterogeneous Smallholder Environments'.
- Dr G. Byju (Senior Scientist) and Dr T. Makeshkumar (Senior. Scientist, CTCRI, Thiruvananthapuram) visited Kampala, Uganda from 18 to 24 June 2012 to participate in the Global Cassava Partnership Second Scientific Conference GCP2-II: Cassava-overcoming challenges of Global Climate Change and Generation Challenge Programme sponsored satellite meeting.
- Dr (Mrs) M.N. Sheela (Principal Scientist, CTCRI, Thiruvananthapuram) visited Kampala, Uganda from 18 to 24 June 2012 to participate in the Global Cassava Partnership Second Scientific Conference GCP2-II: Cassava-overcoming challenges of Global Climate Change and Generation Challenge Programme.
- Dr A.K. Singh (DDG, NRM), Dr D.K. Sharma (Director, CSSRI, Karnal), Dr Bhagwati Prasad Bhatt, (Director, ICAR-RCER-Patna) and Dr B.Venkateswarlu (Director, CRIDA, Hyderabad) visited Colombo, Sri Lanka from 21 to 23 June 2012 for participation in the ICAR-IWMI Steering Committee Meeting.
- Dr A.K. Srivastava (Director, NDRI, Karnal); Dr R.K. Bhatt (Principal Scientist & Head, CAZRI, Jodhpur); Dr T.K. Bhati (Principal Scientist, Agronomy, CAZRI, Jodhpur) ; Dr B.K. Mathur (Principal Scientist, Animal Nutrition, CAZRI, Jodhpur); Dr Mohammed Osman (Principal Scientist (Agro.), CRIDA, Hyderabad); Dr G.R. Maruthi Shankar (Principal Scientist, CRIDA, Hyderabad); and Dr Sreenath Dixit (Principal Scientist, Agriculture Exension, CRIDA, Hyderabad) visited Dubai UAE from 25 to 28 June 2012 for attending the Workshop for CGIAR Research Programme on 'Dryland System (CRP 1.1) Integrated Agricultural Production Systems for the Poor and Vulnerable in Dry Area'.
- Dr (Mrs) S. Uma (Principal Scientist, NRC for Banana, Tiruchirapalli,Tamil Nadu) visited Indonesia from 9 to 13 July 2012 for attending the meeting of the 'MusaNet Diversity Working Group' (9 to 10 July 2012) and follow up a Consultation meeting on the 'Musa Wild relative for pre-breeding' (11 to 13 July 2012).
- Dr K.C. Bansal (Director, NBPGR, Pusa, New Delhi) visited Rothamsted, United Kingdom from 30 to 31 July, 2012 for attending the Heat and Drought Consortium Planning meeting.
- Dr C. Mohan (Senior Scientist, CTCRI, Thiruvananthapuram) visited Belgium from 20 to 31 August 2012 to attend the advance course on Modern Breeding Techniques for Improvement of Sweetpotato.
- Dr Pratibha Sharma (Principal Scientist, Division of Plant Pathology, IARI, New Delhi) visited New Zealand from 27 to 30 August 2012 to attend *Trichoderma* and *Gliocladium* 2012 Workshop on 'TG2012 Innovations and Applications'.
- Dr K.K. Vinod (Senior Scientist, IARI Research Station, Aduthurai, Tamil Nadu) visited Philippines from 27 to 31 August 2012 for attending the training Workshop on 'Molecular Marker Breeding of Rice with tolerance to phosphorus (P) deficiency'.
- Dr Raj Shekhar Misra (Principal Scientist, Regional Centre, CTCRI, Bhubaneshwar); Dr M. Anantharaman, (Principal Scientist, CTCRI, Thiruvananthapuram); and Dr Soibam Basanta Singh (Joint Director, ICAR Research Complex for NEH Region, Mizoram Centre) visited to China from 28 to 31 August 2012 for participation in the 'Regional Workshop of the Food Security through Asian Roots and Tubers (FoodSTART) Project'.
- Dr Shaik N. Meera (Senior Scientist, DRR, Hyderabad) visited Phillipines from 1 September 2012 to 28 February 2013 to support the further development of the Rice Knowledge Bank at IRRI, Manila, Philippines.
- Dr Sankar Prasad Das (Senior Scientist, ICAR Research Complex for NEH Region, Tripura Centre) visited Philippines from 2 to 9 September 2012 for attending the Workshop-cum-Training on 'Marker Assisted Breeding for Drought Tolerance'.
- Dr Suresh Pal (Head, IARI, New Delhi) visited Washington DC, USA on 11 September 2012 for attending the Advisory Committee Meeting of Agricultural Science and Technology Indicators programme of CGIAR.
- Dr (Mrs) B. Meenakumari (DDG, Fisheries) visited Bangladesh from 16 to 17 September, 2012 for participation in the Regional Workshop on 'Hilsa Fish and its Potential for Aquaculture'.
- Dr A.P. Sharma (Director), Dr Utpal Bhaumik, (Head), Dr B.K. Behera (Senior Scientist) and Dr A.K. Sahoo, (Scientist, CIFRI, Barrackpore) visited Bangladesh from 16 to 18 September 2012 for participation in the Regional Workshop on 'Hilsa Fish and its Potential for Aquaculture'.

- Dr S.L. Goswami (Director), Dr N. Sivaramane (Senior Scientist), Dr Ranjit Kumar (Senior Scientist) and Dr K. Srinivas (NAARM, Hyderabad) visited Katmandu, Nepal from 24 to 26 September 2012 for attending the launch Workshop of the NAARM–CIMMYT Collaborative Research Programme on'Production and investment outlook of Maize for regional food security in South Asia'.
- Dr J.V.N.S. Prasad (Senior Scientist, Agronomy, CRIDA, Hyderabad) visited Germany from 8 to 10 October 2012 for attending the Workshop on 'Evaluation of mitigation options for smallholder at whole farm and land scape scales'.
- Dr (Mrs) Indu Sharma (Project Director, DWR, Karnal) visited Addis Ababa, Ethiopia from 8 to 14 October 2012 to attend the conferences on'Wheat for food security in Africa at the United Nations Conference Centre (UNECA-UNCC) and the IVth Wheat Management Committee (W-MC)'.
- Dr Trilochan Mohapatra (Director, CRRI, Cuttack) and Dr B.C. Viraktamath (Project Director, DRR, Hyderabad) visited Philippines from 11 to 12 October 2012 for attending the IInd Global Science Forum on 'Structural transformations in the rice sector: Implications for research and development'.
- Dr T. Ram (Principal Scientist), Dr P. Revathi (Scientist, DRR, Hyderabad), Dr P. Ramya, (Scientist, IARI, New Delhi) and Mr B.L. Meena (Scientist, Plant Biotechnology), ICAR-RC for NEHR Tripura Centre, Lembucherra) visited Netherlands from 15 to 26 October 2012 for participation in the Integrated Breeding Multi Year Course.
- Dr Yashpal Singh Sahrawat (Senior Scientist, IARI, New Delhi) visited *Punta del Este*, Uruguay from 26 October to 1 November 2012 for attending the Global Conference on Agricultural Research for Development meeting.
- Dr K.D. Kokate (DDG, Agriculture Extension) visited *Punta del Este*, Uruguay from 29 October to 1 November 2012 for participation in the Global Conference on Agricultural Research for Development.
- Dr H.S. Gupta (Director, IARI, New Delhi) and Dr (Mrs) Krishna Srinath(Director, DRWA, Bhubaneshwar) visited *Punta del Este*, Uruguay from 29 October to 1 November 2012 for participation in the Global Conference on 'Agricultural Research for Development'.
- Dr M. Anandaraj (Director, Indian Institute of Spices Research, Calicut) visited Colombo, Sri Lanka from 30 October to 2 November 2012.
- Dr Sridhar Gautam (Senior Scientist, Central Institute for Subtropical Horticulture, Lucknow) visited Urugudy from 26 October to 3 November 2012.
- Dr Gaurav Kumar Sharma (Project Director, FMD, IVRI Campus, Mukteshwar) visited *Jerej de la Frontera*, Spain from 29 October to 2 November 2012 to attend OIE/FAO Reference Laboratory Network Annual Meeting.
- Dr C.R. Mehta (Head AMD, CIAE, Bhopal) visited Peradeniya, Sri Lanka from 23 to 25 October 2012 for attending the 8th session of the Technical Committee of United Nations Asian Pacific Centre for Agricultural Engineering and Machinery.
- Dr Ramesh Chand (Director, NCAP, Pusa, New Delhi) visited Bangkok, Thailand from 1 to 2 October 2012 for participation in the 'High-level Regional Consultation on Policies to Respond to High Food Prices in Asia and the Pacific'.
- Dr (Mrs) Kavita Gupta (Senior Scientist, NBPGR, New Delhi) visited Washington DC, USA from 26 to 27 April 2012 for participation in the Invasive Species Consortium (ISC) Meeting; Universitas Gadjah Mada, Yogyakarta, Indonesia from 8 to 10 October 2012 for presenting a paper in the Asia Pacific Forest Invasive Species Network Workshop; and Bangkok, Thailand from 12 to 13 November 2012.
- Dr N.V.P.R. Ganga Rao [Senior Scientist (Plant Breeding), Directorate of Oilseeds Research, Hyderabad] visited Nairobi, Kenya for another two years, i.e. upto 22 January 2013.
- Dr Himanshu Pathak (Senior Scientist, IARI, New Delhi) visited Bonn, Germany from 14 to 25 May 2012 to the United Nations Frameworks Convention on Climate Change negotiations; and visited Bangkok, Thailand from 28 August to 5 September 2012.
- Dr M. Anandraj (Director, IISR, Calicut) visited Vietnam from 7 to 8 August 2012 for participation in the International Workshop on 'Pests and Diseases Control in HCMC', organized by International Pepper Community, Indonesia.
- Dr S.V. Alavandi (Senior Scientist, CIBA, Chennai) visited Bangkok, Thailand from 9 July to 1 August 2012 for participation in 'Asia Pacific Emergency Regional Consultations on Shrimp Early Mortality Syndrome/Acute Depatopancreatic Necrosis Syndrome'.
- Dr K.M.L. Pathak (DDG, Animal Science) visited Bangkok from 16 to 17 August 2012 for participation in the Regional Policy forum/ Dialogue on Asian Livestock Challenges, Opportunities and the Response.
- Dr K.P. Jitendran (Principal Scientist, CIBA, Chennai), Dr Toms C. Joseph (Senior Scientist, CIFT, Kochi), Dr G. Rathore (Senior Scientist, NBFGR, Lucknow). Dr P.K. Sahoo (National Fellow, CIFA, Bhubaneshwar) and Dr N.K. Sanil (Scientist (SG), CMFRI, Cochin) visited Bangkok, Thailand from 25 to 26 July 2012 for participation in the Workshop on 'Regional Proficiency Testing Programme for Aquatic Animal Disease Laboratories Asia-Pacific'.

- Dr A.G. Ponniah (Director, CIBA) and Dr M. Muralidha (Senior Scientist, CIBA,Chennai) visited Bangkok, Thailand from 14 to 15 May 2012 for attending the 'Aqua-Climate Project Partners Meeting and Regional Workshop on Climate Change' and Regional Impacts of Climate change on Fisheries and Aquaculture on 16 May, 2012.
- Dr A.G. Ponniah (Director, CIBA, Chennai) visited Bangkok, Thailand from 3 to 5 July 2012 for participation in the FAO/NACA/APFIC Regional Workshop on 'Application of Aquaculture Assessment Tools in Asia Pacific'.
- Dr T. Mahapatra (Director, CRRI, Cuttack) visited France from 3 to 4 July 2012 for participation in the Global Rice Roundtable on Future Options for the International Rice Commission: New Vision, New Strategies at Montpellier.
- Dr S.S. Raju (Principal Scientist, Agricultural Economics, NCAP, Pusa, New Delhi) visited Islamabad, Pakistan from 17 to 18 July 2012 for participation in the Consultation meeting on 'Assessment of Diversity of Veterinary Services (Public and Private Sector) in the SAARC Countries'.
- Dr V.K. Bhatia (Director, IASRI, New Delhi) visited Bangkok, Thailand from 18 to 20 July 2012 as a Member of Steering Group for Agricultural Statistics (SGAS) for attending the Second Meeting of the SGAS of United Nations Economics and Social Commission for Asia and the Pacific.
- Dr Shiv Kumar (Head, Division of Crop Improvement, Indian Institute of Pulses Research, Kanpur) visited Aleppo, Syria for another two years, i.e. upto 30 April 2014.
- Dr J.C. Dagar (ADG,A&AF) visited Bangkok from 11 to 12 April 2012 for participation in the APAARI/CCAF's organized Workshop on 'Climate Smart Agriculture in Asia; Research and Development Priorities.
- Dr K. Sunilkumar Mohamed (Principal Scientist and Head, Molluscan Fisheries Division, CMFRI, Cochin) visited Penang, Malaysia from 3 to 4 April 2012 for participation in the 'Second Bay of Bengal Large Marine Ecosystem Health Indicators Working Group Meeting'.
- Dr (Mrs) B. Meenakumari (DDG, Fisheries) visited Cambodia from 27 to 29 March 2012 for participation in the 24th Governing Council Meeting of the NACA.
- Dr (Mrs) Malvika Dadlani (Joint Director, Research, IARI, New Delhi) visited Dhaka, Bangladesh from 4 to 5 April 2012 for participation in the 3rd meeting of the *ad hoc* Committee of the SAARC Seed Forum.
- Dr H.S. Gupta (Director, IARI, New Delhi), Dr K.C. Bansal (Director, NBPGR, New Delhi), Dr (Mrs) Indu Sharma (Project Director), Dr Rajkumar Gupta, (Principal Scientist), Dr Gyanendra Singh (Principal Scientist, Directorate of Wheat Research, Karnal) and Dr Jagdish Rane (Head, Division of Drought Stress Management, NIASM, Baramati) and Dr S. Naresh Kumar (Sr. Scientist, Division of Environmental Sciences, IARI, New Delhi) visited Bangkok, Thailand from 26 to 27 April 2012 for participation in the Regional Consultation on Improving Wheat Productivity in Asia.
- Dr H.S. Gupta (Director, IARI, New Delhi) visited Rome, Italy from 25 to 27 June 2012 for participation in FAO's Consultancy Workshop on 'Plant Sciences for Sustainable Crop Production: Strengthening Partnership between Europe and Developing Countries'.
- Dr B.H.M. Patel (Senior Scientist, IVRI, Izatnagar) visited Bangkok, Thailand from 8 to 10 May 2012 for participation in the 4th Workshop for Advanced Concepts in Animal Welfare.
- Shri V.K. Singh (Under-Secretary, DARE New Delhi) visited Bonn, Germany from 14 to 25 May 2012.
- Dr U.C. Sood (Head, Division of Sample Survey, IASRI, New Delhi) visited Bangkok, Thailand from 13 to 18 May 2012 for attending FAO-AFMA Workshop on 'Regional Workshop on Sampling for Agricultural Censuses and Survey'.
- Dr A.K. Singh (DDG, NRM) visited Kandy, Sri Lanka on 1 June 2012 for participation in Mid-term Review Meeting of SAARC-Australia project on 'Developing Capacity in cropping systems modeling to promote food security and the sustainable use of water resources in South Asia'.
- Dr M.M. Pandey [DDG (Agriculture Engineering)] visited Bangkok, Thailand from 15 to 16 May 2012 for participation in the Asia Pacific Network for testing Agricultural Machinery 'ANTAM' Technical Working Group and Steering Committee Meeting at Bangkok and FAO/APACAEM meeting on sustainable Agricultural Mechanization in Asia on 17 May 2012.
- Dr N. Subash (Senior Scientist, Agromet) and Dr Mohammad Shamim, (Scientist, Agromet), PDFSR, Modipuram, Meerut) visited Kandy, Sri Lanka from 26 May to 1 June 2012.
- Dr P. Vijaya Kumar (Senior Scientist, Agricultural Meteorology, CRIDA, Hyderabad) visited Kandy, Sri Lanka from 26 May to 1 June 2012 .
- Dr. P.K. Mahapatra (Senior Scientist, Agro-Forestry, NRM); Dr Anup Das (Senior Scientist, Agronomy; and Dr B.U. Choudhury (Senior Scientist, Soil Science, NRM, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya) visited Kandy, Sri Lanka from 26 May to 1 June 2012 for attending the SAARC Agriculture Centre organized Pre-Workshop, Second Training Workshop and Midterm Review Meeting of SAARC-Australia project on

'Developing capacity in cropping systems modeling to promote food security and the sustainable use of water resources in South Asia'.

- Dr Dipaka Ranjan Sena (Senior Scientist, SWCE, CSWCR&TI, Dehra Dun) visited Kandy, Sri Lanka from 26 May to 1 June 2012.
- Dr R. Jeyabaskaran (Senior Scientist, CMFRI, Cochin) visited Phuket, Thailand from 30 to 31 May 2012 for participation in Regional Workshop on 'Strategic Action Programme Fisheries Indicator'.
- Dr R.K. Yadav (Principal Scientist, CSSRI, Karnal) visited Kandy, Sri Lanka from 26 May to 1 June 2012.
- Dr P.K. Mahapatra (Senior Scientist, Agro-Forestry, NRM); Anup Das, (Senior Scientist, Agronomy) and Dr B.U. Choudhury (Senior Scientist, Soil Science, NRM, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya) visited Kandy, Sri Lanka from 26 May to 1 June 2012.
- Dr Malavika Dadlani (Joint Director, IARI, New Delhi) visited *Punta del Este*, Uruguay from 29 October to 1 November 2012 for participation in the Global Conference on 'Agricultural Research for Development'.
- Dr Ramesh Chand (Director, NCAP, Pusa, New Delhi) visited *Punta del Este*, Uruguay from 29 October to 1 November 2012 for participation in the Global Conference on Agricultural Research for Development.
- Dr S. Ayyappan (Secretary, DARE and Director General, ICAR) visited Uruguay from 29 October to 2 November 2012 to participate in IInd Global Conference on 'Agricultural Research for Development' (GCARD-II) followed by Fund Council VIIIth Meeting.
- Dr Jitendra Kumar Sundaray (Principal Scientist, CIBA, Chennai) visited Dhaka, Bangladesh from 7 to 12 November 2012 for attending the Challenge Program on 'Water and Food Meeting on Aquaculture and Homestead'.
- Dr Bir Pal Singh (Director, CPRI, Shimla) visited CIP Hqrs. Lima, Peru from 19 to 23 November 2012 to attend meeting of Board of Trustees of CIP.
- Dr Dhiman Burman (Senior Scientist), Dr S. Subhasis Mandal (Senior Scientist) and Dr S.K. Sarangi (Senior Scientist, CSSRS Regional Research Station, West Bengal) visited Bangladesh from 7 to 12 November 2012 for participation in the review and planning workshop of CPWF-G2 Project.
- Professor S.K. Datta (DDG, Crop Science) visited Mexico from 12 to 15 November 2012 to attend the Wheat Yield Consortium Funders Conference.
- Dr Yashpal Singh Sahrawat (Senior Scientist, IARI, New Delhi) visited Sri Lanka from 12 to 16 November 2012 for participation in the Agricultural Model Inter-comparison and Improvement Project, South Asia Kick-off Workshop.
- Dr B. Gangwar (Project Director), Dr Harbir Singh (Principal Scientist) and Dr N. Subhash (Senior Scientist of PDFSR, Modipuram) visited Colombo, Sri Lanka from 12 to 16 November 2012 to attend the Agricultural Model Inter-comparison and Improvement Project, South Asia Kickoff Workshop.
- Dr R.K. Sharma (Principal Scientist, DWR, Karnal) visited Mexico from 14 to 17 November 2012 for participation in the International Wheat Initiative's Ist meeting of the Institutions' Coordination Committee (ICC) and a follow up discussion on Wheat CRP activities (16 to 17 November 2012).
- Dr M.M. Mustaffa (Director) visited Taiwan from 19 to 24 November 2012 and Dr Thengavelu (Senior Scientist) and Dr M.S. Saraswathi (Senior Scientist) visited Taiwan from 19 to 22 November 2012 to participate in the International Banana Symposium.
- Mrs Sumita Dasgupta [Under-Secretary (CG), DARE] visited Philippines from 19 to 24 November 2012 for participation in the training Leadership Course for Asian and African Women for Research and Extension.
- Dr V.K. Gupta (ICAR National Professor, IASRI, New Delhi) visited United Kingdom from 26 to 28 November 2012 to attend the CRP 1.1 Dryland systems–Integrated agricultural production systems for the poor and vulnerable in dry areas of the CGIAR meeting.
- Dr B.P. Singh (Director), Dr Sanjeev Sharma (Senior Scientist) and Dr S. Sundaresha (Scientist, CPRI, Shimla) visited Dhaka, Bangladesh from 28 to 29 November 2012 for participation in the Workshop on 'Biotechnology for Food Security and Farmer Prosperity and ABSP-II Potato Partners Meeting'.
- Dr P.P. Thirumalaisamy (Scientist, Plant Pathology, Directorate of Groundnut Research, Junagarh) visited Bangkok, Thailand for attending the working group meeting of Asia on 'Groundnut Bacterial Wilt and *Sclerotium* Stem for disease' from 11 to 12 December 2012.
- Dr T.K. Srinivasa Gopal (Director, Central Institute of Fisheries Technology) visited Colombo, Sri Lanka from 3 to 5 December 2012.
- Dr Himanshu Pathak (Senior Scientist, IARI, New Delhi) visited Doha, Qatar from 26 November to 8 December 2012.

The International visits of DARE/ICAR personnel visited on International deputation and trainings are given in Annexure XII.

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20. National Fund for Basic, Strategic and Frontier Application Research in Agriculture

Although most of the projects under the NFBSFARA are expected to have long-term focus for the application, results have started flowing in. In addition to the tangible results, the expectations from these projects are development of much needed and highly specialized quality human resource for globally competitive research and building-up rapport and partnership for collective exchange and development of ideas for innovative science. These expectations are gradually getting fulfilled. For example, among the fifty-three ongoing projects, forty are multi-institutional, and a number of them include reputed institutions of research outside the NARS.

During the year, a number of important activities regarding policy matters, calling for new projects, project monitoring and project execution were taken up. In the identified thrust areas for the XII Plan, 29 projects have been approved with a budget of ₹ 71.69 crore.

From this year, a new system has been introduced to assist project proponents, whose concept notes have been selected, in developing full proposals to increase frequency of selection of more meaningful proposals. This assistance has increased the success rate in getting approval of the Empowered Committee.

Nineteen out of the twenty-one projects awarded at the initiation of the National Fund have completed term on 31 March 2012. The NFBSFARA has 53 on-going projects at present with a budget of ₹173.54 crore.

The fourth call for submission of the research concept notes was made in August 2012. In response, 597 concept notes have been received. The process of their selection and award is in progress.

Monitoring and Evaluation

The Second Annual Review Workshop of the National Fund was organized on 23 and 24 July 2012 in the presence of the Empowered Committee and also of the Divisional Heads of the Council. The overall progress of the NFBSFARA was reviewed and the mid-course corrections and modifications were suggested. Progress of the nationally important mega project entitled 'Phenomics of Moisture Deficit and Low Temperature Stress Tolerance in Rice' was assessed by the Chairman of the Empowered Committee at the IASRI, New Delhi. A novel attempt has also been made to chalk out a path for integrating activities between this project and the other two projects entitled 'National Agricultural Bioinformatics Grid' and 'Bioprospecting of Genes and Allele Mining for Abiotic Stress Tolerance'. Two Advisory Committee meetings of 21 of the 22 projects initiated under Call II were completed. Third collective Advisory Committee meetings for the Thematic groups were held for four RNAi projects, four Alternate energy projects, four Abiotic stress projects on animal and fish, and four on Post-harvest technology and value-addition projects.

Based on the experience gained and learning from the execution of the Fund during XI Plan, the ICAR has planned to enlarge NFBSFARA substantially during the XII Plan.

SIGNIFICANT ACHIEVEMENTS

From the Call I, 19 projects that completed term on 31 March 2012, as many as 73 scientific papers have been published in peer-reviewed journals. And 4 patents have been filed and one has been obtained.

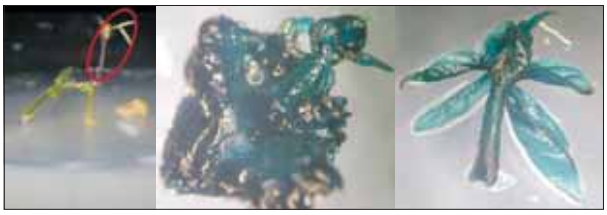
Patents filed/obtained

Sl No.	Project name	Patent title
Filed		
1.	Transcriptional level of developmentally important genes in buffalo pre-implantation embryos	Buffalo embryonic stem cell derived teratomas for the assessment of pluripotency
2.	Application of reverse genetics: a novel approach for studying the molecular basis of immune response in Indian cattle breed	A novel foot-and-mouth disease virus Asia I (Indian vaccine strain) replicon based viral vector for vaccine research and development
3.	Rumen microbial manipulations for mitigation of methane emission and productivity enhancement in dairy animals	Reduction of methane emission
4.	Role of small signal peptides in systemic defense response of Indian mustard (*Brassica juncea*) to aphids (*Lipaphis erysimi*)	A peptide elicitor of NPR1 and PR proteins mediated pathogen defense in Indian mustard (*Brassica juncea*)
Obtained		
5.	Increasing nutrient availability from roughage based rations through enhancing rumen efficiency or reducing enteric methane production by use of secondary plant metabolites	Fermentation vessel for conducting gas production studies (*in vitro*: Fabrication, protocol and uses)

Research Highlights

Plant sciences

- Transformation protocol for pigeonpea was optimized using *Agrobacterium* strain EHA105,



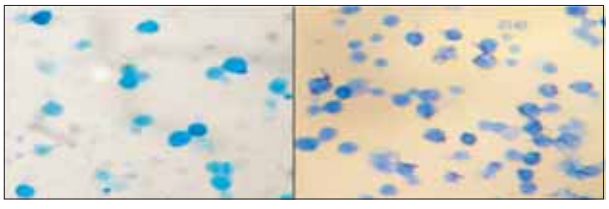
A. Efficient inhibition of chimeras in pigeonpea; **B.** Histochemical localization of GUS expression during regeneration; **C.** Shoot elongation

harbouring binary vector pBI121. Two antibiotics, Kanamycin during initial regeneration and Geneticin during shoot elongation, were used to efficiently screen out chimeras from pigeonpea tranformants.

- In sorghum, ovule-specific promoter FM 1 has been cloned from *Arabidopsis* and its expression has been validated. A unique target sequence of *SERK 1* gene (on chromosome 6) for RNAi silencing has been subcloned, and is being used in transformation of sorghum-plants.

Animal sciences and fisheries

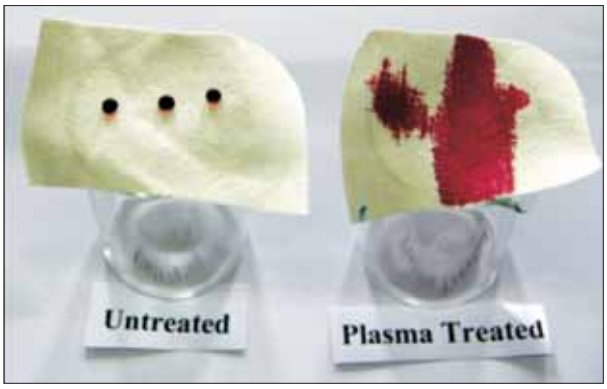
- Stem cell culture has been established using pig bone marrow mesenchymal stem cell lines. These cell lines will be used for producing transgenic pluripotent cells which in turn can be used for development of transgenic pigs. Immortalized Human Embryonic Kidney 293 (HEK 293) cells are being cultured for production of lentiviral particles. These particles will be used in the current project for reprogramming of pig cells to generate iPS cells and also for silencing target genes by RNA interference in reprogrammed iPS cells.
- A patent has been obtained on fermentation vessel for conducting rumen-gas production studies in *in-vitro*.
- *Argulus siamensis* has been identified as the most prevalent species, followed by *Argulus japonicus*, causing highly damaging parasitic disease, argulosis, in Indian aquaculture systems. A PCR-based marker for identification of two species has been developed.
- Parameters of infection for *in-vitro* challenge of head-kidney-derived macrophages with *Mycobacterium fortuitum* and *in-vivo* challenge of catfish and zebra fish have been optimized. A battery of tests (PCR as well as ELISA based) and microscopic smear examination for detection of *Mycobacterium paratuberculosis* and screening of infected animals have been optimized.
- Levels of expression of 5 genes, *BMP 15*, *GDF 9*, *MATER*, *ZAR 1* and *IGFBP 1*, were identified as markers for the development competence of oocytes to be used for *in-vitro* embryo production in buffaloes and in helping improve *in-vitro* production protocol.



Acid-fast staining of macrophages showing presence of bacteria inside them

Post-harvest technology and value-addition

- Indigenous lab-scale atmospheric pressure cold-plasma reactor with and without cooling system for environment friendly treatment of cotton-fabrics for effective dyeing and other qualities has been designed. Generation of atmospheric pressure cold plasma has also been achieved.



Surface modification of textile using plasma

- Pressure treatment at 400 MPa and above resulted in rapid dissociation of casein micelle. Micellar proteins are fully denatured and serum proteins denatured partially due to pressurization. In buffalo, disruption of casein micelle at 400 MPa or above pressure for 10 minutes indicated that casein fraction is the major site for high pressure-induced effect. The change in casein fractions affected viscosity and colour, apart from affecting HCT and rennet coagulation time (RCT). Shelf-life of high pressured (400 MPa for 10 min) treated samples of both cow and buffalo milk could be stored up to 20 days in refrigeration (5±2°C) without changing functional characteristics and spoilage. Above 400 MPa, the casein protein got denatured.
- An autoclavable microencapsulation system with multistage break-up two fluid nozzle has been developed for microencapsulation of sensitive food components, which are prone to contamination (microorganisms and their products) including bacteriocins. Microencapsulation of probiotic species of yeast, *Lactobacillus casei*, and pediocin, nisin, xylanase, pectinase and amylase has been done. Patent has been filed and technology has been transferred.

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21. National Agricultural Innovation Project

Indian Council of Agricultural Research (ICAR) initiated National Agricultural Innovation Project (NAIP) with the assistance of the World Bank and is being implemented since July 2006. The project became effective on 18 September 2006. The closing date of the project was extended to 30 June 2014. The specific objective of NAIP is to accelerate the collaborative development and application of agricultural innovations between public research organizations, NGOs, farmers, private sectors and other stakeholders. To address project objective, research agenda is divided into four components, namely (*i*) ICAR as the catalyzing agent for management of change in the Indian National Agricultural Research System (NARS); (*ii*) Research on production to consumption systems; (*iii*) Research on sustainable rural livelihood security; and (*iv*) Basic and strategic research in the frontier areas of agricultural sciences. In addition, three subprojects under Component 3 are funded by the Global Environment Facility (GEF) Trust Fund of the World Bank.

ICAR as the catalyzing agent for management of change in the Indian NARS

The NAIP initiated many activities which are showing impacts and have potential to act as catalyzing agent to improve the system-wide efficiency, effectiveness and productivity. It has five sub-components, namely information, communication and dissemination system; business planning and development; learning and capacity building; policy, gender analysis and visioning; and remodelling financial and procurement system with 43 approved sub-projects. Some of the salient achievements include development of world class state-of-art infrastructure and National Agricultural Bioinformatics Grid (NABG) for hosting different types of ICT applications including genome sequence data and their management are in progress. A total of 327 e-courses in Agricultural Sciences were developed on Moodle (an e-learning platform). An online central repository of doctorate dissertations in agriculture, *Krishi Prabha*, consisting of 7,627 abstracts and 6,000 full texts was created.

Under the sub-project on Agropedia, KVK-Net (Krishi Vigyan Knowledge Network) and vKVK (virtual Krishi Vigyan Kendra) were developed to help farmers and extension workers. KVK-Net provides a platform to the officials of the KVKs to share and discuss their experiences and issues and vKVK is for disseminating tailor-made information to the farmers on their mobile phones in local languages. Under the sub-project on Mobilizing Mass–Media Support periodic media meets/ interactions were organized in which 207 media persons and 1,123 farmers entrepreneurs participated. Dissemination of information on new innovations/ technologies was carried out through 600 news clippings and 276 TV/Radio programmes.

A 24×7 Rice Knowledge Management Portal (RKMP) was e-launched. The RKMP is equipped with 20 platforms with more than 12,000 pages on content, 3,000 minutes of audio and 50 video clips.

About 361 NARS scientists availed international training in 27 cutting-edge areas of science. Further, 268 scientists obtained international training under approved consortia. About 73 national trainings involving international experts have also been

Impact of CeRA

Consortium for e-Resources in Agriculture (CeRA) facilitates 24×7 online access with approximately 3,000 scholarly journals from 7 major publishers and catering to about 142 institutions under the NARS. After setting up of CeRA an annual increase of about 18.5% in the number of publications in NARS during 2011-12 compared to 2008-09 was observed. Till August 2012, the number of visitors to the site exceeded 3.5 million with total download of more than 5.0 million full text articles and 20,850 articles under Document Delivery Request Service (DDRS).

Impact of Business Planning and Development Units (BPDUs)

Established ten Business Planning and Development Units (BPDUs) equipped with modern laboratory facilities, besides having working pilot plants and office/ bench space with modern ICT facilities for the use of incubates (prospective entrepreneurs) on charge basis to develop processes/ products and/ or to gain confidence before taking up the full-fledged commercial ventures.

Technologies (78) developed by NARS generated revenue of ₹ 13.222 crore on commercialization, and 336 entrepreneurs were incubated. BPDUs also synergized with national initiatives for enhanced incubation support through Micro, Small and Medium Enterprises (MSME), DST and DBT, benefitting seven BPDs through additional funding of Rs 6.5 crore. The Zonal Technology Management (ZTM)-BPD Unit at IARI, New Delhi launched a Farmers Producer Company in the name of 'Beej India Producer Company Ltd' under Companies Act 1956. BPD–CIRCOT is promoting commercialization of *Bt* cotton detection kit in South Africa and China. The ZTM-BPD Unit, South Zone also provided technical consultancy in the area of thermal validation of seafood to M/s Mandhoo Fisheries Complex, Republic of Maldives. The BPD Unit at JNKVV, Jabalpur formed a seed consortium to promote production of hybrid seeds in the state.

completed. Trained manpower is being used to develop Centres of Excellence in cutting-edge technologies.

Gender Work Participation Disparity Index (GWPDI) was developed to characterize the gender work participation scenario on regional and all India bases. The value of GWPDI varies between 0 and 1 (greater the index value more will be the disparity). The GWPDI value for India indicates that the disparity in work participation between men and women has narrowed down over the years. Commodity price forecasts for 36 commodities were disseminated for the benefit of farmers across the country. Based on online database repository called commodity market outlook statistics (CMOS), a decision support system for agricultural commodity market outlook was developed, which is capable of generating outlooks for cereals and oilseeds on four key components of the food balance sheet, namely demand, supply, trade and prices, for next 15 years. Eleven market intelligence centres established have so far made 298 commodity price forecasts and published in 130 leading dailies besides posting on websites (www.tnagmark.tn.nic.in, http://amickau.nic.in) and also communicated directly to 160,000 farmers through mobile. A carbon tool kit for sustainable agro forestry clean development mechanism (CDM) projects was developed. Energy-based household interventions like replacement of traditional electricity bulbs with CFL bulbs, introduction of energy-efficient cook stoves (*chulhas)* and solar lanterns were introduced.

Production to consumption system

Fifty-one value chain consortia covering all commodities, viz. horticulture, crops, animal sciences and fisheries are covered under this component and significant achievements are given here.

Sorghum-based products were popularized by road shows-cum-nutritional campaign in Hyderabad. *Jowar* products with DSR's Eatrite brand were launched.

Clinical trials on foxtail millet based diabetic food confirmed that it is beneficial to diabetic, obese and heart patients. The diabetic mix was well received by diabetic patients.

A vacuum filtration system for production of clarified sweet sorghum juice was developed. The produced syrup can be used as a sugar replacement in developing value-added food products.

Polythene mulching technology in tomato controlled weed, diseases and pests, reduced evaporation of irrigation water, helped in better utilization of applied nutrients, and protected the crop from sudden and excess rainfall etc., resulting in better-quality fruits with improved yield. Thus integrated crop management in tomato reduced the cost of cultivation to the tune of ₹ 17,525/ha and increased yield by 20.2%.

Techniques for off-season flowering in malligai (*Jasminum sambac*) through physiological intervention under open and protected conditions were standardized. As value added products of jasmine combined with tuberose have high demand in the market, tuberose spikes were tinted with different acid dyes.

The broodstock development of cobia in sea cages was standardized by using standard feeding protocols with sardine and squid at *ad lib*. levels. Filleting technology of murrels and use of gelatin obtained from murrel wastes was popularized among the entrepreneurs for manufacturing pharmaceutical products. Methods were standardized for masking fish smell, removal of excessive oil from the fried products and softening pin bones to palatable consistency.

Testing of fuel-efficient propellers (developed in the sub-project on Responsible Harvesting of Small Pelagic) on 21 vessels confirmed that it saved 19% fuel. With this intervention the sector having about 1,100 vessels saved around 14–19 million litres of diesel per annum worth around ₹ 63–78 crore.

Installation of sub-surface drainage system in the saline soils of Maharashtra improved production of soybean, sugarcane, Bengal gram and wheat by 74 to 114%. Simultaneously, drain water collected in ponds was utilized for fish culture which provided substantial income to the farmers. Fish grew to 950 to 1,100 g in 10 months indicating that growth in sub-surface drain

Success story

Biomass-based power generation

Energy shortage remains the major constraint in the development of agro industries and services in the rural sector. Two units of power plant (50 kW) capacity were installed and commissioned at sites for establishment of biomass-based decentralized power generation using gasification route. The generated power is used for operating the briquetting plant and water pump of the municipal corporation of Raisen (Madhya Pradesh). Developed a commercial granular charcoal filter to treat the waste water of biomass-based power plant of 20 kW capacity, reducing chemical oxygen demand (COD) to 60%.

World's first cloned pashmina goat — Noori

Goat embryos were cultured to blastocyst stage in the laboratory and transferred to many Pashmina goat recipients at the SKUAST farm. Two goats got pregnant and first Pashmina goat-kid produced through hand-guided technique was christened as 'Noori'.

water is at par with normal freshwater ponds.

Strengthening potato value chain: Model chain for French fries was strengthened in Gujarat in collaboration with private sector. Kufri Frysona recorded yield of 54.2–56.8 tonnes/ha which is 11–42% better over other varieties besides the improvement in quality. No internal defect was observed in tubers, dry matter ranged between 21.5–23.4% and variety had excellent fry colour. In storage studies, line testing of stored tubers also exhibited very good results having only 1.1–1.6% of internal defects (limit, 5%), 9.9–10.9% external defects (limit, 12%) and total defects 11.5–12% (limit, 12%). K. Frysona had 22.1–23.6% solids, excellent fry colour without any sugar end.

Market development and branded oyster products : Two new value chains were developed, viz. Fresh depurated oysters for live consumption in high-end restaurants and value-added-products of farmed oysters were intensified.

Little millet based sports food: The suitability of little millet sports food for growing children and athletes was established. The product is available at affordable cost of ₹180/kg.

Research on sustainable rural livelihood security

The major objective of the component is to improve livelihood security of the rural people living in selected disadvantaged regions through technology-led innovation systems. The consortia focused on identification of new beneficiaries, demonstration of various interventions among these beneficiaries, continued support to beneficiaries covered during pre-extension phase and data analysis. Some of the significant interventions were also reported.

IFS model for Bidar district: An innovative idea of transplanting of red gram was demonstrated in 400 ha area in Bidar, Karnataka. The major advantage of transplanting was contingent measure due to erratic rainfall and reduced water requirement with higher yield. Accordingly, red gram transplanting based model for 1 ha area and backyard poultry with 10 birds was integrated to give a net return of ₹ 153,200.

Water harvesting based livelihood model for Vindhyan region: In Eastern Uttar Pradesh the Vindhyan region faces the problem of availability of irrigation water due to surface run-off of rain water and water underutilisation of river sources leading to low productivity and cropping intensity.

Check dam constructed under the project, Mirzapur

Watershed based farming system modules with the interventions, viz. construction of eight check dams and 24 water harvesting bunds (WHB), distribution of plastic delivery pipes (2.5" PVC delivery pipes to 121 farmers' groups) and diesel pumps (30 water lifting pumps to 30 farmers' groups) were initiated.

These interventions resulted in an increase of 37.7% in irrigation water facility; and increase in area under winter season pulses and oilseeds. Similarly, near the check dams, area under rice in rainy season and wheat during winter has increased due to prolonged availability of water. Near some check dams in cluster II, it was possible to cultivate summer vegetables, pulses and fodder crops. With the enhanced availability of irrigation water and appropriate crop varieties, the cropping intensity improved up to 188.7, 193 and 183.4% in cluster I, II and III, respectively, recording an overall enhancement of 36.1% as compared to baseline value. The average water table near the water harvesting structures has risen to 1.12 m.

Availability of irrigation water accompanied with the use of quality seeds, better input use and production technology improved yield of cereals, pulses and oilseeds over two-folds in the vicinity of water harvesting structure. Near check dams productivity enhancement of field crops was higher than water harvesting bunds because it retained water for longer periods.

Groundnut, a viable second crop, for small and marginal farmers: In 15 villages of Lodhashuli cluster, *kharif* groundnut was adopted by 1,706 farmers in 165.62 ha and *rabi* groundnut by 802 farmers in 90 ha. The groundnut production of 2 to 2.5 tonnes in *kharif* and 3.5 to 4 tonnes in *rabi* was very high over the baseline value of 1–1.5 tonnes/ha. This innovation helped to build the trust among the farmers of the project area resulting in adoption of the technology and increased production of groundnut (600 kg/ha)

Groundnut is a viable second crop for small and marginal farmers of Lodhashuli, Midnapore

and an additional income. A marketing outlet was also established in Midnapore town for sale of produce.

An innovative irrigation technique for vegetable cultivation: Shri Ramesh Bariya in Jhabua, Madhya Pradesh, raised bitter gourd, and sponge gourd in late summer season but delayed monsoon affected the crop in early stages. This prompted him to take up an innovative method of drip irrigation i.e. using empty saline bottles. Six kg of empty saline bottle @ ₹ 20/ kg procured could save this crop getting a net profit ₹ 15,200. This indicated the possibility of getting ₹ 1.5 to 1.7 lakh/ha by vegetable cultivation using this innovative drip irrigation technique.

An innovative irrigation technique for vegetable cultivation

Patents: Three patents, namely Low cost technology for prevention and treatment of sub-clinical mastitis in bovines; Mineral based-technology for estrus induction and synchronization in bovines; and Low cost multiplication of media for plant bio-enhancers, were filed.

GEF funded sub-projects

In Sundarban region of West Bengal, 42.5 ha area was covered under land shaping which has the potentiality of harvesting 169,980 m^3 of rain water. About 34 ha of additional (monocropped) area was brought under multi-crop cultivation through irrigation in dry season and about 8.5 ha land was brought under aquaculture. The gross income of farmers increased by ₹ 48,000–52,000/year/household (HH). Paddy-cum-fish cultivation/integrated farming was introduced in 19.69 ha, which improved the gross income of farmers by ₹ 45,000–49,000/year/HH. About 144.68 ha of land was brought under cultivation of improved/salt-tolerant varieties of vegetables (cabbage, cauliflower, knol-khol, beet, brinjal, chilli, spinach, okra, cucurbits, basilia, etc.), pulses (moong), oilseed (sunflower, sesame), cotton and *kharif* and *rabi* rice. In the area of crop nutrient management, 74.4 ha land was covered under improved nutrient management practices like green manuring, integrated nutrient management (INM), vermin-composting, etc.

Bioresource inventorization programme for plant, animal and fish resources in Chamba (Himachal Pradesh), Udaipur (Rajasthan) and Adilabad (Andhra Pradesh) is being carried out effectively with multiplication of prominent landraces and species. Community Gene Banks were created for distribution of seed of local landraces to farmers. Biodiversity registration was initiated to help the farmers in terms of enhanced income levels. Market linkage was developed with a private group for the targeted production of 200q each of the traditional landraces of redgram and rice from Adilabad district. This would help in conservation as well as enhanced income to the beneficiary farmers.

Interventions on animal health and nutritional feeding immensely benefited farmers in managing livestock and also enhance milk production meaning thereby that the local breeds may become cost-effective. This would help in conserving the local breeds. Owing to vaccination against foot-and-mouth disease (FMD), peste des petits ruminants (PPR) and haemorrhagic septicaemia (HS) and blackquarter (BQ), no major disease outbreak was observed in the target areas.

The intervention on laser levelling and water delivery system such as groundwater pipeline and sprinkler system led to improved efficiency in water transport and delivery system.

Through an innovative service called ‘m-Krishi-Fisheries’, in one village of 32 fishing boats, diesel saving of 70,000 liters per month could be attained amounting to saving of 150,000 kg of CO_2.

Climate change characterization of past weather and agriculture in Dhar, Mewat, Ganjam and Raigarh districts was done. The Integrated Coastal Management (ICM) introduced in flood-prone area proved very beneficial to the farmers, as they got 51% higher yield than their own practice. Demonstration of System of Rice Intensification (SRI) resulted in 5.20 tonnes/ha grain yield which is 13.5% higher than traditional practice with 20% saving in water. Short-duration rice varieties tolerant to moisture and temperature stresses were introduced in 50 famers’ fields covering 11.5 ha. Owing to this intervention, farmers gained an additional net income of ₹ 15, 000 to 31,000 in addition to assured food security for the family.

Basic and strategic research in frontier areas of agricultural sciences

Abiotic stress tolerance in agriculture: It is functionally validated *in planta* that *OsFBK1* gene confers stress tolerance; however, its expressivity in transgenic rice plants also altered expression of some agronomic traits. A variant allele of *cry1Aa* gene from a microbial isolate NB7 was cloned in expression vector pET28a. Five isolates of *Bacillus* and derived genera and 23 archaebacteria tolerant to saturated NaCl conditions were described; isolate AKS07 has potential for use as a broad spectrum bio-agent for control of various crop pests- and/or vector-borne diseases since it harbours multiple insecticidal genes [9 cry genes and 7 other (cyt, vip, chit, etc.) genes].

Resistance to biotic stresses in agriculture: Allele mining of *Avr-Pita* gene was completed from 80 isolates of rice blast causing organism, *Magnaportheoryzae*, collected from different parts of India, and allele specific markers developed from the available sequence thus variation. Isogenic lines of Pusa Basmati-1 were developed, pyramiding 1-3 resistant *Pi-* genes in their genetic background; using 7 genes which are resistant against different races of the pathogen.A triple gene fusion construct was developed to build-up broad spectrum diagnostic tool to simultaneously detect papaya ring spot virus (PRSV), cucumber mosaic virus (CMV) and groundnut bud necrosis virus (GBNV).

Isogenic lines of Pusa Basmati-1 carrying major blast resistance gene(s)

Four polyclonal antibodies developed against cucumber mosaic virus (CMV), papaya ring spot virus (PRSV), groundnut bud necrosis virus (GBNV) and peanut mottle virus (PeMoV) were extensively validated on wide-ranging (17) crops. Biochemical test keys for differential identification of entomopathogenic nematodes, *Xenorhabdus*, *Photorhabdus* and *Provedencia*, were simplified. Two root-specific nematode responsive promoters were identified; one of these promoters is expressed exclusively at the feeding site (gall). RNAi approach extended to migratory nematodes has revealed function of two genes involved in muscle contraction, wherein RNAi of these genes leads to complete paralysis of worms.

Molecular genetics and breeding: Functional characterization of a cotton fibre related gene, *Aquaporin*, was done by *Agrobacterium* mediated genetic transformation of cotton (*G. hirsutum*) var. coker 310. Eleven full length gene clones of genes involved in cotton fibre development, including *Aquoporin*, were developed in transformation vectors. Structural proteins involved in cotton fibre cell initiation and elongation were isolated and characterized. Sesame recombinants with more than 2% higher linoleic acid content were identified from crosses of cultivated *S. indicum* with the donor *S. mulayanum*. Three collections of *Cucumissativus* field resistant to *Alternaria* fruit rot and 7 carotenoid rich collections of cucumber were discovered. New, convenient agro-techniques for mass cultivation of medicinal plants, *Hedychiumspicatum, Origanum vulgare, Valerianajatamansi* and *Gymnemasylvestre*, were developed.

Biodiversity: Mango phenology data analysis system was developed to infer from phenological data matrix of off-season mangoes. Ten promising ecotypes with consistent mango fruit yield in off-season in Kanyakumari area were identified. Farmer's field demonstration was conducted for the paclobutrazol-application time in Alphonso mango trees to advance their flowering by 2½–3 months (September–October) and early harvesting (mid-January to mid-March) along west coast of Konkan. PCR based method for differentiating *kusmi* and *rangeeni* strains of lac insect was developed. Morphometrics for 7 female lines (30 specimens each) was completed with 60 characters. DNA sequence data of 25 specimens of *Lamellidens* and *Parreysia* were generated to confirm the identity of freshwater bivalves.

Nanotechnology: Two fungal isolates of *Aspergillus* capable of synthesizing the ZnO nanoparticles and one isolate for use in extracellular synthesis of Fe nanoparticles were identified. Molecular identification of efficient fungal isolates capable of iron oxide nanoparticle synthesis was achieved. The 32 KDa extracellular proteins from different fungal species helped in the biosynthesis of nanoparticles. Starch nano-composite film was validated for major criteria in food packaging such as improvement in mechanical and barrier properties, and good sealing-ability of pouches.

Precision farming: A ground-based integrated sensor and instrumentation system was developed to measure real time crop conditions, and interfaced with a differential GPS receiver, which supports multi-source information acquisition and management in the farming field.

GIS application in agriculture: Mealy bug stress indices in cotton for area-wide assessment of crop infestation and damage through remote sensing were developed. Fixed precision sampling plans were devised for assessment of cotton mirid,

Crenotiadesbiseratense, population density in *Bt* cotton at user defined levels to help in accurate estimation of timing for pest management interventions based on a set economic threshold.

Natural resource management: Multiple microbial diversity indices for the soils of Indo-Gangetic plains and brown soil regions were derived; and estimated values of saturated hydraulic conductivity were used for generating quantitative soil drainage maps.

Structures and processing engineering: Quantification of impact of rubber check-dams installed in Odisha have shown availability of upstream water for 6–7 weeks more at two locations, i.e. up to first week of May, where the nearby streams had dried up by mid-March. Common maturity index was developed for 9 cultivars of mangoes (*Alphonso, Dushehri, Langra, Maldah, Chausa, Mallika, Kesar, Banganpalli, Neelam*). Indigenously produced spiral wound membranes were adopted for separating disaccharides, pentoses, hexoses, furfural derivatives and organic acids.

Social sciences in agriculture: Four participatory rural appraisals (PRAs) were prepared to meet the information need of farmers in West Godavari, Krishna and Nalgonda Districts of Andhra Pradesh. A Wine Grape Insurance Structuring Automation Tool (WIGISAT) was developed and tested in a stakeholders interface dialogue.

Animal reproduction and health: Three embryonic stem cell lines are being maintained and regularly confirmed for their pluripotency. Use of soymilk extender in cryo-storage of spermatozoa was more effective in maintaining mitochondrial membrane potential, and comparable in pregnancy rates on first insemination compared to the conventional egg yolk extender. A biochip capable of detecting mastitis-causing pathogens and specific virulence genes was developed. A herbal acaricide formulation was characterized for safety, stability and activity against acaricide resistant ticks. At 5× concentration the formulation did not show any unwanted reaction on animals. The extract was stable up to 120 days at room temperature without any change in efficacy. Pen trial on crossbred male calves gave nearly 70% protection against repeated high challenge infestations. Large scale validation of two herbal formulations in 3-phase clinical trials in different states was successfully done. 3D model of rohu TLR2 was constructed to analyze its biological function, and critical domains that recognize bacterial PAMPs were identified.

Milk and dairy production: A prototype microfluidics device was fabricated for online analysis for multi-analytes (residues and contaminants) in milk**.** A novel micro-technique for detection of bacteria (*enterococci*) in milk was also developed. A field portable biochip device for ultrasensitive analysis of aflatoxin M1 in milk, and novel enzyme-substrate based bio-assay for real time detection of *Listeria monocytogenes* in milk were developed. A real time enzyme substrate assay for detection of *E. coli O157:H7* in milk was optimized. Large scale awareness on various milk detection kits developed for adultrants (detergent and urea) was created among stakeholders through field demonstrations. Cell envelope proteinase (*PrtR*) gene from *Lactobacillus rhamnosus* was cloned.

Rumen physiology and ecology: *In vitro* experiments using recombinant microbes improved digestibility. *In vitro* trials conducted with recombinant yeast gave a maximum of 54.6% of dry matter digestibility of paddy straw, which is an improvement of over 13.8% over the control. Feeding of nitrate @ 3% of diet to buffaloes reduced methane emission 34.1%, and significantly improved feed conversion efficiency and average daily body weight gain by 9.6%.

Meat production: A stable myoblast cell line was developed through Lentiviral mediated gene transfer, using backbone of pLKO.1 sh2 construct, shRNA construct integration in the genome of myoblast cells was confirmed.

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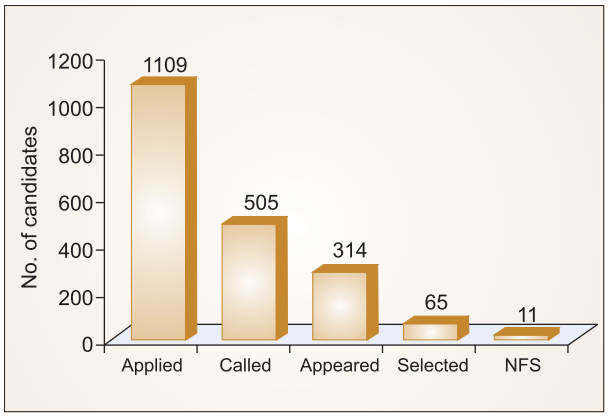
22. Science Resource Management

The Agricultural Scientists' Recruitment Board (ASRB), as an independent recruitment agency, has undertaken a number of reforms to make assessment and recruitment more transparent and efficient. The highlights of some of the major activities undertaken during 2012–13 are:

Direct Recruitment

During the year, of the 76 posts, only 85.5% posts were filled up mainly due to non-availability of suitable candidates. Of these, 17% were Research Management Positions (RMP), 15% were in the middle-level cadre (Project Coordinator, Joint Directors of other than National Institutes and Head of Divisions), and 68% were at the level of Principal Scientists and Senior Scientists.

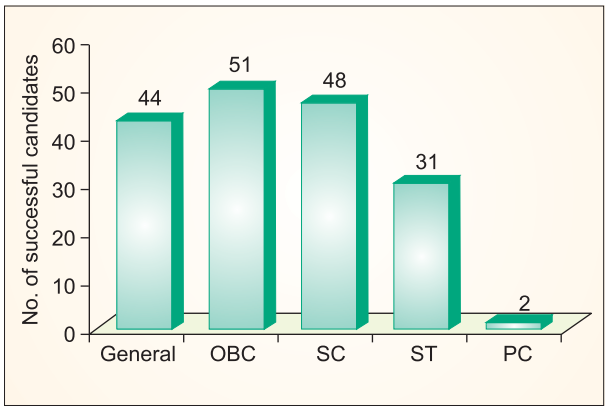


Details of 76 direct selection posts.
NFS, Non found suitable

ARS/NET Examination

The Agricultural Research Service (ARS)/National Eligibility Test (NET) preliminary examination and main examination 2011 for ARS were conducted by the Board at 33 centres in 23 disciplines covering eight major groups, viz. Agricultural Sciences (4), Veterinary Sciences (4), Fisheries Sciences (2), Natural Resource Management (3), Social Sciences (4), Agricultural Engineering and Technology (4) and Dairy Sciences and Technology (2) and Basic Engeineering and Textile Sciences (2) on 19 February 2012. Of the 28,445 candidates applied for the examination, 20,935 candidates (73.6%) appeared in the examination. However, only 2,344 cleared NET. The success ratio for NET was 1 : 9.

The ARS main examination was held for the recruitment of 303 scientists in 49 disciplines. Of the 14,143 candidates that applied for the ARS Examination, only 7,328 (51.8%) appeared and of these, 549 candidates who had obtained marks above the cut-off level were called for ARS interview for the 303 advertized vacancies. But only 176 vacancies could be filled up and

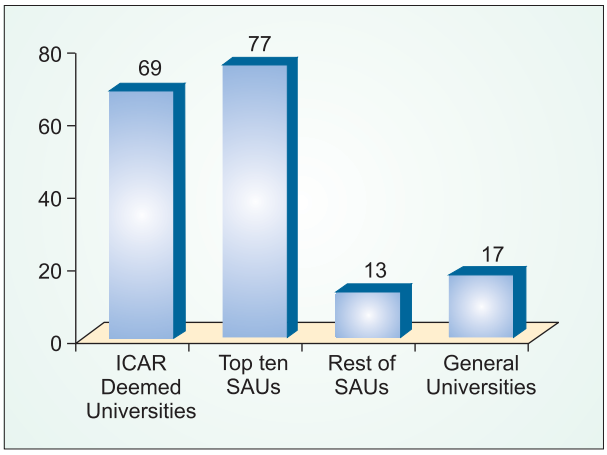


Category wise details of selected ARS candidates in different groups, i.e. General, Other Backward Classes (OBC), Scheduled Tribe (ST), and Physically Challenged (PC) in ARS 2011

the success ratio for ARS worked out to be 1 : 42 . No candidate qualified in Agricultural Chemicals/Organic Chemistry, Soil Science-Pedology, Soil Science-Soil Physics/Soil-Water Conservation, Textile Manufacture and Electrical Engineering. Analysis of the ARS results points to some interesting trends.

The Board usually interviews/calls five candidates against each vacancy. During 2012–13, sufficient number of candidates were not available in the disciplines of Nematology, Biochemistry-Plant Science, Plant Physiology, Agricultural Physics, Home/Family Resource Management, Agricultural Statistics and Mechanical Engineering.

- The interest of the female candidates in agricultural sciences is increasing and during this year, of the 176 selected candidates, 22.7% were females.
- Candidates belonging to OBC category outperformed the general category, and claimed 9 seats of the general category. Candidates belonging to SC and ST categories also performed fairly well and claimed three and one seat, respectively, from the general category.
- State-wise distribution indicated that 77% of ARS scientists belonged to 10 states—West Bengal, Karnataka, Tamil Nadu, Kerala, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Haryana and Odisha.
- Data showed that of the 176 posts, 83% of the selected candidates were from 10 State Agricultural Universities/Deemed-to-be Universities and the remaining 7% from rest of SAUs and 10% from general universities. Of the successful candidates, 51% were those who had written ARS examination for the first time.



Organization-wise performance in ARS 2011-12

Assessment/Promotion of Scientists under Revised Career Advancement Scheme

The revised Career Advancement Scheme according to the recommendations of Sixth Pay Commission has been approved by the Hon'ble Union Agriculture Minister and President of ICAR Society. During the year, Board has received more than 700 proposals in 57 disciplines for promotion of scientists from Research Grade Pay of ₹ 9,000 to Research Grade Pay of 10,000. The assessment process of these proposals has been completed and results have been forwarded to the Council. The discipline-wise details of the assessment cases are 251, 29, 128, 165, 57, 43 and 75 candidates in major disciplines such as Crop Science, Horticulture, Natural Resource Management, Veterinary Science, Fisheries, Agricultural Engineering and Technology, and Social Sciences respectively.

Reforms

Revision of eligibility qualifications and scorecard for direct recruitment

- Model Qualifications for Direct Recruitment to all scientific positions have been revised and notified based on Dr R.S. Paroda Committee recommendations;
- Scorecard for Direct selections revised and notified;
- Application format for Direct selections revised for radical rationalization;
- Special efforts made for inducting best talent from other than ICAR research institutes through direct recruitment.

Revision of eligibility qualifications for ARS and New schemes for conducting ARS examination and National Eligibility Test

- ARS and NET made as two independent examinations with NET to be held twice in a year;
- Disciplines and syllabi both for ARS and NET were completely revised and updated.

New Initiatives

Developing, Commissioning, Operating and Managing an Online System for NET/ARS-Prelim Examination in ASRB, ICAR

Contract agreement between ASRB and the outsourced agencies for Procurement of Equipment/ Goods/Services for Developing, Commissioning, Operating and Managing an Online System for NET/ARS Prelim Examination at ASRB (Hq) (NOEC) and 23 Nodal Centres across India was finalized on 1 October 2012. The Project is under implementation stage.

Assistant Grade Examination (Direct Recruitment) for filling up vacancies at ICAR (Hq) and its Research Institutes

On the basis of performance in the Main Examination held in 2011, around 500 candidates were called for the document verification and also for exercising options for the place of posting. The process of document verification and collecting options for the posting continued for about 10 days, wherein around 450 invited candidates completed the exercise. The list of selected candidates along with reserve list was compiled and sent to the ICAR for taking further necessary action for appointment of Assistants at ICAR (Hq) and respective institutes.

The online examination process and also the process of document verification and merit linked options collected from the candidates for the place of posting were very unique, and innovative activities were adopted for the first time in the ICAR system. The whole process showed a tremendous success and this exercise was completed in a very efficient, effective and transparent manner.

- Analysis of the Assistant Grade Examination results showed that of the 368 posts, 37.2% of the selected candidates were from Delhi and 51.6% belonged to Haryana, Uttar Pradesh, Bihar, Rajasthan, West Bengal, Kerala, Maharashtra, Andhra Pradesh and Karnataka, and the remaining 11.2% to other states of the country.
- This year, of the 368 selected candidates, 24.5% were females.

The analysis further revealed that all the advertized vacancies were duly filled under various categories of candidates with maximum candidates under General Category (239), followed by Other Backward Classes (65), Scheduled Castes (35) Scheduled Tribes (20) and Physically Challenged (9).

Right to Information Act, 2005

During 2012–13, the Board received 157 cases, mainly concerning the disclosure of names of experts, marks secured in the screening and interviews, procedure for screening of applications for direct recruitment posts, marks secured in the ARS/NET examination, proactive orders/decisions of the Board and implementation of Section 4 of the RTI Act. Out of 157 cases, only 10 candidates filed appeal with CIC against the ASRB decision. All the cases were disposed off successfully to the satisfaction of all concerned. ❑